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MULTIPLE CROPPING : PRINCIPLES AND PRACTICES TO INCREASE CROP PRODUCTION FOR SUBSISTENCE FARMERS

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MULTIPLE CROPPING : PRINCIPLES AND PRACTICES TO INCREASE CROP PRODUCTION FOR SUBSISTENCE FARMERS

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INTRODUCTION

Multiple cropping, a farming pattern inwhich two or more separate crops whether of the same or a different kinds are grown on the same piece of land, is an age-old practices (Chang, 1972). Farmers have been practiced this cropping system for thousands of years. Researchers have investigated the effect of crop rotations and sequences of crops on total productivity for several years. The modern concepts of multiple cropping, however, are new (Harwood, 1973).

The primary reason inwhich multiple cropping has been given an emphasis to increase food production and raising farmer incomes, is due to the difficulty lying with an attempt to increase yield of crops and food production through expanding land areas and improvement of yield of individuals crops particulary in tropical countries (Pookpakdi,1980 c).

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PROBLEM OF INCREASING FOOD PRODUCTION AND FARMERS INCOMES IN THE TROPICS

In the tropical countries like Indonesia and Thailand, dense population become critical in the term of agricultural production. In order to produce food and raw materials enough to serve the population requirements, the production of agricultural commodities has to be increased either by expanding the land and/or improvement of yield of a given crop. Total population of 45 millions in Thailand and 12 millions in Taiwan with the land areas of 158,000 and 35,961 square kilometres respectively (Thailand Year Book, 1979, FFTC, 1974) do not easily permit the expansion of arable land. Excessive expansion of areas by clearing forest lands result to the destruction of natural resources, destroying wild life, and water sources, reducing soil fertility and infestation of terestrial weeds as experiences in Thailand and Indonesia (Pookpakdi, 1980 c, Effendi, 1980).

An attempt to increase food production and farmer incomes by increasing yield of crops per unit areas were also difficult to achieve. So far, only wheat, rice, and maize are the only grain crops inwhich yield have been remarkedly increased as the result of Green Revolution. However, the yield of other crops like pulse crops such as chickpea, pigeon peas, mungbean, lentils remains at a low yield level and pulse production is either stagnant or dropping (Swaminathan, 1972).

With this evidence, it is clearly seen that neither new high-yielding varieties of non cereal crops such as grain legumes nor improved technology has been developed, so gradually part of the land in many countries that once grew pulses has shifted in winter to wheat and in summer to rice or maize. As Borlaug (1972) pointed out that the high-yielding Mexican wheat varieties often able to increase their yields from 909 kg to 4544-5680 kg/ha. This spectacular increase had taken place on many millions of hectares. As a result, the new seeds, and new technologies have made wheat production highly profitable in such countries as India and Pakistan. Therefore, many farmers have begun to shift to wheat part of their land that formerly was grown to other crops such as grain legumes.

Regarding this situation, the reduction in a production of grain legumes is not only undesirable interm of food production but also in nutritional point of view. Grain legumes are essential in the amino acid balance needed for normal growth development and maintenance of health in most of the Asian diet that depend primary on cereals and root crops.

With the problem of difficulty in increasing food production and farmers income, as a result of increasing land areas and increasing yield per unit land planted, multiple cropping has been considered as an alternative choice of increasing food production. Advantages of rotational effect in practicing sequential cropping scheme, the increase in crop production by planting more than one crop on a given areas, the advantage of better pest and disease protection and stabilizing soil fertility using legume in rotation places multiple cropping practice as a suitable scheme of increasing food production and farmer incomes where resources for agricultural production are limited.

MULTIPLE CROPPING ; AN OLD PRACTICES

It is believed that the Chinese people from Taiwan started multiple cropping practices in 1600's. The emigrants of Chinese from Mainland China to Taiwan increased tremendoesly due to the invasion of Chings or Manchurians to South China and Fukien during that period. Food production in Taiwan became limited and the local administration decided to constructs numerous resevoirs to support agricultural production (FFTC, 1974). Consequently, the local administration also encouraged food production by provision of working animals, farm tools and capital funds for farming. Rice, tobacco, tomato and buckwheat were planted in Taiwan as early as 1661 (FFTC, 1974).

