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CROPPING SYSTEMS WORK IN THAILAND

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Rice-based cropping systems research in farmers' fields has been conducted systematically in 1977 at four locations namely Pimai and Ubon in the Northeastern Region, and Bangpae and Inburi in the Central Region of Thailand. The first three sites are in the rainfed lowland category and the fourth site represents the partially irrigated condition. The program is assisted technically and financially by the International Development Research Centre. Organizational Chart on page 62 showed the set-up of agencies involving in the conduction of the research experiments. Ubon and Pimai sites are under the agronomic supervision of the Rice Division while Inburi is under the Technical Division, both of the Department of Agriculture. Economic research supervision of these three sites is under the Division of Agricultural Economics of the Ministry of Agriculture and Cooperatives. Faculty of Agriculture in cooperation with Faculty of Economics and Business Administration of Kasetsart University is responsible for the agronomic and economic research efforts or the last Bangpae site.

In connection with the research attempts, there are six rice experiment stations in the Northeastern Region, three in the Central Region, helping in the back-stopping researches within the stations. Regional Research Centers in the Northeast and in the Central Regions are also doing cropping pattern trials within the centers producing useful information for the rice-based cropping systems work in farmers' fields.

The program is a coordinated one among researchers and instructor-researchers of the agencies involved. So that good cooperation among people concerned is the first priority for the success of the research undertakings. Even though research responsibilities are divided into four major locations, regular interchange of ideas, and physical and technical helps among different workers are always presented as the work is progressing on. This report is trying to present the cooperative linkage, research activities, agronomic and economic results and analyses. Four major research locations will be described lengthly with the addition of other research activities presently going on in the country. The report will also present the training component of the program together with future plans.

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A. Ubon site

A.I. Description of the site

Ubon site is located in the Northeastern Region. It is in the eastern part of the Northeast representing a rainfed area of about 500,000 hectare. By road, it is about 700 kilometer from Bangkok. There are three seasons in the area: the monsoon rainy season from May to September, the cool season from November to February and the warm season during March and April. Ubon area receives rainfalls regularly during the early monsoon but rains cut off sharply toward the end of the rainy season (Fig. A.1). Rainfall distribution is unimodal. In 1977, drought situation occurred in the area during the early part of the monsoon rainy season. Rains started in the latter part of April recorded at 62.5 mm. for the month. Rainfall was normal in May but the amount of it dropped to 81.7 mm. for the month of June creating unsufficient rains for farmers in the area for the preparation of rice seedbed. Again in July, rainfall amount was one-half below the average. However, rains in August and September were plenty and farmers transplanted their rice crop even though the length of time for the crop growth from transplanting to harvest was short for the local photoperiod sensitive varieties. Then the rains stopped abruptly in October recorded at 38.8 mm. which was one-half of the average representing the occasional sudden end of rainfall pattern for the area. The situation was not condusive for good yield of rice due to the inadequate amount of rains for the rice panicle formation. Soil series in experimental sites mostly belong to Roi-Et and Ubon series. These soils are sandy loam to loamy sand to sandy. Soils are low in fertility with percent of organic matter content about one percent or less, pH values range from 4.5-5.5 for the Roi-Et series and 5-5.5 for the better drained Ubon series. C.E.C. value is 1.2 me/100 gm on the average. Farmers usually grow one crop of rice and getting rain yield about 1.5 ton per hectare on the average from size of five hectare. In connection with the abrupt cessation of precipitation at the end of monsoon in some years, rice could not have enough moisture for the grain formation which is resulted in low yield.

A.II Designed cropping patterns

The testing cropping patterns are to utilize the soil moisture effectively. Figure A.1 shows the rainfall distribution of the tested site. Early photoperiod sensitive varieties of rice are required. Rice will either be direct-seeded or transplanted during middle of June through the end of July. Rice will then be harvested in early November. An upland crop will be planted either relaying or in sequential after rice. Or two crops of rice can be grown during the monsoon by using non-photoperiod direct-seeded as first crop and then is followed by the photoperiod transplanted rice. In 1977, a pattern is being tested using vegetables as first crop and followed by transplanted rice as a second crop. Because of the terrace-like topography of land in the site, the last pattern can be done by planting vegetable in upper fields which have better drainage.

A.III Methodology and Results

In 1977 cropping patterns trials have been conducted in 15 farmers' fields at the Ubon site. Figure A.2 showed the patterns and their planting and harvesting time during the year. Results of the trials are presented in Table A.1 and are discussed as follows:

Pattern No. 1 Yard long bean + rice. By growing the yard long bean in early May, the crop could be harvested in the middle of Agusut. Results from the test showed that the pattern could be practiced successfully except for one plot which has been damaged by sudden flood. One factor which merits consideration is the market situation of the vegetable. This is a high risk crop and a great amount of yard long bean available at the market may reduce the price of it. However, at the time of harvesting or the crop in August, the scarcity of the product at the market in Ubon commanded a reasonable price indicating good chance of the crop to be accepted by the farmers. Yield of rice which followed the yard long bean is considered low (1.4 ton/ha) in terms of fertilizer applied (50-31-25 kg/ha of N, P_2O_5 and K_2O respectively). The reason was time between transplanting and flowering of the variety NSPT was short (70 days) and insufficient for a good plant growth. Adjustment of rice variety by using a non-photoperiod sensitive one may be the answer for the better rice yield.

Pattern No.2 Rice-cowpea. Rice variety used was RD 6 a recommended glutinous photoperiod sensitive one. Direct seeding method was better than transplanting in terms of producing better yield for the crop giving 2.7 ton/ha as 1.2 ton/ha respectively. There is a possibility of growing cowpea successfully after rice utilizing limited residual moisture but market introduction of the crop is required. People in the area are not familiar with the crop.

Pattern No.3 Rice-glutinous corn. One problem associated with harvesting rice in the middle of the growing season when no other rice is in the surrounding fields is the rat and bird damages. One plot assigned to the pattern was lost due to this problem but the other two plots produced reasonable yields of 2.5 ton/ha by using non-photoperiod sensitive variety RD 9 and direct planting. Glutinous corn after rice promises to bring more income to the farmers. Quite a number of marketable ears (23,500 ears/ha) of corn were harvested from the pattern trial but the problem of not enough moisture for corn has to be considered.

Pattern No. 4 Rice-peanut. This pattern is considered as having great potential for the research site. RD 7 produced reasonable yield of 2.7 ton/ha by direct planting. Peanut has some tolerance to drought or limited moisture after rice planting. The peanut yield averaging 1.1 ton/ha is considered low but with minimum labor and fertilizer inputs a crop of peanut could be obtained producing more income. Rice-peanut combination indicates a stable pattern, more refinement on agro-techniques and crop variety used could produce a very acceptable pattern.

Pattern No. 5 Rice-rice. This pattern at the design stage shows promise. But the first rice PMI6646-3-4-15, a glutinous non-photoperiod sensitive selection is susceptible to root-knot nematodes especially under the non-submerged soil condition. Two plots have been destroyed by the root-knot nematodes. The following crop of rice did not perform well due to the relatively short period of time for the growth duration of the HY 71 variety which is a glutinous photoperiod sensitive variety normally harvesting about November 4. New varieties that will meet these conditions are needed.

For the Ubon cropping pattern trials as a whole direct seeding of rice is the focal point that other upland crops or rice should be evolved around this method of rice planting. Some of the results are encouraging and meriting further study; rice-peanut pattern indicated stable combination and rice-cowpea suggesting a possibility except market outlet of the crop is a problem. Instead of one rice crop in a year under rainfed condition, research findings point to another upland crops or rice which will bring more income to the farmers.

A.IV A short description of cropping systems experiments in 1978

After the 1977 results and experiences, six cropping patterns are selected for testing in 24 farmers' fields in four villages at the Ubon site in 1978. Within a selected village a complete set of six patterns is included. There are 2 double cropping and 4 sequential cropping patterns. It is almost certain to the research team that three-crop-patterns can be grown successfully under the rainfed condition such as Ubon. Farmers are very cooperative this year after they have seen what crop could be possibly grown in their area in 1977. Crops such as peanut, mungbean and yard long bean will gain the prominent places in the cropping patterns for the rainfed small farmers of the Ubon and similar agro-climatic locations in the Northeast Region in the future. The six cropping patterns are as follows:

1. Rice - Rice (RD 7 - RD 6)
2. Rice (RD 5) - Ratoon
3. DMR sweet corn - Rice (RD 7) - Peanut
4. Yard long bean - Rice (RD 6) - Peanut (Tainan 9)
5. Mungbean - Rice (RD 7) - Glutinous Corn
6. Peanut - Rice (RD 6) - Mungbean

In pattern No. 2, 3 and 6 fertilizer trials are super-imposed. It has been known that the Northeast soils are so poor of plant nutrients, soil improving organisms or material are always needed especially the cheap ones. Therefore, agronomic practices such as green-manure incorporation and Rhizobium innoculation are being conducted within the selected patterns. Also rice ratooning technique is tried after experience has

been gain about the ratoon work in irrigated areas. In addition, economics research and analyses are conducted accordingly.

B. Pimai site

B.I Description of the site

Pimai site is located lower western part of the Northeastern Region. It is about 300 kilometer from Bangkok. The site potentially represents the rainfed area of about 850,000 hectare for increasing cropping intensity. Climatic conditions of the Pimai site are somewhat similar to the Ubon site. There are three seasons in the area. Major difference is rainfall distribution. It is bimodal with occasional drought periods during the early monsoon. Soil types in the area are derived from semi-recent and old alluvium, textures of the soils range from light to heavy clay composed of low Humic Gley, Gray Podzolic and Alluvial soils. During the rainy season, farmers grow a crop of rice in the lowland paddy fields, cassava, kenaf and others in the upland fields. Average farm size is about five hectare. Due to erratic rainfall during early monsoon season, rice cultivation is risky especially transplanted rice. Farmers are poor and in some years they have to abandon their farms and seek work in the urban area. This is mainly attributed to the normal occurring of drought periods during the early monsoon. So that stabilization of rice cultivation is needed and in addition, introduction of field crops in the lowland paddy area to be grown during the early part of the monsoon is also required. The practices will increase the cropping intensity and income.

In 1977, rainfall record examplified the typical bimodal distribution of the area, (Fig B.1). Southwest monsoon rains started in April and gradually increasing to the first peak of the bimodal in May recorded at 200 mm. for that month. The rains then dropped to 122 mm. in June reaching the bottom between the two peaks in July for a 63 mm. rainfall record. Toward the end of July and the beginning of August, there was a period of 2-week rainless days. The rains started to build up their second peak on the sixth of August and the monthly record was 265 mm. Again in September the amount of rain was above the 200 mm. mark. Rainfall record was then went down to 76 mm. for October signifying the end of Southwest monsoon rain for the Pimai area. This year, farmers could not grow transplanted rice until August indicating severe water shortage in the fields at the early monsoon season. It was worth mentioning that the year marked one of the worse droughts situation for the Northeastern region in years causing 30 percent damages to the rice crop of the region.

B.II Designed cropping patterns

The rainfall pattern typical of Pimai area is bimodal, rain usually comes in April sufficiently enough for land preparation and crop growth. The testing cropping patterns are developed to utilize the first

rains of the monsoon. Crops to be grown during the time should utilize moisture effectively. Fourteen-year rainfall average records at the Pimai Rice Experiment Station indicated that there were about 30 and 75 mm during March and April and approximately 150 mm each during the months of May through August (Fig. B.1). In designing the cropping patterns, the requirement is to have field crops with short maturity and possessing some degrees of drought tolerance to be grown before rice. The crops will be grown starting from the middle of April and to be harvested in July. Crops under consideration are mungbean, peanut, glutinous corn and vegetables. After harvest the upland crops, rice could be grown either direct-seeded or transplanted. After the rice has been harvested in November, third crops in the cropping sequence could be tried to utilize the residual moisture in the fields.

B.III Methodology and Results

The cropping patterns to be tested are:

First crop: mungbean, peanut, corn, cucumber, corn/mungbean

Second crop: 3 rice varieties; KPM 148, HD and KDML 105

Third crop: Pumpkin

The farmers were selected around four different sites so there are four groups of farmers. In each group there were five farmers.

Twenty farmers have cooperated with the research team to conduct the experiments in 1977. The first-second crop combinations namely mungbean-rice, peanut-rice, cucumber-rice, corn-rice and corn-mungbean intercrop-rice could be grown with some successes for soil salinity and drought except some plots which are damaged by soil salinity spots. The third crop pumpkin due to limited residual moisture in the soil.

The results of the trial together with the fertilizer component technology are presented as follows:

Cropping pattern and super-imposed fertilizer trials at Pimai site

Pattern No. 1 Mungbean-Rice. Previous experiment in 1976 showed that mungbean grown before rice could be practiced in the Pimai area producing an average yield 500 kg/ha from three farmers' fields, the pattern was tested again in 1977 utilizing 7 rates of fertilizer applications for the determination of fertilizer response on mungbean. The results are shown in Table B.1. Even though some of the tested plots were located in the salinity spots and no yield was obtained, two farmers produced reliable yield for analyses with means of 0.5 ton/ha mungbean and 2.3 ton/ha rice. It was concluded that for the upland crop. The variability in the field and the lack of response of mungbean to the lower levels of fertilizer suggest that little or no fertilizer will be used by farmers. The phosphorous had some effect but more work will be

needed to optimum levels. The negative effects of potash would indicate no more should be used.

Pattern No. 2 Peanut-Rice. The high degree of variability between farms made testing of patterns very difficult and analysis of components in the pattern nearly impossible. Two factors stood out in this pattern. Added potash had a strong negative effect on yield. This response was also observed in mungbean but not as strongly. Phosphorous appears to have become a limiting factor at the higher rates of nitrogen and may be the main nutrient constraint (Table B.2).

Pattern No.3 Glutinous Corn-Rice. Drought conditions during the growth of corn resulted in low yields which did not even show corn being responsive to nitrogen. It is of interest that those plots which did not receive phosphorous had the lowest yields (Table B.3).

Pattern No.4 Cucumber-Rice. The yield of cucumber in the plot with the highest level of fertility was in the high end of the field and so suffered more stress than the other plots. Considering the first 6 treatments it appears all major elements are needed with nitrogen and phosphorous being the most important for cucumber (Table B.4).

Pattern No. 5 Glutinous Corn/mungbean intercrop-Rice. The corn yield levels off at 125 kg/ha of NPK indicating that other factors became limiting. The mungbean shows no response to fertilizer nor did it seem particularly affected by the stand of corn (Table B.5).

In the five patterns under investigation, the rice yields tend to show some increase in yields due to a residue effect of fertilizer from the first crop, the increase is not significant. This slight increase in yield occured in several of the patterns. Further research is needed on residue effects.

To gain a better understanding of the variability of yields a comparison between the soil analysis and yields of each field was made. It was found that there was a highly significant relationship between the percent silt and total nitrogen available in the soil and yield of peanuts. Calcium and percent clay were found to have significant relationship with yield of peanuts. There was no relationship found between yields of corn, mungbean and corn/mungbean intercrop and the components of the soil. Further soil samples were taken to gain a better understanding of the effect of salinity on various crops but analysis is not completed at this time.

Economics of Fertilizer Trial at Pimai Site

There are several conclusions that can be drawn from the economic study of the fertilizer trials at Pimai (Table B.6). First fertilizing legume crops does not appear to pay. The legumes do not increase yield enough to pay for the fertilizer and at low rates there is very little residual effect on the following rice crop. Although phosphorous shows some effect on mungbean it is doubtful that the response is sufficient

to pay for the fertilizer. Second corn alone did not appear to be able to make as efficient use of the fertilizer as the intercrop of corn and mungbean. Even at the highest rates used the intercrop showed a positive return on money invested in fertilizer although not statistically significantly different due to a high CV. The plots that had been fertilized for corn or corn and mungbean had a 20 percent higher yield than those receiving no fertilizer on the first crop. The data on cucumbers shows a high degree of variability but no rate of fertilizer paid.

Since many of the first crops in the pattern did very poorly due to the lack of rain it is possible that in a good year some of the residue effects observed this season would not be found. It is possible a good crop would use up most of the fertilizer.

Cropping systems supporting study from Pimai Rice Experiment Station in 1977

The experiment was originally designed and conducted for five rice experiment stations in the Northeast in 1977 under rainfed lowland conditions. But results of only one experiment station was reliably obtained. Four upland crops namely, mungbean, peanut, cucumber and glutinous corn were planted before rice. Four different varieties of rice were used in connection with particular upland crops. Randomized Complete Block design with three replications was employed. Results of the experiment were shown in Table B.7. Unfortunately, results of only one location at Pimai station produced reliable data. Other stations have experienced severe drought situations and the first upland crops failed. At Pimai, average yield of mungbean was 405 kg/ha which was at the same yield level of the previous year under farmers' fields condition. Peanut yield was quite low due to poor germination. Cucumber and glutinous corn performed reasonably good. From the rice yield standpoint, RD-15 produced the highest yield followed by RD7, RD6 and KDML 105 respectively. Even though all rice entries are photoperiod-sensitive except one (RD7) the sub-normal length of growth duration of each entry did not affect the yield very much. Research results of the four patterns under study suggest that the possibility of growing selected short-maturity upland crops before rice can be done under rainfed lowland paddy field condition of the Pimai-type agro-climatic area of the Northeast.

B.IV. A short description of cropping systems research in 1978

At Pimai location, the soils are heavier than the Ubon site. Topography of the land is almost flat with sparsely grown big tree in it. The area is ideal for big tractor operation especially in the preparation of soil for early planting. So now a numberof farmers prefer to use custom plowing for their broadcasted rice growing. For the cropping systems study, 20 farmers are selected in 1978 to work with the program at Pimai. There are four cropping patterns tested:

1. Peanut (local) - Rice (KDML 105) - Pumpkin
2. Mungbean (Uthong 1) - Rice (KDML 105) - Pumpkin

3. Sesame (black type) - Rice (KDML 105)
4. Glutinous corn + peanut (intercropping) - Rice (KDML 105)

Simple fertilizer trials are super-imposed on patterns No. 1, 2 and 3. Component technology research such as variety trials of mungbean, peanut and sweet corn are conducted in a farmers' field. Entomology research is super-imposed on pattern No. 4 to test different doses of four insecticides on corn and peanut. From the 1977 encounter, it was found that leaf rollers were presented in two peanut fields causing some damages.

C. Inburi site

C.I. Description of the site

Inburi Sub-district, Inburi District, Singburi Province is the lowland plain of the Central Region, about 160 km from Bangkok with Chao Praya River running through this district. Parallel to the Chao Praya River, are the two main irrigation canals namely Baromdhart Canal and Maharaj Canal carrying water from Chao Praya Dam, Chainat Province. So that the Inburi research site receive water from both natural rainfall and irrigation water.

Soil types vary from light clay to sandy clay loam with the pH ranging from 5.3 to 5.7.

The site generally represents climatic conditions of the Central Region. Monsoon rainy season begins in May and ends in October with average rainfall approximately 1,084 mm. per year. Maximum rainfall is in September averaging 268 mm. (10-year record).

Upon consideration of the area's general condition, it is found that Inburi-Sub-district is rich in farming resources sufficient for crop growing all the year round. Dry season cropping has already been done by some farmers. By means of selecting suitable cropping patterns and improving production technology, it is, therefore, decided to choose the village No.5 of Inburi Sub-district as the research site for the experiments. This village is connected with Baromdhart Canal on the right bank of the Chao Praya River, which is on higher elevation suitable for paddy farming and growing other crops during the dry season. The land surface is gradually sloping away from the canal towards the lower plains with high water level suitable for deep-water rice using broadcasting method during the wet season. On the other hand, the tested site is closed to the roadside which is in access to communication and transporation of products to the market. Besides, this experimental site is not far from the village offering conveniences for closely research supervision.

The primary study is aiming at:

1. The study of existing resources and utilization of traditional cropping system.

2. The study of cost and retun on the tested systems.

3. Accumulation of data for future farm planning.

C.II Methodology and Results

1. The tested cropping pattern was: RD5 rice variety (transplanting) - groundnut - sweet corn.

2. There were 11 farmer-cooperators in the experiment work.

3. Each farmer will be provided with necessary agricultural materials, such as, fertilizers, chemicals, and certain amount of seed; but each has to responsible for his own labor.

4. Crops cultivation

4.1 RD5 rice variety cultivation. Transplanting RD5 rice variety at the beginning of August until the middle of August, 1976 with seedlings aging about 25-30 days. Transplanting was made according to previous practice by local farmers who usually plant 30-40 hills per sq.m. Seven to ten days after transplanting, ammonimum phosphate (16-20-0) at the rate of 20 kg per rai was first applied. Second application was done at panicle initiation stage by using ammonium sulphate (20%) at the rate of 14 kg per rai. Before second fertilizer application, weed control was done once. Regarding to insect control, Sevin was sprayed as needed. Rice was harvested starting from the latter part of November until the early part of December of 1976.

4.2 Groundnut cultivation. After rice harvesting has been completed, farmers immediately prepare the land by using buffaloes ploughing once and harrowing twice. Before the last harrowing, N-P_2O_5-K_2O fertilizers were applied at the rate of 4.8-6-6 kg per rai respectively as basal application. When the soil was turned over to cover the fertilizer then furrows were being made for row seeding with spacing of 30 cm between rows. On account of the farmer's practice, the planted groundnut without using supplementary water which help to reduce the amount of weeds causing no problem concerning with weed control. Harvesting time was made at the end of March, 1977. Harvesting groundnut is utilized as boiling groundnut by the people.

4.3 Sweet corn cultivation. Super sweet corn variety was planted at the beginning of April until the middle of April, 1977 after preparation of the fields. Seeding was done in rows with spacing between rows of 75 cm. and between hills of 50 cm. One hill consisted of 2 plants. Fertilizers were applied at the rate of 12-12-6 kg per rai of N, P_2O_5 and K_2O respectively. Ammonium phosphate (16-20-0) at the rate of 30 kg per rai together with Ammonium sulphate (20% N) at the rate of 6 kg per rai and Potassium Chloride (60% K_2O) at the rate of 10 kg per rai were applied at basal. Two hand weedings were done. When corn was about 15 days and 30 days old after the second weeding, fertilizers was applied for the second time as top dressing at the same rate as basal application. Then the soil was hilled up at base of corn plants. Corn was supplied with water from nearby irrigation canal every 7-10 days by water pumps. Azodrin was sprayed when necessary.