In 1684 or at the beginning of Ching dynasty, farmers in Taiwan started to organize themselves to develop irrigation schemes which enabled the planting of two crops of rice a year. The area of paddy fields increased to 200,000 hectares of which 100,747 hectares had irrigated facilities. Up to 447 varieties of rice and other upland crops such as wheat, sorghum, jute, cotton and tobaco were also introduced from overses. Vegetables including cabbage, mustard, kale, cerely, etc, were also grown. Farmers started practices growing two crops of rices followed by vegetables during winter season taking the advantage of irrigation facilities. Therefore, we may consider that the system of three crops a year were practiced during the Ching Dynasty in 1600's.

It should be understood that multiple cropping which was practiced by Chinese people is strictly a multiple cropping under irrigated condition. Chinese people had been putting large emphasis on reservoir construction, irrigation scheme since the early reclamation of land in Taiwan. Moreover, during the period of 1895-1945, when Japan occupied Taiwan, one of the most outstanding achievements in agricultural development made by Japanese was the construction and repair of irrigation facilities (Chang, 1972).

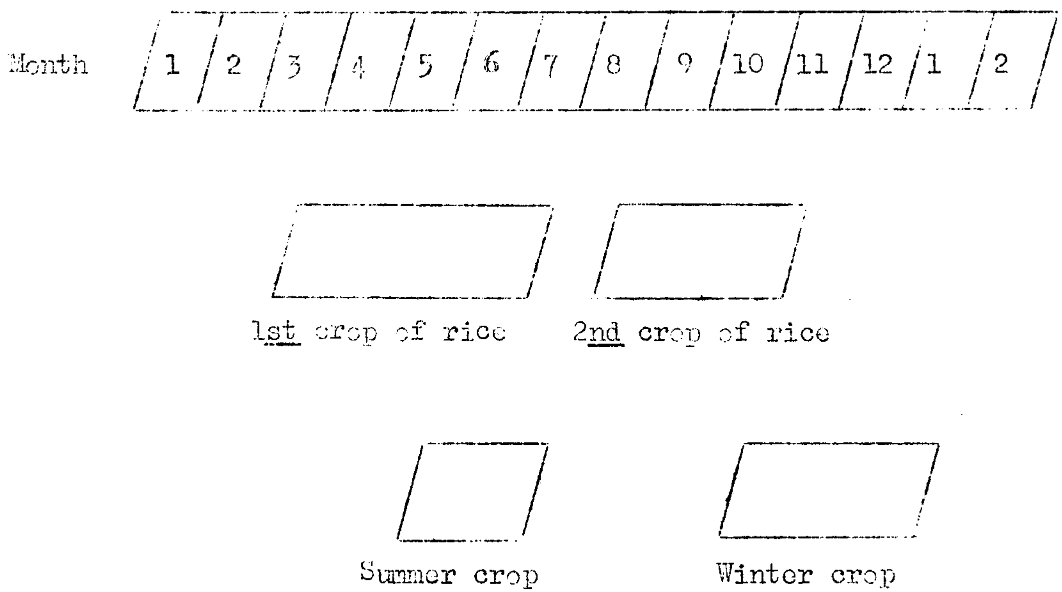
The Taiwanese was considered as the first country which practices multiple cropping technique with greatest efficiency and resulted to a remarkedly increase in food production and elevated their national economic status through agriculture. Their success was partly due to their effort in researches with an attempt to improve their multiple cropping system. The development of rice variety Taichung No. 150 and new varieties of tobacco and wheat for multiple cropping purpose in 1938 were the example (FFTC, 1974).

Researches and extension works on the use of both chemical fertilizer and farm manures had correspondingly increase the yield of brown rice by 85 % from 1201 kg/ha to 2217 kg/ha in 1938 (FFTC, 1974).