5. Economics study. The study was conducted in the forms of farm survey by questionaires and interviews with local farmers of Inburi. Farmers were selected at random by using the two stage probability sampling method which was described as follows:

5.1 First-Stage Sampling was made in order to randomly select about 30 percentof the whole villages in the Inburi Sub-district.

5.2 Second-Stage Sampling is to randomly select every 10 households from the villages where there are less than 100 households and every 15 households in the villages within which the numbers are more than 100 households.

At each stage, systematic sampling was employed with the exception of village No.5 which is the cropping systems research site where all 14 farmer-cooperators were put under economic study of crop growing. In addition, another 10 households in the village No.5 were selected for study representing the local farmer situation.

With the application of sampling method, information has been obtained in the survey of 3 villages with 30 families being interviewed. So that it made a total of 4 villages being surveyed and 54 families interviewed including village No. 5.

Result of study

1. Existing farming resources and their utilization.

Average farm holding or size is 32.89 rai per family. From this figure only 29.8 percent of the farm families own their land, and 9.82 percent work on the fields which were rent free of charge. The size of family is about 6 people, working persons (age 15-60 years) accounted for 59 percent.

Farmers in the studied project area on the average own 31.42 rai of paddy fields or 95.53 percent of their farm holdings. Only parts of their lands are possible for additional crop growing after harvesting the rice crops.

As regards to their capital, it could be estimated from a simple way of their saving or cash saving at 2,028.82 baht per family on the average. Labor availability for regular or permanent farm work was estimated at 2.59 man per annum plus 1 temporary farm worker (Table C-1).

In terms of land use, it was found that 9.12 percent of the farmers grew second crops after rice accounting only for 109.12 multiple cropping index. Out of their capital, they spent 8,423.70 baht for crop growing (Table C-2). Taking expenses of fertilizer and pesticide into consideration, they averaged about 3.27 and 2.23 percent of fertilizers and pesticides respectively but of the total farm expenditures. While major expenses were for land rent and hired labor accounting for 38.36 and 28.28 percent respectively. During a year, farmers spent 2412.85 hours for farming, 53.91 percent from within the family labor and 33.04 and 13.05 percent from the hired and exchanged labors respectively. It was thus indicated that the labor shortage did existed presently at Inburi.

2. The study on cost and returns of the tested cropping patterns to compare with the similar cropping patterns before the introduction of the Project.

As assumption has been made that farmer's practices of crop growing before the project had low production inputs and low management level. If given increasing production inputs especially fertilizers, pesticides, labor and management and under the supervision of the researchers, yield and returns must increase undoubtedly which will likewise increase the returns per unit area of land use. However, price of inputs and yield must remain the same as the previous years before the start of the Project.

Yield of the crops grown during crop year 1976/77 is shown in Table C-3. Table C-4 showed the cost and returns of the tested pattern. Also Table C-5 showed that net income above total variable inputs or cost (estimate plus actual expenses) of land use in a rai in a year (receive irrigation water) under the supervision and advice of the cropping systems project researchers is 3,024.99 baht. The amount is 934.45 baht more than

amount the farmers received after growing the same crop pattern which produced 2,090.54 baht per rai. It is worth noted that the increase of production factors especially fertilizers and pesticides in transplanted rice and corn contributed to the increase of crop yield as well as the increase of net income over variable costs. In the case of additional production factors to groundnut cultivation, the yield is increased unsubstantially and more capital had to be spent causing the reduction of income over variable costs. It is, therefore, firstly assumed that by increasing production inputs especially fertilizers and pesticides did not increase the groundnuts yield in a proper margin leading to the continuation of research study to find out the suitable production resources needed.

One finding which laad to an assumption was that the methods of fertilizer application may not be correct. For example, fertilizers applied by broadcasting into the last land preparation prior to planting may not appropriate. At that time, the fields had little moisture and no additional water was supplied causing the plants to utilize moisture ineffectively. Therefore, methods and levels of fertilizer application must be further studied.

C.III. Conclusion

Only one cropping pattern of RD5 rice variety - groundnuts - sweet corn has been studied at Inburi for the crop year 1976/77. Therefore, no comparison with other cropping pattern is made, except, the improvement of production inputs and management to compare with the similar cropping pattern without improvement (before the introduction of the Project). The results of the research attempts may be summarized as follows:

1. Farmers own 31.42 rai on the average of paddy land. Total crop land accounts for 32.01 rai. Farmers use only 9.12 percent of their land for the second crops after rice.

2. Farmers spent 38.36 percent of the total agricultural expenditures mainly on land tenancy, 28.28 percent on labor, 3.27 percent and 2.23 percent on fertilizers and pesticides respectively.

3. Each farm had to employ 2412.85 hours of farm labor per year, 33.04 percent of which is for hired labor, 13.05 percent for exchange labor, and only 53.91 percent came from family labor.

4. Cost of the tested cropping pattern is increased in accordance with the increase of production inputs especially fertilizers and pesticides. However,it was found that net income over variable cost of improved crop pattern was greater than the farmer-practiced pattern about 934.45 baht per rai per year (farmer pattern produced income of 2090.54 baht per rai per year, while the improved one produced 3,024.99 baht per rai per year).

C.IV. Problems and recommendation

1. Utilization of land after rice harvest appeared to be very low, the fields should be utilized for more crop cultivation purpose by means of improving irrigation systems, and levelling of land area so that the farmers get more water and use it more effectively. At present, although the cultivation area is near the irrigation canals, getting water into the fields is sometimes resorted to the use of motor-pump, causing more expenditures.

2. Since farmers lack capital and labor, plan should be laid out to use labor efficiently in connection with the cropping patterns used. Consideration must be given of finding credit for the farmers for the purchase of labor-saving equipments. Lending institutions should give special attention to this matter.

3. Market demand should also be studied as the outlet of the introduced crops in the systems.

4. Study should be conducted on the application of proper production inputs in order to obtain the highest beneficial returns especially from fertilizers and their application.

5. Different cropping patterns should be studied at the same time at the tested site in order to evaluate their performances more broadly and constructively.

C.V. Summary of Socio-economic Survey at Inburi Site

The socio-economic survey of farmers at Inburi under cropping systems project was undertaken during April 1976. The results of the survey are summarized as follows:

1. The average size of household is about 6 persons per family; male and female are about even. About 15 percent of them have finished 7th grade elementary school and 21 percent cannot read and write. The rest is in between the two groups.

2. The total average size of land holding is about 33 rai; 30 percent of them are rented. Of total land holding 96 percent are paddy land and less than 1 percent is upland area. The rest are home plot, fruit trees and vegetables.

3. Of total family members about 44 percent are permanent farm labor; 17 percent are temporary labor and the rest 39 percent are non-farm labor. The average human labor for total crop production is about 2,400 hrs. Of total human labor about 54, 13 and 33 percent are family labor, exchanged labor and hired labor respectively.

4. The survey area represents partially irrigated rice area. Rice growing is in wet season (June-December) and the second crops after rice in dry season (January-June) are corn and legumes. The average yields per rai of transplanted rice, broadcasted rice, corn, mungbean and peanut (unshelled) are 440 kg, 350 kg, 2,400 ears, 92 kg. and 338 kg respectively. Multiple cropping index is about 109.

5. The average farm asset is about 156,000 baht and the average debt per farm family is about 2,500 baht. Of the total sample farmers about 30 percent are in-debted.

6. The total average net cash farm income is about 9,742 baht. Of total net cash farm income about 79 percent come from rice, 11 percent from second crops and vegetables and the rest 10 percent from livestock. The average family net cash income and net farm income are about 16,197 baht and 20,215 baht respectively. The average cash living expenditure of the total sample farmers is about 14,168 baht.

7. The major problems of the farmers are production, land, and indebtedness. Of the total sample farmers about 56 percent have to rent the land and 30 percent are indebted. The other problems are instability of crop prices, lack of labor and lack of proven production techniques.

D. Bangpae Site

D.1 Description of Site

Bangpae was selected to represent an agro-climatic zone in which cropping system will be studied under rainfed condition. Bangpae is one of the districts in Rachaburi province located approximately 100 kilometers south west of Bangkok. Geographically, it is located between 13° 14' and 13° 45' north latitude and 99° 51' and 100° east longtitude. The area is generally plain and approximately 2.2 meter above sea level.

There are 15,200 hectare of arable land, population is 8212 or 1440 families with the average farm size of 6 hectares. According to the baseline survey, 80% of the crop grown during the rainy season is rice. Generally, 85 percent of rice growing area are planted to broadcast method while the rest are transplanted rice. During the period before and after rice crop, mungbean is grown in the field for subsidiary income.

D.1.1 Rainfall

Twenty year average rainfall (1958-1977) ranged between 463 to 1515 mm. Generally rainfall at Bangpae is considerably low for crop requirement. However, certain areas receive supplementary water from irrigation canals passing through Bangpae from irrigation project located at nearby provinces. This enable farmers to plant corn or mungbean during the dry season in the field adjacent to the irrigation canal.

Base on twenty year average rainfall pattern (Figure D.1), rainy season at Bangpae generally starts in the middle of April. The amount of rainfall increase until it reach the peak of 110-120 mm. in June, drops in July and increase again in August, reach the second peak of 180 mm. in September, then decrease drastically in October. From December to early April, there was less than 10 mm. rainfall, therefore, crop growth after rice growing season is strictly dependant upon the amount of soil moisture left over after rice crop.

The amount and distribution of rainfall in 1977 was considerably poor compared to the normal year. A large amount of rainfall did not occur before June, while the peak rainfall appeared between late June to early September and drop drastically afterward. Drought occurred severely throughout the country therefore the crops suffered severely due to the lack of water.

D.1.2 Soil

Soil in Bangpae is generally alluvial deposit exhibiting a clayey texture with high water holding capacity and poor aeration. Soil samples taken from 71 locations displayed a remarkable difference in soil reaction and fertility. The soil pH ranged from 5.3-7.16. Organic matter level was 2.1-3.0 percent, available phosphorus and exchangeable potassium range from 20 to 60 ppm and 40-180 ppm, respectively.

D.1.3 Existing cropping pattern

There are three major crops grown in Bangpae namely rice, mungbean, and corn. Rice is exclusively grown in the rainy season while corn and mungbean are grown before and after rice crops. Growing corn and mungbean before rice are seldom practised by farmers unless rainfall in that particular season is adequate. Growing mungbean after rice is practiced by more farmers than growing corn. However, if rainfall in the particular season does not occur after rice these crops suffer tremendously due to moisture stress in the soil(Figure D.2).

D.1.4 Labor resource and farmers income

The average family number of Bangpae is 5.7 persons. Its breakdown for small, medium, and large farms are 4.38, 6.04, and 6.80 respectively. The average labor use per farm in terms of man-equivalents, for farm and non-farm work is 2.85 (Table D.1). The income of farmer covered in the study included farm and non-farm incomes. Farm income mainly consisted of revenue from two crops of the area, rice and mungbean. On the average, farm income constitutes 51% of the family income. The detailed breakdown of farmers income is shown in Table D.2.

D.2 Background of research conducted in 1977

It has been over a year since the Multiple Cropping Research Project of Kasetsart University started its research activity in the farmers' fields at Bangpae district, Rachaburi Province, Thailand. During this particular period, several experiments have been conducted and evaluated. The experiments that the project has conducted in the farmers' fields were grouped into two categories, cropping pattern experiments and component technology experiments. In addition, economic studies have been conducted to evaluate the input and economic feasibility of cropping pattern tested by the project in comparison to the normal cropping practiced by farmers.

D.2.1 Cropping pattern experiments

The cropping pattern experiments composed of several field crops experiments which had been conducted before and after rice growing season. It also included rice experiments using local rice varieties (photosensitive varieties) and recommended varieties (non photosensitive varieties). The prime objective of cropping pattern experiment is to identify the suitable cropping pattern that can be applicable and economically feasible to the farmer.

Within a year beginning April 1977, four field crops grown before rice, two rice varieties and five field crops grown after rice which make up 40 combination were tested under village condition (Table D.3). Out of 40 combination, M 7A variety of mungbean grown before and after recommended variety of rice appeared to be the most suitable among the system tested. The average yield of M 7 A mungbean grown before rice was 650 kg per hectare in our plots. Some of the farmers who grew local variety of mungbean could not harvest their crop; due to several problems, like more susceptability to insects and disease. Local variety of mungbean planted before rice yielded about 500 kg/ha. The yield of M 7 A mungbean grown after rice was 600 kg per hectare in our test. Farmers were able to obtain the same amount of yield when they used our variety. However, the yield of local mungbean variety grown by farmers was about 450 kg/ha. Severe drought which occurred last year affected other field crops either grown before or after rice, recommended variety of mungbean which are short in maturity appeared to tolerate and grow under limited moisture condition better than other crops. However, rainfall condition in 1977 was rare compared to normal year, therefore, there is a possibility that other cropping system may also be suitable under normal condition.

D.2.2 Components technology experiments

Components technology experiments are designed to study certain specific problems within a cropping season. Therefore, a component technology experiment which had been conducted before rice growing season may be different from those conducted during the period when crops were grown after rice. These experiments were fertilizer, insecticide, cultural practices, and weed control experiments.

Three mungbean and two corn experiments were conducted as part of component technology experiments before rice crop. Fertilizer and herbicide trials were tested using recommended and local rice varieties in rice growing season. During the season after rice, four mungbean, black gram and one crop of sweet corn, sweet potato and soybean were also studied as part of component technology experiments. The list of component technology conducted are shown in Table D.4.

The yield of corn and mungbean increased significantly in fertilizer treatments. However, fertilizer gave rise to better weed growth therefore severe weed competition occurred to crops. The application of pre-emergence herbicide in combination with fertilizer gave better weed control and higher crop yield. Regarding insect problems in mungbean, the use of Furadan for controlling beanflies damages and Phosdrin for leaf and pod attacking insects were shown to give quite satisfactory results. Planting mungbean in rows resulted in better crop stand, better weed control and higher seed yield. At present, number of data have been collected, analyzed and evaluated. The result of both cropping pattern and component technology will be presented in Multiple Cropping Research Project Annual Report 1977 available not later than August 1978. However several experiments in component technology will be reconducted to reconfirm the result that have already been obtained and to gather more beneficial information. As mentioned earlier, drought that occurred in 1977 affected all component technology so much so that crop performance data should be collected to compare the experiment result between normal and drought year.

D.2.3 Economic Studies

There were three categories of research activities which have been studied by economic component since the beginning of Multiple Cropping Research Project activities at Bangpae in late 1976. Firstly, a detail work on modification of the base-line survey. Secondly, a study on resource use in and returns to crop production of the cooperating farmers. Thirdly, a study on selected subjects in relation to crop production in Bangpae area.

D.2.3(1) Modification of the base-line survey

The base-line survey was done in 1976 covering three different possible research project sites of Bangpae, Khao Cha-ngoom, and Tungbua. A detailed elaboration on the application of base-line data was done for the Bangpae site in order to use it as a guide in the planning of research activities in the area and to be used as base-line data for evaluating the result of the project in the future. The main work concentrated, on relating the base-line data with the national standard data and interpreted them into the possible alternatives as appeared to be found in the Bangpae area.

D.2.3(2) A study on resource use in the returns to crop production of cooperating farmers

Data collection and analysis on resource use and returns to crop production was done for the three periods of April - July, July - January, and January - April. As of now, only the results of the first period had finished. They covered the patterns of the uses of land, family labor, draft animal labor, tractor and machine services, and modern farm production inputs. Its costs and returns on the production of selected crops of the 20 cooperative farmers were then analysed. It is hoped that the same type of work for period 2 and 3 would be completed very soon.

D.2.3(3) A study on selected subjects related to crop production

The work done in this part was primarily dealt with personal observation and informal discussions with the cooperating farmers and researchers themselves. It was aimed to gather relevant information for the use of researchers in agronomy and other related fields in planning and evaluating their research acitivities in the project area. The work has been concentrated on the following subjects.

a. A study on economics of the use of farm machinery in farming

b. A study on the attitudes of cooperators towards the application of modern inputs and technologies, and

c. A study on the spread effects of the research work.

Most of the work of the above subjects are underway. Some studies just started collecting information. Some subjects are ready for the analysis. It is hoped to continue and finish working on these subjects in 1978.

E. Other Cropping Systems Research

In Thailand, many different groups are conducting research which could be defined as cropping systems research.

Chiengmai University has been conducting cropping pattern trials for 8 years and have put out over 40 publications. Their methodology has been based on developing a total package in the station and then taking it out to the farmers.

Khonkaen University has been conducting cropping pattern trials in farmers fields for 4 years and have over 10 publications.

In addition, each of the regional research centers has been conducting some work on cropping patterns. The Department of Agriculture has studied on intercropping and relay interplanting in corn, sugarcane, cassava, rubber, coconut, and, orchard crops. The East-West Centre's Cropping Systems Program is working with Kasetsart University on the

effect of legume crops in rotations. A number of bilateral aid programs are found in many parts of the country conducting some research on cropping patterns. The following brief summary of research highlights from various organizations in Thailand is meant only to give an indication of the type of work being conducted in the different regions of the Kingdom. All results reported are from the Proceedings of the First National Seminar on Cropping Systems, July 11-14, 1977.

During the rainy season, 13% of the cultivated land in the Northeast of Thailand is not planted to any crops while, for all of Thailand, the figure is 22%. There is a great reverse of labor even in the busiest month of July, 38.5 of the agricultural labor force was unemployed that month. Farmers supplied only 25% of the capitalused in the cultivation of crops. The remaining 72% was supplied by a variety of agencies. Thus, new technology should be aimed at increasing the use of land and labor, p.1-24.

The Northeast

In the Northeast where an upland crop is to be grown before rice, it has been found the latest that the first crop should be harvested in the end of August, p. 51. One of the main reasons for so much idle land in the Northeast is that farmers are only able to plant rice on the upland areas one year out of five. Switching these fields to upland cropping patterns may help the farmer the most, p. 73. Many agencies have tried sorghum with limited success due to bird damage, poor stands, and, some management problems, p. 83, 56, 49.

Phosphorous levels are low in most soils of the Northeast. In Sansai soils, 9 ppm. extractable P is sufficient for rice production. Analysis of P in leaf sheath at 45 DAT can establish the critual level of P for rice, p.190. Intercropping with cassava appears to have some potential but the management of the second crop is still not solved, p. 241. It was found that cassava and other crops were not consistently responding to fertilizer and the high variability of yield made their production a high risk venture, p.243. Intercropping legumes with kenaf has not paid due to very low legume yields, p.291. In the irrigated areas of the Northeast liming was not found to pay and the use of herbicides was no better than hand weeding, p.348. It was noted that cropping patterns that gave high net returns had high total costs, p.389. This indicates the use of capital intensive technology.

The North

In nitrogen trials on cropping patterns in the mountains of the North, there was no response due to the high levels of organic matter soil phosphorous and potash, p. 92. In a series of fertilizer trials in the North, three crops were grown in sequence with only the first receiving fertilizer. The second crop of soybeans responded to residue P_2O_5 and K_2O. The third crop of sweet corn showed no significant effect. The second crop of mungbean responded to

residue nitrogen and P_2O_5, p. 153-176. In those areas currently having irrigation and growing two crops, mungbean appeared to have the most potential for a third crop but the rest problem must be solved, p. 226. An additional problem of soybean and peanut is lack of good seed, p.364. Small farmers were found to be more commercially oriented than larger farmers who culd rely on our production for food needs, p.461.

Central

It was found interplanting mungbean and soybean in sugarcane did not affect yield of sugarcane but yields of legumes were very low, p. 380. Soybeans, sweet corn, cotton, and, peanuts have been found to be the most suitable crops in rice based cropping patterns, p. 39.

The South

In the South, in certain areas the population pressure on land is forcing land-holdings down to 1.5 ha of rainfed land. The people rather than grow a second crop are going into the forest for slash and burn agriculture, p.425. Those with irrigation find it is unreliable, p.425.

F. Training

From 1971 to 1978, 28 Thai participants have been enrolled in the IRRI cropping systems training courses. The majority of the trainees came from the Department of Agriculture with some from Kasetsart University. Upon the completion of their trainings, most of them returned to their previous respective fields of work and involved in the on-going cropping systems programs. Trainees from the Rice and Technical Divisions of the Department of Agriculture will participate fully in the cropping systems work. They became coordinators and/or technicians at the research sites. People from component technology disciplines such as entomology and plant pathology usually devote some of their times to help supervising the component researches at the sites. Nevertheless, the returned trainees help in some ways or others to carry out the cropping systems research and development work. In addition, the Thai programs sent six persons to study at UPLB with IRRI cooperation for graduate studies in agronomy and agricultural economics. Also seven research workers have been granted IDRC scholarships to receive academic trainings both at the B.S. and M.S. levels within the country. It is important that in order to achieve a successful cropping systems program, competent, hard-working and well-trained people must be acquired through intensive trainings in the short-course ones as well as in the academic category. So that the training component must be further carried on until the requirement has been fulfilled which will take a considerable period of time.

II. 1979-1981 Plans

Objectives

A. To strengthen the coordinated cropping systems research program and to develop effective operational procedures for this type of research.

B. To develop cropping systems technology for rainfed and partially irrigated rice areas by (1) evaluation of established cropping systems and (II) improvement of these cropping systems through agronomic and economic research on farmers' fields.

C. To demonstrate and evaluate the cropping systems developed on farmers' fields.

D. To train Thais in the methods of cropping systems evaluation and development.

E. To develop cropping systems concepts applicable to Thailand.

Methodology

1. Detailed study of cropping systems will be continued. Since 1977 was so dry, data is of limited value in understanding what usually happens.

1979 - Continued at Pimai and Ubon and Bangpae, Inburi stop. Work begin at Kampangpet.

1980 - Possibly stop Pimai and Ubon. Work start at other potential sites.

1981 - Kampangpet and other sites.

In place of detailed studies special studies to answer specific problems will be used as the program moves away from descriptive research. At present it appears cash, management and probably marketing will be the priority study areas.

The data collected for this work will also be used in helping the National Policy Board establish guides for the future.

In 1981, it is expected that work on farming systems may be possible. This would include interaction of power and sources of farm work with cropping systems. The work on combining cropping patterns to form a cropping system would also be under study by 1981.