One of the most successful scheme of multiple cropping in Taiwan were the development of the system called relay planting inwhich an overlapping of growth periods of two crops in the same piece of land was done. No official record is available to show the history of the developmant of relay planting scheme. However, the technique of relay planting when practiced with sequential cropping, inwhich the latter is defined as planting one crop after another in a rotational manner, would allow more crops to be planted in a single year in the same piece of land. Thus, farmers can harvest more products and obtain incomes more frequent.

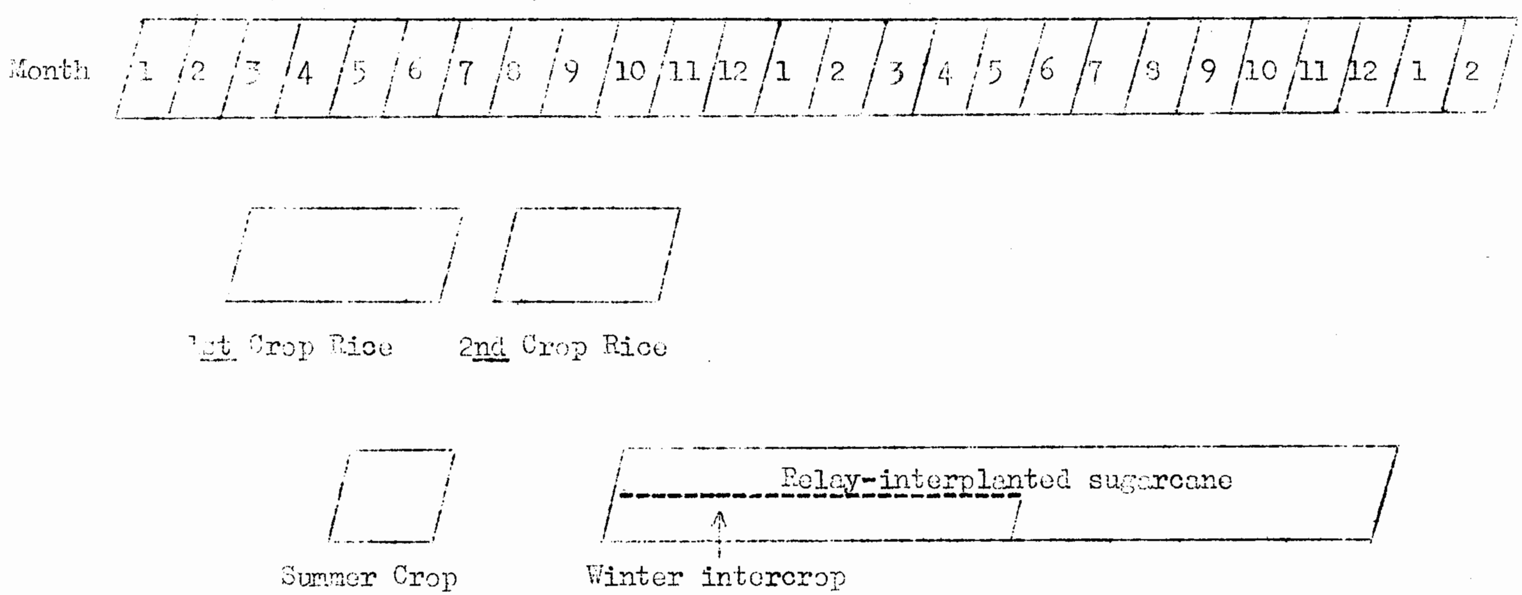
Figure I, II and III showed the diagram of the cropping pattern practices in Taiwan. During 1945-1971, multiple cropping has become more and more popular among farmers in Taiwan (Table I). During that period, the system had been refined and intensified. In the Central Taiwan, 80 percent of the rice field were planted to winter crop following the second crop of rice. However, in the same area, only 2 percent of the rice fields were planted to other crops after the first rice crop. Inothe large area of south central plain where irrigation water was available, multiple cropping has also been taken up widely and rapidly. The reconded highes hectarage of various crops

Figure I   Multiple cropping pattern — Rice and crops with a short growing period.