2. Cropping Pattern Trial

1979 - Continuation of promising cropping patterns trials at all four sites. It is likely that several new pattern will be tried to meet different environmental factors, such as, soil moisture conditions. It is also likely that the patterns will be tested on a greater number of farmers fields to test stability. The crops that will be considered in the pattern trials are rice, mungbean, cowpea, soybean, yardlong bean, corn, peanut, sweet-potato, cassava, sesame, melon type crops, black gram and kenaf. The major emphasis though is on rice and legume crops.

1980 - This year should supply the final confirmation on the patterns. It is likely that the patterns will be grown on many farmers' fields as a final check with a limited amount of data collected. The patterns would be supervised by extension trainees who are becoming familiar with the proposed patterns.

1981 - The final year would be to confirm the environmental limits of the proposed pattern so extension personnel can be guided as to its range. This will also serve as a basis for deciding on the next environmental area to be worked on in detail.

Table A.1. Results of cropping pattern trials in farmers' fields at the Ubon site, 1977-78 crop year.

Pattern	Crop variety	Farmer	Planting M/D/Y	Spacing cm	Fert. kg/ha $N-P_2O_5-K_2O$	Harvesting days	Yield kg/ha
1	Yard long bean - Local	1	5/16/77	50 x 100	25-31.25-25	56-98	6,644
		2	5/9/77	"	"	78-105	5,300
		3	6/8/77	"	"	-	flood damage
	Transplanted rice - NSPT	1	9/10/77	25 x 33	25+25-31.25-25	139	1,775
		2	9/13/77	"	"	141	1,087
		3	-	-	-	-	-
2	Direct or transpl. rice - RD6	1 T	8/10/77	25 x 35	25+25-31.25-25	158	1,156
		2 D	5/10/77	33 bet. row	"	189	2,562
		3 D	5/17/77	"	"	183	2,825
	Cowpea - Local	1	11/29/77	25 x 33	25-31.25-25	91	312
		2	12/2/77	"	"	78	1,050
		3	11/30/77	"	"	89	1,287
3	Direct rice - RD-9	1	5/10/77	33 bet. row	25+25-31.25-25	136	3,612
		2	7/6/77	"	"	109	1,387
		3	5/16/77	"	"	-	bird, rat damage
	Glutinous Corn - Local	1	11/6/77	25 x 100	50-50-25	88	25,000 ears/ha
		2	11/19/77	"	"	73	36,562 "
		3	11/9/77	"	"	85	8,750 "
4	Direct. rice - RD-7	1	7/1/77	33 bet. row	25+25-31.25-25	126	1,287
		2	7/4/77	"	"	124	3,125
		3	5/7/77	"	"	149	3,750
	Peanut - Lampang	1	11/12/77	25 x 33	25-31.25-25	-	drought damage
		2	11/18/77	"	"	101	1,075
		3	11/20/77	"	"	101	1,131
5	Direct rice - DMI 6646	1	5/26/77	33 bet. row	25+25-31.25-25	130	2,206
		2	5/11/77	"	"	-	nematode damage
		3	5/18/77	"	"	-	
	Transplanted rice - HY 71	1	10/15/77	25 x 33	25+25-31.25-25	98	550
		2	10/3/77	"	"	-	-
		3	-	-	-	-	-

Table B.1. Average yield of 2 farms of mungbean and 1 farm of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Mungbean yield kg/ha	Rice yield kg/ha
1	0-0-0	403	3275
2	31.25-31.25-31.25	475	2075
3	62.5-62.5-62.5	537	2719
4	93.75-0-0	387	2762
5	93.75-0-93.75	325	2837
6	93.75-93.75-0	662	3025
7	93.75-93.75-93.75	587	2781

ANOV Mungbean

Among farm <1

Treatment

Trtx Farm*

C.V. = 17%

Differences

N effect (P-0, K-0) 206*

P effect (N-93.75, K-0) 731**

(N=93.75, K-93.75) 287*

K effect (N=93.75, P-93.75) -275*

ANOV Rice

Treatment n.s.

C.V. 3.5%

Table B.2. Average yield of 3 farms of peanut and 2 farms of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Peanut yield kg/ha	Rice yield kg/ha
1	0-0-0	2356	3347
2	31.25-31.25-31.25	2731	3609
3	62.5-62.5-62.5	2912	3775
4	93.75-0-0	2806	4225
5	93.75-0-93.75	2712	3962
6	93.75-93.75-0	3294	4381
7	93.75-93.75-93.75	2531	4141

ANOV Peanut

Among farm**

Treatment*

Trt x Farm $^{n.s.}$

C.V. = 10%

ANOV Rice

Among farm**

Treatment $^{n.s.}$

Trt x Farm $^{n.s.}$

C.V. = 11%

Differences

N effect (P=0, K=0) $450^{n.s.}$

P effect (N=93.75, K=0) 494*
(N=93.75, K=93.75) $181^{n.s.}$

K effect (N=93.75, P=93.75) -762*

Table B.3. Average yield of 2 farms of glutinous corn and 1 farm of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Corn yield ear/ha	Rice yield kg/ha
1	0-0-0	4934	3650
2	62.5-62.5-62.5	6066	3837
3	125-125-125	5833	4044
4	187.5-0-0	4533	4025
5	187.5-0-187.5	5066	3987
6	187.5-187.5-0	5200	3581
7	187.5-187.5-187.5	6767	3500

<u>ANOV Corn</u>

Among farm$^{n.s.}$

Treatment <1

Trt. x Farm <1

C.V. = 33%

<u>ANOV Rice</u>

Treatment <1

C.V. = 21.40%

Table B.4. Average yield of 1 farm of cucumber and 1 farm of rice at 7 rates of fertilizer application, Pimai site, 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Cucumber yield kg/ha	Rice yield kg/ha
1	0-0-0	4531	2100
2	31.25-31.25-31.25	6212	2015
3	62.5-62.5-62.5	7487	865
4	93.75-0-0	3350	869
5	93.75-0-93.75	6925	844
6	93.75-93.75-0	8900	1737
7	93.75-93.75-93.75	4875	2250

ANOV Cucumber

Treatment$^{n.s.}$

C.V. = 23%

ANOV Rice

Treatment$^{n.s.}$

C.V. = 17%

Table B.5. Average yield of 2 farms of glutinous corn + mungbean intercrop and 2 farms of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Corn yield ear/ha	Mungbean yield kg/ha	Rice yield kg/ha
1	0-0-0	8331	372	2700
2	62.5-62.5-62.5	20000	416	3256
3	125-125-125	30838	484	3356
4	187.5-0-0	29169	403	3466
5	187.5-0-187.5	30000	278	4347
6	187.5-187.5-0	35412	394	4216
7	187.5-187.5-187.5	32500	434	3816

<u>ANOV Corn of 1 farm</u>

Treatment$^{n.s.}$

C.V. = 24%

<u>ANOV Mungbean</u>

Among Farms <1

Treatment <1

Treatment x farms <1

C.V. = 35%

<u>ANOV Rice</u>

Among Farms$^{n.s.}$

Treatment$^{n.s.}$

Trt. x farm$^{n.s.}$

C.V. = 14%

Table B.6. Pimai fertilizer costs and returns 1977[1/]

Fertilizer rate	Fertilizer cost	Additional Income			Residual effect on rice	Additional Income Minus Fertilizer Cost (฿/ha)		
		Peanut	Mungbean	Cucumber		Peanut rice	Mungbean rice	Cucumber rice
0 - 0 - 0	0							
31.25-31.25-31.25	1300	388	375	538	162	-750	-763	-600
62.5-62.5-62.5	2606	1544	862	946	12	-1050	-1732	-1648
93.75-93.75-93.75	3912	100	1200	110	500	-3312	-2212	-3302
93.75 - 0 - 0	1219	1906	-225	-378	212	899	-1232	-1385
93.75-93.75 - 0	3112	1706	1650	1398	488	-918	-974	-1226
93.75 - 0 - 93.75	2012	1138	-375	-266	0	-874	-2387	-1246

		Corn	Corn/ Mungbean	Residual effect on rice	Corn Rice	Corn/Mungbean Rice
0 - 0 - 0	0					
62.5-62.5-62.5	2606	2475	5256	12	-119	2662
125-125-125	5212	1962	9062	712	-2538	4562
187.5-187.5-187.5	7819	3981	7956	1181	-2650	1325
187.5 - 0 - 0	2438	-881	2244	688	-2631	494
187.5-187.5 - 0	6224	681	4644	1662	-3831	82
187.5 - 0 - 187.5	4024	288	4106	1362	-2347	444

1/ Value used in Baht

N = 13/kg K_2O = 8.5/kg Mungbean = 6/kg Corn = 0.35/ear

P_2O_5 = 20.2/kg Rice = 2/kg Peanut = 3.25/kg Cucumber = 2/kg

1 U.S.$ equivalent to about ฿20.00

Table B.7. Cropping systems study under rainfed condition at Pimai Rice Experiment Station, 1977 wet season.

Cropping pattern	Crop variety	Planting	Spacing cm	Fert. kg/ha $N-P_2O_5-K_2O$	Harvesting days	Ave. yield kg/ha
	Mungbean-M7A	5/25/77	10 x 50	31.25-62.5-62.5	67	405
1	Rice-KDML 105	Transpl. 9/8/77	25 x 25	25 + 31.25 - 37.5-37.5	114	2,619
	Peanut-Lampang	5/25/77	10 x 50	31.25-62.5-62.5	102	1,364
2	Rice RD-15	Transpl. 7/8/77	25 x 25	25 + 31.25- 37.5-37.5	112	3,387
	Cucumber-Local	5/25/77	100 x 100	31.25-62.5-62.5	56	14,875
3	Rice RD-6	Transpl. 9/8/77	25 x 25	25 + 31.25- 37.5-37.5	122	2,869
	Glutinous corn corn-local	5/25/77	50 x 100	62.5-62.5-62.5	67	15,625 ears
4	Rice-RD7	Transpl. 9/8/77	25 x 25	25 + 31.25- 37.5-37.5	129	3,037

ANOV Rice

Treatment*

C.V. = 17%

L.S.D. 5% 506 1% 766

Table C-1. Existing average resources per farm.

Land (rai)*						Capital (baht)	Man Power (man)	
For holding	Housing area	Paddy field	Field crops	Orchard	Others	Money saving	Permanent labor	Temporary labor
32.89	0.88	31.42	0.25	0.20	0.14	2,028.82	2.59	0.99

* One rai is equal to 1600 sq.m. or 0.16 ha.

Table C-2. Resource utilization per farm.

Land			Capital			Labor (for agricultural purpose)		
	Rai	Percentage		Baht	Percentage		Hour	Percentage
Farm holding used for crop production	32.00	100	-Total expenses	8,423.70	100	Total man power	2,412.85	100
Transplanted rice (Monsoon season)	12.68	39.62	-Seed	437.70	5.16	Household man-power	1,300.82	53.91
Broadcasted rice (Monsoon season)	18.73	58.51	-Fertilizers	275.10	3.27	Exchanged man-power	314.87	13.05
Upland crops	0.25	0.78	-Pesticides	187.75	2.23	Hired labor	797.16	33.04
Vegetable	0.02	0.06	-Fuel	157.91	0.87			
Orchard	0.33	1.03	-Man power	2,382.22	28.28	Animal power	168.90	-
Second crops after rice	2.92	9.12	-Animal power	20.87	0.25	Mechanical power	46.86	-
			-Machinery	1,643.17	19.51			
			-Land Tenant	3,231.88	38.36			
			-Land duty	90.09	1.07			
Total planting area in one year	34.93	109.12						

Table C-3. Yield production of RD5 rice variety, groundnut and sweet corn at Inburi in the crop year 1976/77.

No. of farmer	Yield of RD5 (kg/rai)	Groundnut (shelled) (kg/rai)	Sweet corn (ear/rai)
1	735.114	482.23	4984
2	787.648	386.78	-
3	762.295	340.30	4975
4	739.025	224.33	-
5	826-629	367.69	3911
6	728.155	302.12	4500
7	761.649	-	4043
8	706.649	-	-
9	845.388	-	4419
10	765.900	-	7771
11	776.420	-	3916
Average	766.81	350.575	4814.8

Table C-4. Variable inputs, production and net income above variable input per rai of the tested system (within the project).

Description	RD5 Rice		Groundnut		Sweet Corn		Total price (Baht)
	Amount	Price (Baht)	Amount	Price (Baht)	Amount	Price (Baht)	
1. Total yield production (kg)	366.80	1,712.47	350.84	1,694.14	4,815 ear	2,343.34	5,749.95
2. Variable Cash input	-	301.71	-	643.33	-	430.02	1,375.06
- Seeds (kg)	3.88	9.62	25.43	393.71	2.87	47.53	-
- Fertilizers(kg)	34.00	123.00	40.00	175.00	83.00	278.50	-
- Pesticides Sevin (gm)	26.70	2.50	30.00	2.76	95.00	8.75	-
- Azodrin (c.c)	31.00	6.20	178.00	35.60	154.00	30.80	-
- Man labour wages (hr.)	44.83	91.90	-	-	7.23	20.02	-
- Mechanical cost (hr.)	0.83	35.12	1.43	14.41	-	-	-
- Fuel cost	10.48	33.37	9.09	21.85	12.00	44.42	-
3. Non-cash variable input	-	393.40	-	406.64	-	549.86	1,349.90
- Self-seed (kg)	10.29	23.33	-	-	-	-	-
- Self-labor (hr)	106.70	218.10	109.00	282.71	155.67	389.17	-
- Self-mechnical power (hr)	14.53	134.29	7.24	85.60	14.52	134.89	-
- Self-animal power (hr)	7.60	17.68	9.54	38.33	2.47	25.80	-
4. Total variable input (2+3)	-	695.11	-	1,049.97	-	979.88	2,724.96
5. Net income above total variable input (1-4)		1,017.36	-	644.17	-	1,363.46	3,024.99

RD5 Rice - Groundnut - Sweet corn
Crop Year - 1976/77
Location - Inburi Sub-district, Inburi District, Singburi Province

Remarks:

1. Fertilizer Use

Rice 6-4-0 kg/rai of Ammonium phosphate (16-20-0) for 20 kg.; 40.50 baht/kg
Ammonium sulphate (20% N) for 14 kg; 3 baht/kg

Groundut: 4.8-6-6 kg/rai of Ammonium phosphate (16-20-0) for 30 kg; 4.50 baht/kg
Potassium chloride (60% K_2O) for 10 kg; 4 baht/kg

Corn 12-12-6 kg/rai of Ammonium phosphate (16-20-0) for 60 kg; 4.50 baht/kg
Ammonium sulphate (20% N) for 12 kg; 3 baht/kg
Potassium chloride (60% K_2O) for 10 kg; 4 baht/kg

2. Capital without opportunity cost

Table C-5. Comparative study of production, cost and returns per rai both before the introduction of the project and during the time of the project.

Crop types	Yield		Price (baht)		Total variable inputs (baht)		Net income above variable inputs (baht)	
	1/	2/	1/	2/	1/	2/	1/	2/
Paddy rice (kg)-RD5	441.0	766.8	992.3	1,712.5	502.7	695.1	498.6	1,017.36
Groundnut (kg)	337.7	350.6	1,631.0	1,694.1	814.5	1,050.0	816.5	644.2
Corn (ear)	2,400.0	4,815.0	1,200.1	2,343.2	415.6	979.9	784.4	1,363.5
Total Net Income							2,090.5	3,025.0

1/ Before the introduction of the project-entirely practiced by the farmers themselves.

2/ During the time of the project - researchers adviced and supervised cooperatively with farmers.

Table D.1. Average family member and man-equivalents (M.E.) per farm by farm size 1975.

Farm size	Average family member	Average M.E. per farm		
		for farm work	for non-farm work	Total
(1)	(2)	(3)	(4)	(5)
Small	4.38	1.38	0.68	2.06
Medium	6.04	2.70	0.48	3.18
Large	6.80	2.94	0.23	3.17
All size	5.73	2.37	0.48	2.85

Table D.2. Family income by farm size 1975.

Farm size	Income (฿ per farm)			Average income per family member
	Farm	Non-farm	Total	
(1)	(2)	(3)	(4)	(5)
Small	1.416	16,416	17,831	4,071
Medium	11,667	9,685	21,352	3,535
Large	24,272	7,350	31,622	4,650
All size	11,507	11,110	22,617	3,947

Table D.3. List of field crops and rice grown at specific cropping season in cropping pattern experiments.

Specific Cropping Season		
Crop before rice April - July	Rice crop August - November	Crop after rice December - March
Mungbean (M7A)	Rice (recommended var.)	Mungbean (M7A)
Mungbean (local var)	Rice (local var.)	Black gram
Sweet corn		Sweet corn
Glutinous corn		Glutinous corn
		Soybean

Table 4. List of component technology experiments conducted at particular cropping season by the multiple cropping project.

Crop	Experimental description
← Crop before rice →	
Mungbean	Method of planting and fertilizer use
Mungbean	Insecticide trial
Mungbean	Hormone application
Glutinous Corn	Fertilizer trial
← Rice crop →	
Rice (local var.)	Pre emergence herbicide trial in direct seeding rice
Rice (local var.)	Post emergence herbicide trial in direct seeding rice
Rice (local var.)	Weed control in transplanted rice
Rice (local var.)	Fertilizer trial
Rice (recommended var.)	Fertilizer trial
← Crop after rice →	
Mungbean	Land preparation experiment
Mungbean	Insecticide trial
Mungbean	Hormone trial
Mungbean	Weed control experiment
Mungbean	The effect of different cultural practices in mungbean upon residue soil moisture
Black gram	Land preparation experiment
Black gram	Insecticide trial
Sweet corn	Straw mulching
Glutinous corn	Straw mulching
Soybean	Straw mulching
Sweet potato	Straw mulching

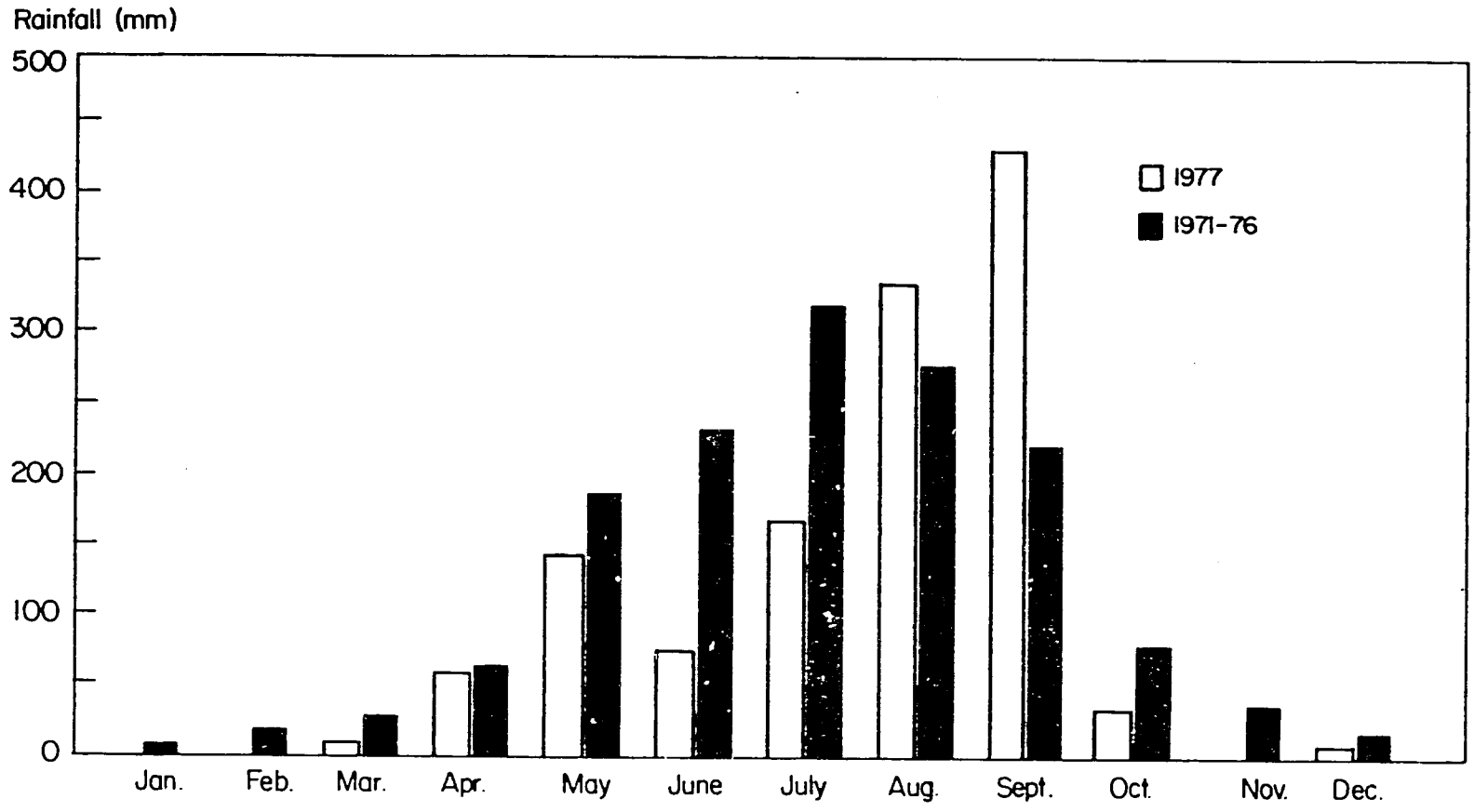


Fig. A.1. Average monthly rainfall at Moeng District, Ubonratchathani Province during 1971-76 and in 1977.