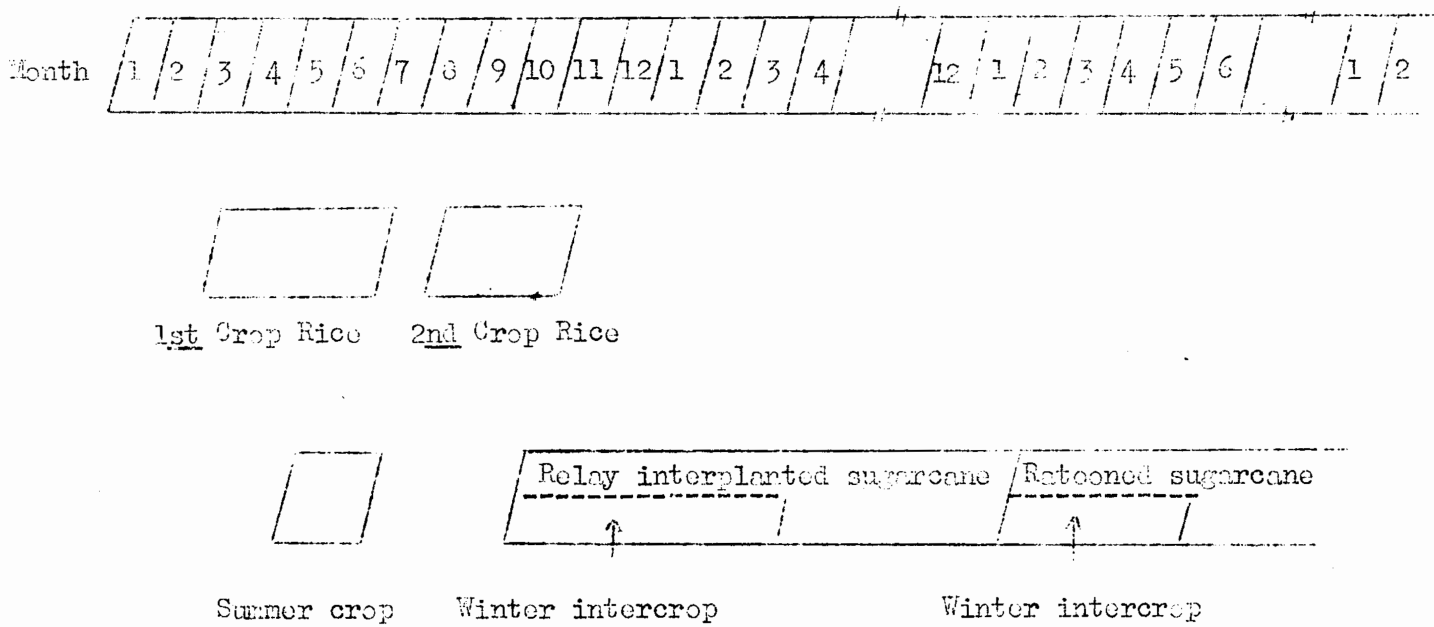
Source : Food & Fertilizer Technology Center, 1974.

Figure II   Multiple cropping pattern — Rice and sugarcane under normal conditions



Source : Food & Fertilizer Technology Center, 1974.

Figure III Multiple cropping pattern — Rice and sugarcane when irrigation available in only one of every three years



Source : Food & Fertilizer Technology Center, 1974.

Table I Crop produced in paddy fields under the multiple cropping pattern in Taiwan 1970 (Source : Food & Fertilizer Technology Center, 1974).

Crops	Area (ha)			Production (M.T.)		
	Multiple Cropping (A)	Total per annum (B)	% (A/B)	Multiple Cropping (C)	Total per annum (D)	% (C/D)
Vegetable	83,270	141,540	58.8	1,012,303	1,685,191	60.7
Corn	10,699	22,641	47.0	30,030	57,416	52.3
Soybeans	32,743	42,749	76.6	52,355	65,174	80.1
Sweet potatoes	39,894	228,713	17.4	412,950	3,440,639	12.0
Wheat	2,003	2,003	100.0	3,664	3,664	100.0
Flax	3,125	3,125	100.0	9,882	9,882	100.0
Tobacco	10,932	11,053	98.9	20,640	20,800	99.5

grown in rice fields in Taiwan during the interval between the two rice crops is shown in Table II.

It should be pointed out that one of the reason why multiple cropping has been successful in Taiwan is due to the well developed irrigation schemes which supply adequate water during the dry season. Moreover, a high level of economy of water use is general, as most Taiwan farmers have a good knowledge of the water holding capacity of their soils and make a practice of applying the maximum possible amount of organic residues to their field, in order to keep the water holding capacity of the soil at as high a level as possible (Food and Fertilizer Technology Center, 1974).

PROBLEM OF HIGHLY INTENSIFIED MULTIPLE CROPPING SCHEME IN TAIWAN

The multiple cropping system which has been practices in Taiwan may posted certain problems to farmers. Such problems may be summarized as followed.

1. Intensiveness of farming and high labor requirements :

Su (1980) pointed out that the growing of many crops in the multiple cropping schemes in Taiwan require high labor input particularly in the system inwhich relay planting and intercropping is involved. Between 1965-1975, the average farm size in Taiwan was lesser than 0.5 hectares for a family of 2-8. This size of farm land and high labor availability was suitable for practicing intensive farming. Later in 1978 to 1980, when the relative importance of

Table II The recorded highest hectarage of vegetable and upland crops grown in rice field in Taiwan in between two rice crops (Source : Food and Fertilizer Technology Center, 1974).

Crops	highest hectarage	year
Sweet potatoes	50135	1963
Corn	10699	1970
Soybean	38157	1967
Tobacco	11952	1969
Rape	19598	1964
Flax	5524	1965
Potatoes	2912	1971
Peas	1904	1971
Pickling melons	1023	1971
Green manure	539031	1964

agriculture in the national economy has declined considerably owing to accelerated development of industry, multiple cropping was faced with shortage of farm labor which caused by the movement of farm youth to urban area.

2. Difficulty to maintain land stability :

The production of several crops in the same pieces of land in one year would gradually change the physical and fertility conditions of soil. Without proper management, yield of crops many slowly decreased due to the reduction in soil fertility (Harwood, 1973). The application of chemical fertilizer as frequent as require by each crop many slowly change the structural soil components and affect crop growth. Application of insecticide and fungicide to one crop many also resulted to toxic residues to the subsequent crops and accumulated as pesticide residues which could cause harmful effect to humanbeing.

3. Increasing production cost :

Taiwan is now experience the increases of production cost resulting from high wages and high cost of pesticides, fertilizers and other farm supplies. As a result, the rate of capital return from agricultural investment were low.

Future development of cropping pattern in Taiwan

With the problems farmers in Taiwan has been facing, diversified multiple cropping patterns tend to slowly changed to monoculture. Farmers with small farms of less than 0.5 hectares continued to intensified their land use by adopting short duration crops including intercropping between field crops, vegetable crops with fruit trees. Farmers who own one hectare or more could not continue their multiple cropping practices easily. They may have to take non-farm employment since they can not effort to make investment of farm machinery. To overcome the difficulty, some effort have been made to promote joint or group farming operation by small farmers as a means of acceralating farm mechanization. Therefore, groups farming is a devise to enlarge the scale of farm operations and to promote farming efficiency, hence, to increase unit yield and reduce production cost without changing the ownership of land.

CONCEPT OF MULTIPLE CROPPING : A PRINCIPLE OF CROPPING SYSTEM DESIGN

Multiple cropping, the use or practices of growing one or more crops on the same piece of land in one year may also be called as cropping system. Cropping system may also be defined as the system of intensive crop production which aim to increase farmer production and income making use of available physical and socio-economic resources of farmers and technology.

Cropping system specialist has given emphasis on the production and income of farmer. Technology should be developed in order to find out how production of crop can be increased. If yield of certain crops can not be easily increased by planting in monoculture, can the crops be produced more than once a year in order to increase production and spreading harvest products. By increasing production of crops, farmers can increased their incomes based on farm productions. Strictly speaking, an increases in crop production and farm incomes are the main targets inwhich cropping systems hope to achieved.