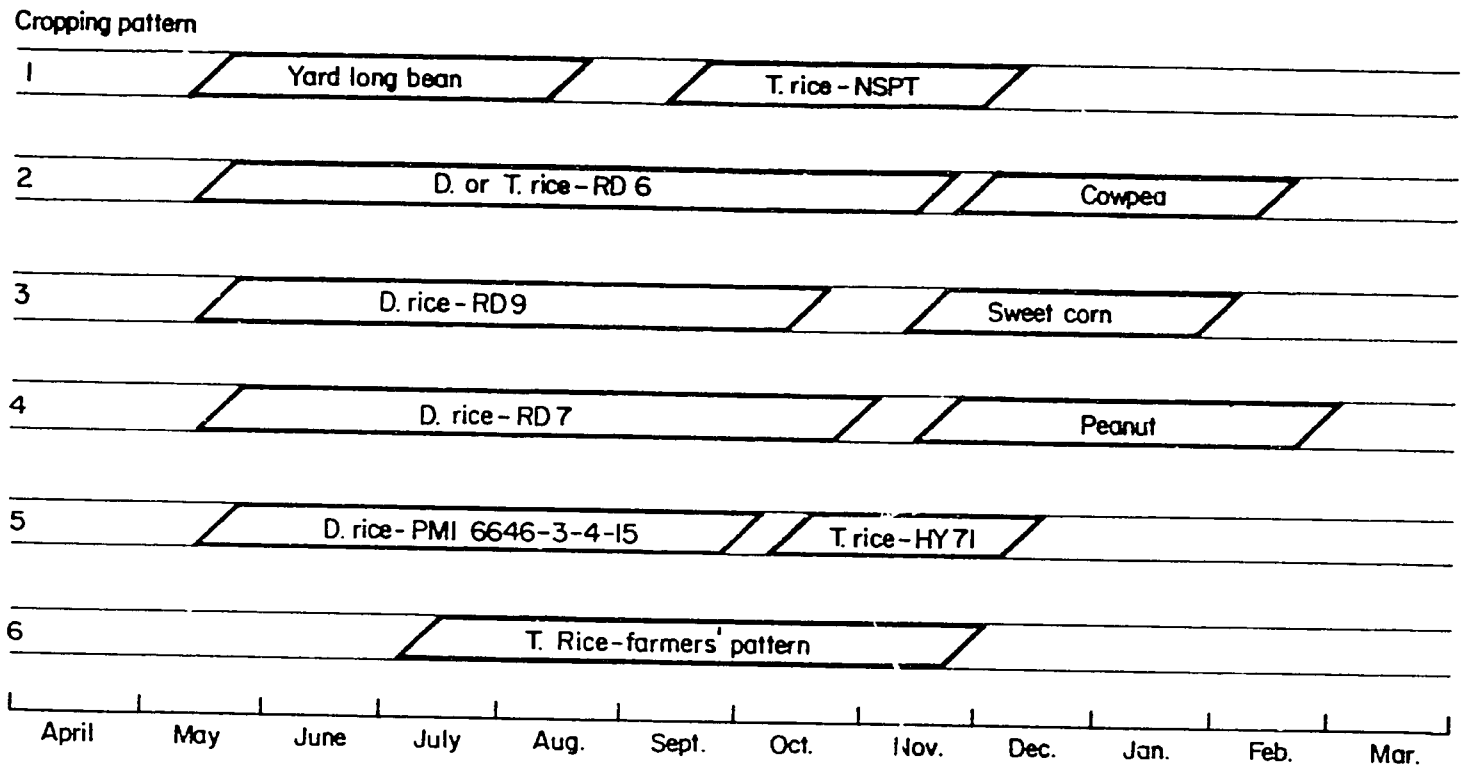


Fig. A.2. Rainfed cropping pattern trials in farmers' fields at Ubon site in 1977-78.

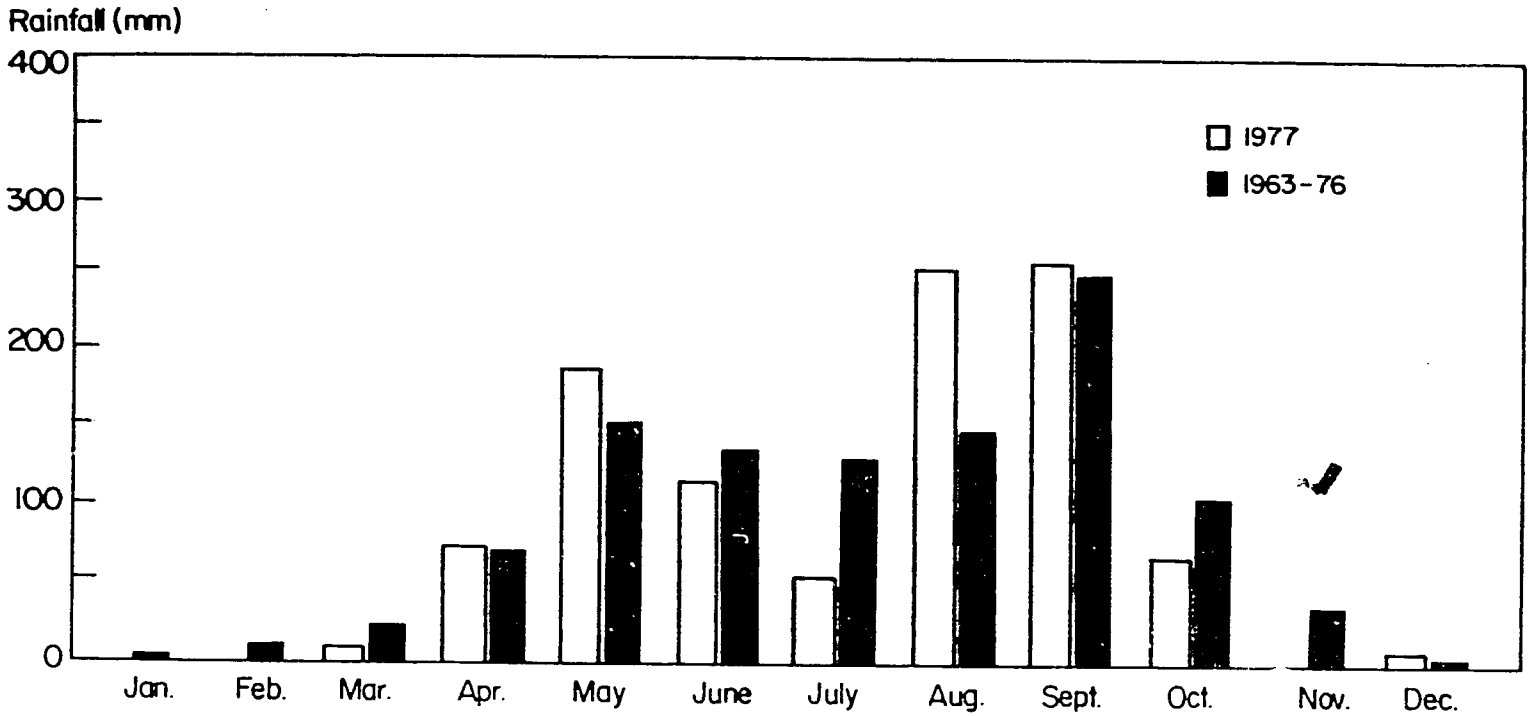


Fig. B.1. Average monthly rainfall at Pimai Rice Experiment Station during 1963-76 and in 1977.

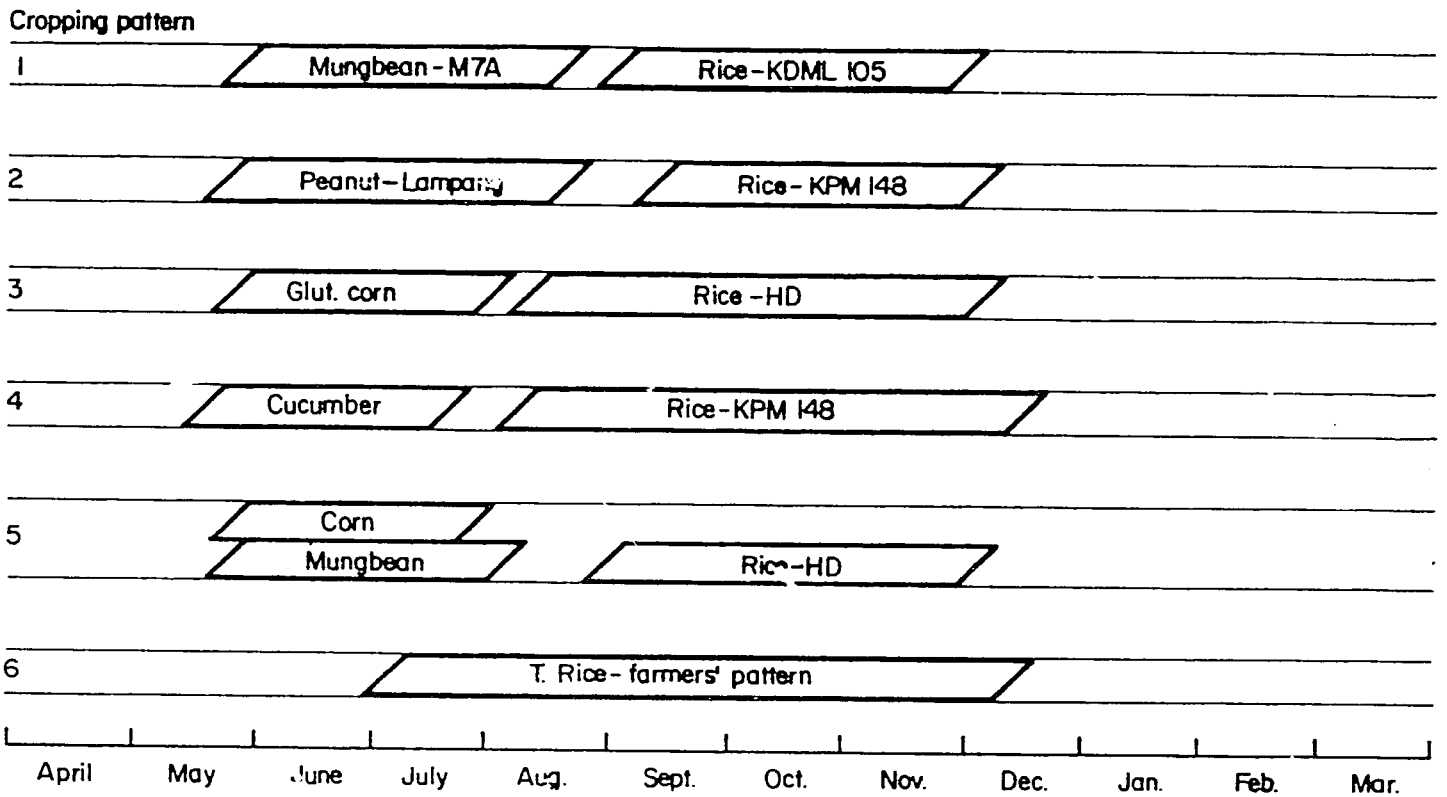


Fig. B.2. Rainfed cropping pattern trials in farmers' fields at Pimai site in 1977-78.