TYPE OF RESOURCES IN CROPPING SYSTEM

In order to increase the productions and incomes based upon the cropping system, farmers have to depend upon the resources inwhich they can make use of. Harwood (1973) pointed out that resources in cropping system can be divided into two groups, natural resources and socio-economic resources.

Natural resources :

The natural resources may be consisted of land, sunlight, and water supply. Each farm unit has available to it a certain amount of land of given topography and soil characteristics. The absolute size has implications and interactions with other resources such as capital, credit and power availability. Cultural practices and water management will also affected by topography. The relationships between land and other resources such as cultural practices and fertility clearly demonstrated the interactions between resources in cropping system.

Water requirement is mostly important and direct the type of cropping system the farmers are likely to practices. Efficient utilization of water by a cropping pattern depend primarily in the selection of crops, planting dates and intensity of their production. Other productions factors such as soil fertility, weed control and tillage practices do affect with water status.

When multiple cropping is practices in the tropics, the duration and intensity of sunlight become critical in crop production (Oldeman and Suardi, 1977). In the monsoon climate, light intensity is often quite low during the rainy months, imposing a sharp limit on yield and on response to inputs such as fertilizers, pesticides and highly productive varieties, In contrary, dryer months usually have considerably more light. Better utilization of light can be obtained when crops is interplanted or relay planted up to 30-40 percent (IRRI, 1972) as shown in Table III.

Socio-economic resources

The socio-economic resources in multiple cropping are labor, credit, power sources and marketting demand. Labor requirement play an important role inwhich the type of multiple cropping can be practices. The most productive patterns in terms of total return and return on labor are those involving high value crops such as vegetables and fruits. However, the extent of these patterns is limited by

Table III Percent of sunlight interception by crops and crops grown in combinations.

Crops	Percent interception		
	30 days	44 days	63 days
Corn (40,000 plants/ha)	48	68	74
Mungbean	51	88	77
Mungbean & Corn	72	94	92

Data from International Rice Research Institute Annual Report 1972.

market availability. In Asia, market uncertainty is often the greatest sources of risk.

Credit is important for farmer to obtain chemical, seeds and additional input for farm production when cash is not available. Credit is often interact with cropping pattern the farmers adopted, the products and market availability in term of risk involved. Power source and availability is also direct the type of cropping system which farmer also practises. Power sources interact closely with natural resources such as land, water supply etc.

TYPE OF CROPPING SYSTEM

The growing of more than one crop on the same piece of land all year round can be done in different ways. The methods inwhich cropping systems can be practices are sequential cropping, intercropping and relay planting. In contrary, crop can also be grown as monoculture or sole cropping.

MONOCULTURE OR SOLE CROPPING

The crop can be grown as monoculture or sole cropping if they are grown only as the only kind of crop in any particular piece of land. That particular kind of crop can either be planted once or more than once in a year and the interval between harvesting and sowing can be at any length of time. In Thailand, farmers usually planted rice in the paddy field in the Central Plain. If water supply is available in summer, they may planted two crops of rice, other wise only single crop of rice is traditionally grown (Rice Division Annual Report, 1975). However, the crop that are grown in the particular area is only rice, it is regarded as monoculture or sole cropping.

Monoculture or sole cropping is not practical interm of pest and disease accumulation. The production of one kind of crop over a period of time may cause the accummulation of pest and disease population due to availability of their food supplies. Stemborer and rat infestation has been frequently observed and control measures are difficult in the area where monoculture is practices.

SEQUENTIAL CROPPING

Sequential cropping is defined as the yearly sequence and spatial arrangement of crops or of crops and fallow on a given area. Sequential cropping is similar to crop rotation only time is given.

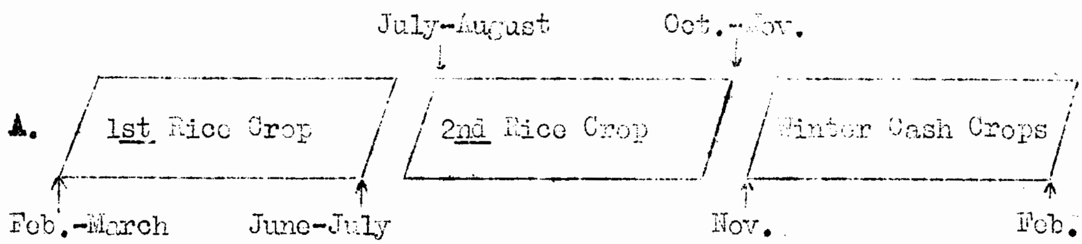
Sequential cropping is regarded as the simplest method of crop intensification, that is to grow two or more crops in rapid sequence with little break down in between. (Herrera and Harwood, 1973). Sequentail cropping is done merely by selecting crops which have relatively short growing periods to preceed or follow rice. The grain legumes are ideally suited for this purpose. They are high in protein, drought tolerant and somewhat tolerant of poor soil structure. Example of successful sequential cropping which farmers has already been adopted as the result of research and extension are mungbean-rice-mungbean and sweet corn-rice-mungbean patterns in rainfed areas of Central Thailand (Pookpakdi, 1980 b) Figure IV demonstrate the sequential cropping practices by farmers in the irrigated areas of Taiwan and rainfed area of Central Thailand.

By growing crops in the sequential manner is also considered as growing crop in rotation. Only sequential cropping demonstrate the definite patterns in the period of one year while general crop rotation does not require definite period or interval inwhich a particular crops are grown. As a result inwhich crops are grown in rotations, if legumes in considered as one component of any sequential pattern, the system will also provide for maintenance or improvement of soil productivity. Moreover, the sequential systems aids in control of many plant diseases and insects.

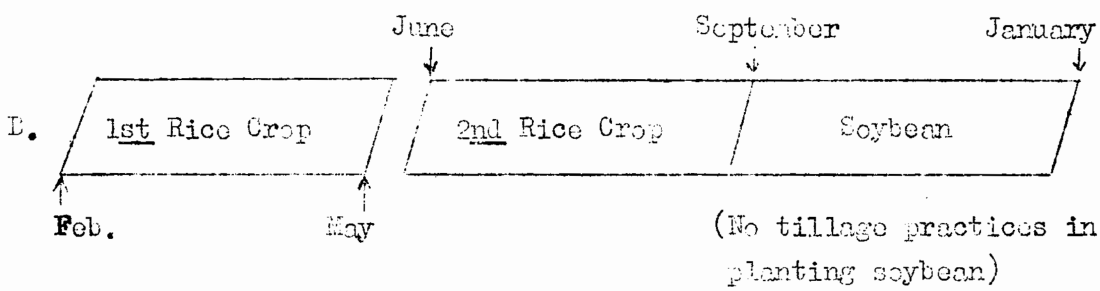
Residual effect of one crops growing after another

Perhaps, researches conducted by the International Rice Research Institutes only demonstrated the injurous effects of previous crop to yield and performance of subsequent crops. This effects could be observed as the results of intensive study on crop interrelationships during the early year of multiple cropping researchs at the International Rice Research Institute between 1970-1974. Herrera and Harwood, (1973) reported that the growth of rice was markedly poored following cowpea than that following corn. The effect was also observed in the field

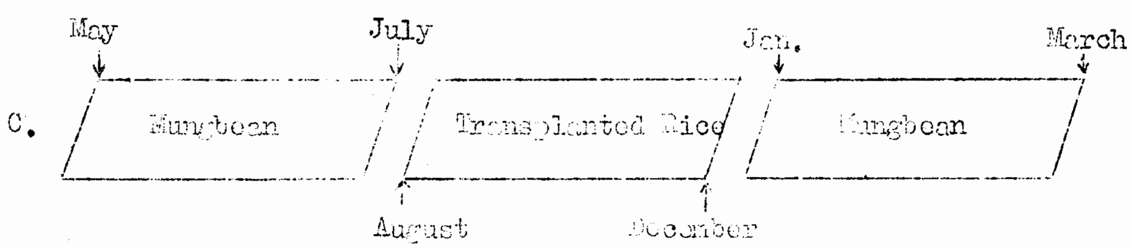
Figure IV Diagram of the sequential cropping practices by Asian farmers. A and B Sequential crops grown under irrigated condition. C Sequential crops practices under rainfed condition.