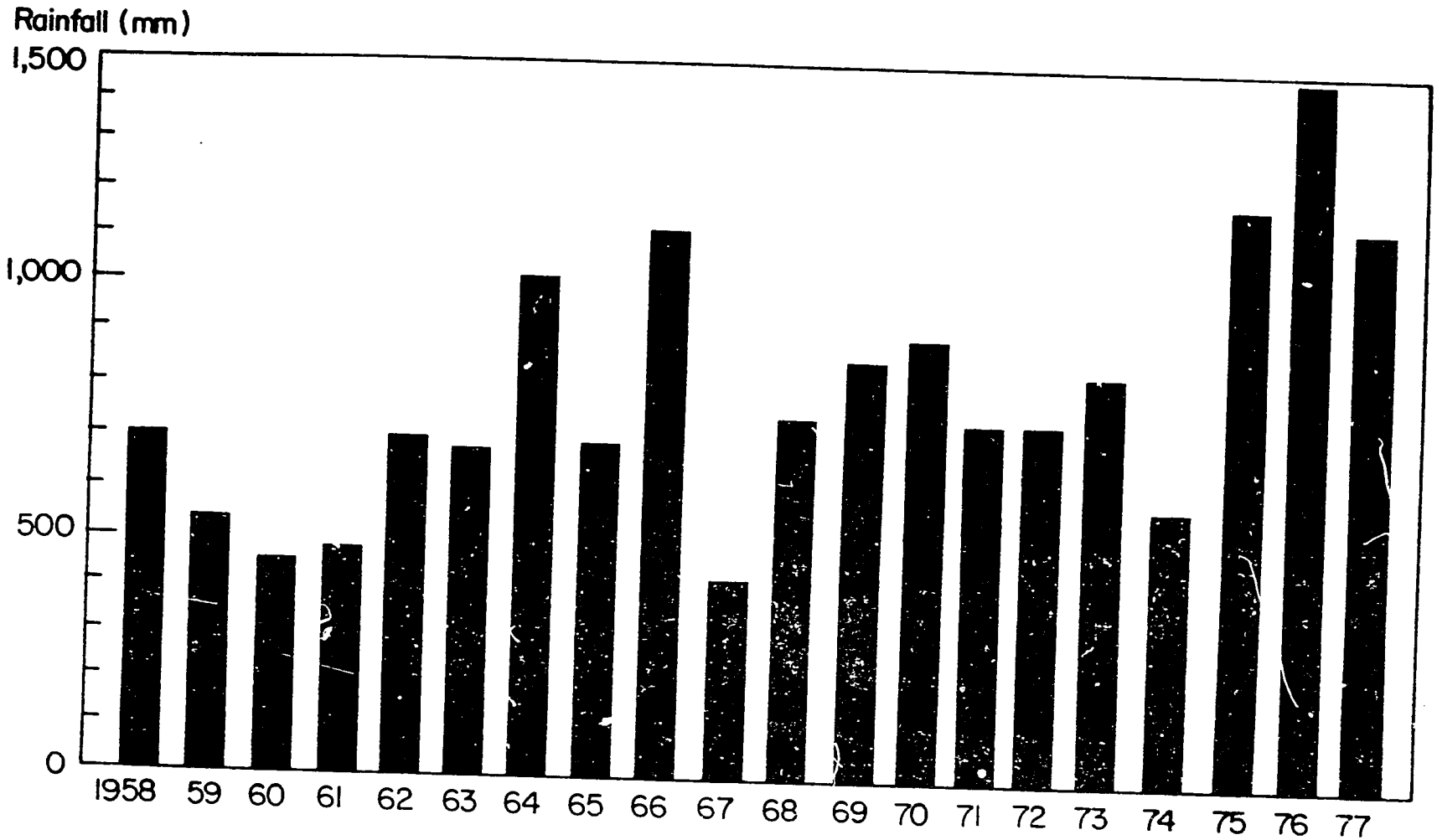


Fig. D.1. Twenty-year average total rainfall (1958-1977).

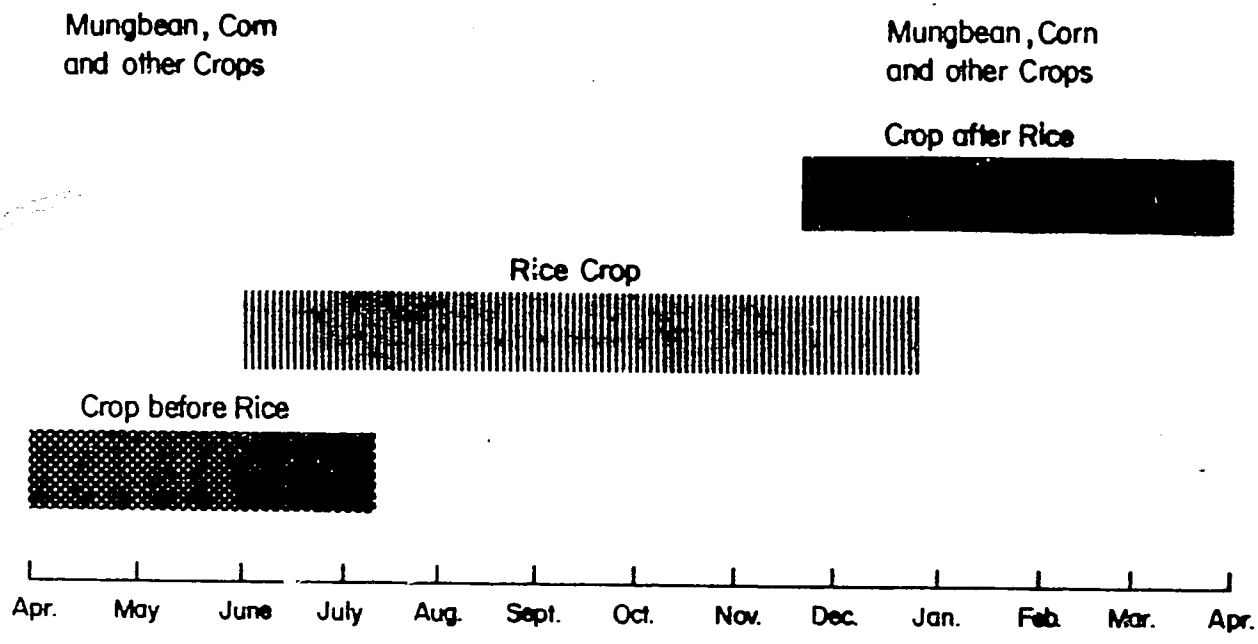
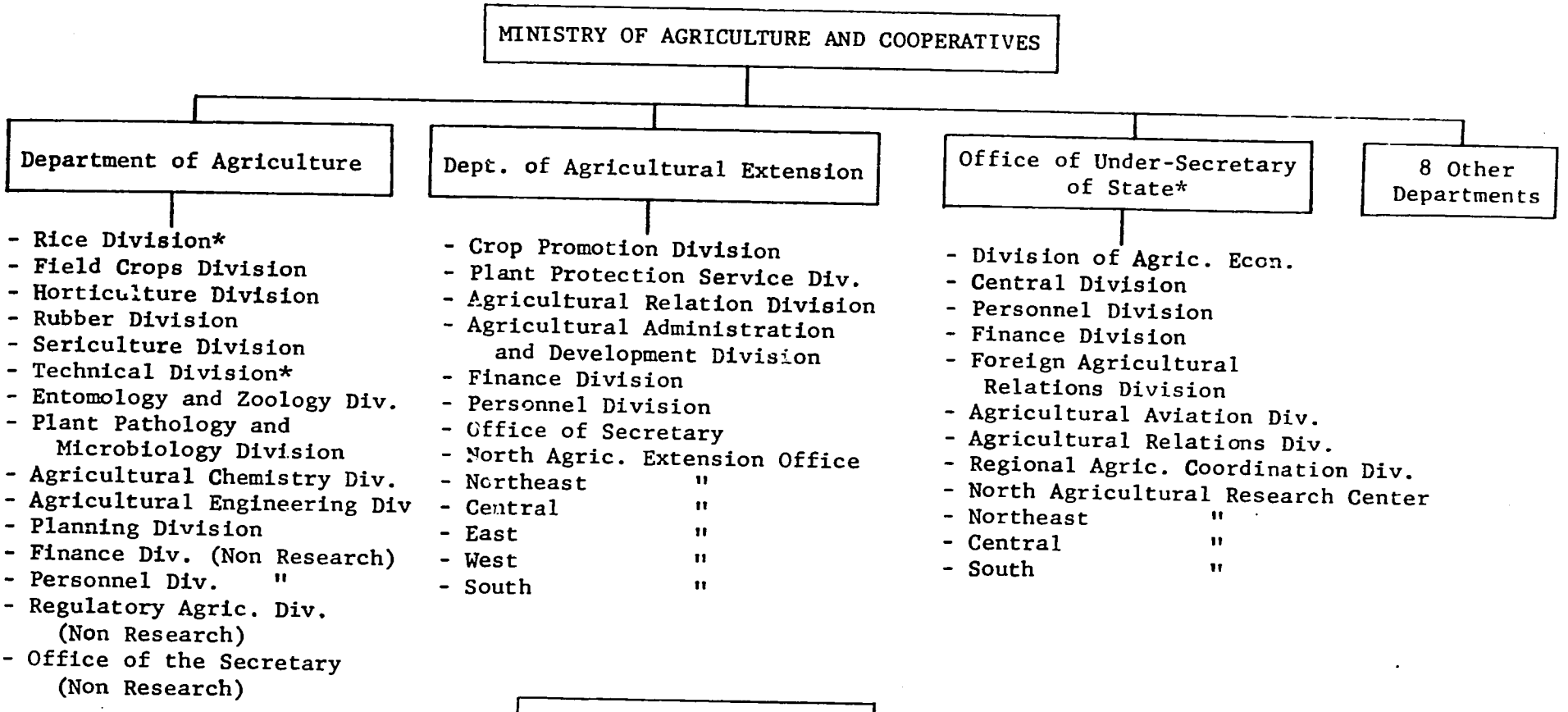
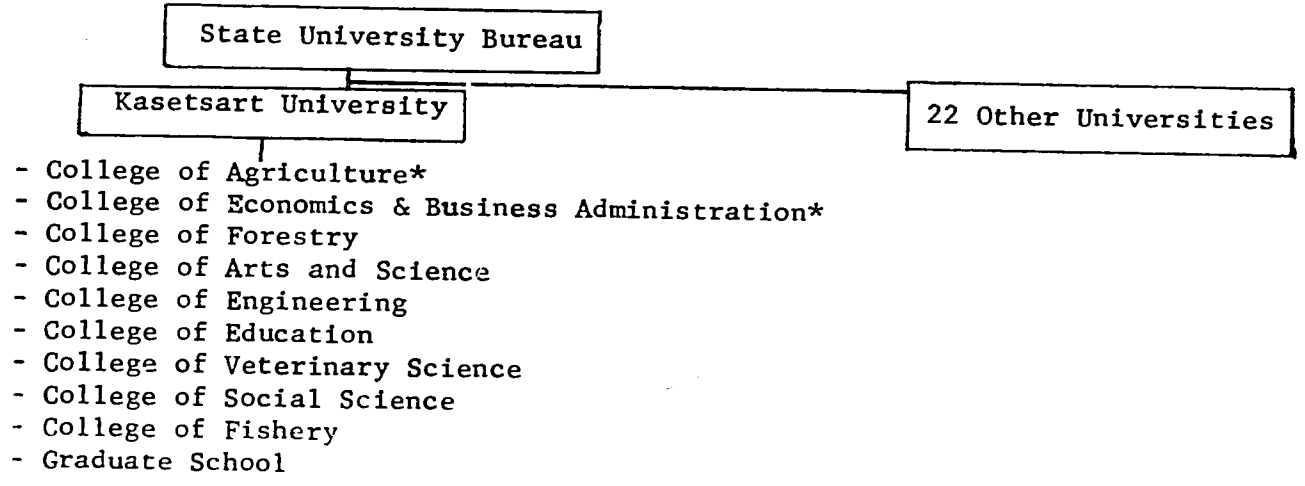


Fig. D.2. Existing cropping patterns commonly practiced by farmers at Bangpae.





Organizational charge of the departments within the Ministry of Agriculture and Cooperatives and Kasetsart University which directly involve in the cropping systems research and development programs.