Central Taiwan



Southern Taiwan



Central Thailand

Diagrams adapted from data and informations obtained from Chang (1972) and Pookpakdi (1980 b).

following intensive cropping of sweet potato, mungbean, cowpea, and soybeans inspite of addition of fertilizer and maintenance of good soil fertility. Table IV and V were the results of the experiments when mungbean and cowpea were immediately grown after different crops at different crops. (Herrera and Harwood, 1973).

The cummulative effect of crop residue was first thought as the toxic effect of root exudate produced by certain legumes like mungbean and cause stunt growth and non productiveness for subsequent crops. However, this effect could not be observed if a time gap of days was provided as an interval between harvesting previous crops and sowing subsequent crops.

INTERCROPPING

Intercropping is the growing of two or more crops in the same field at the same time. The row ratio of the crop is variable. For example, 1 : 2 of cassava-peanut system refer to a system inwhich two rows of peanuts are grown in the interspace between two rows of cassava (Krishnamoorthy, 1978).

Table IV Effect of previous crops on the growth of mungbean (Herrera and Harwood, 1973)

Previous crops	Grain weight (kg/ha) Nitrogen level (kg/ha)			Mean
	0	50	100	
Mungbean	706	725	857	763
Cowpea	647	769	985	800
Corn	900	1006	1121	1009
Mean	751	833	988	

Table V Effect of previous crops on the growth of cowpea (Herrera and Harwood, 1973)

Previous crop	Fresh weight of pods (t/ha) Nitrogen level (kg/ha)			Mean
	0	50	100	
Mung bean	3.26	3.61	4.21	3.69
Cowpea	3.34	3.17	4.39	3.63
Corn	5.61	5.27	6.19	5.69
Mean	4.07	4.02	4.93	

Two socio-economic situation tend to favour the adoption of intercropping. First, population pressure on the land being high with resulting small farm size and surplus of labor. Second, lack of power for tillage either machine or animal resulting in the use of hand labor only. Intercropping is traditionally practiced by farmers in the semi-arid tropics receiving unimodal rainfall of 500-750 mm. per year (Krishnamoorthy, 1978). Seeds of several crops are mixed and broadcasted. The variants are intercropping in the row and between the rows of the base crops. When the crops are broadcasted, all subsequent operations are done manually. In India, the most popular combinations are sorghum-pigeon pea ; pearl millet-pigeon pea ; peanut-pigeon pea and castorbean-peanut. In Africa, corn-cowpea, sorghum-millet and some combination with cassava and yam are common (Krishnamoorthy, 1980).

Types of Intercropping

There are many possibilities inwhich two or more crops are grown in the intercropping systems. The most simple criteria to classify the type of intercropping is to consider the maturity of crop growing in combinations as followed :

I. Crops grown with each others having similar or close in maturity

The example of this type of intercropping is to grow glutinous corn in an alternate row with mungbean (Figure V) as practiced in the

Figure V Diagram showing the different type of intercropping system

A. <u>Crops growing with each others having similar or close in maturity</u>

Corn (sweet/glutinous) 75 days for green cob production

Mungbean 60 days for seed

B. <u>Short season crops intercropped with long duration crops at the early growth stage</u>

Cassava 10 months

Peanut 120 days

Sugar cane 12 months

Mungbean 60 days

C. <u>Intercropping field crops with fruit trees or plantation crops</u>

Central Plain of Thailand. Growing glutinous corn for green cob production take approximately 75 days from planting. Mungbean take approximately 60-65 days to harvest. The intercropping of early maturing crops such as glutinous corn and mungbean are suitable for the system inwhich rice is planted as subsequent crop, as it was found suitable in Central Thailand (Pookpakdi, 1980 d).

The growing of two crops having similar maturity particularly when both of crops have a different plant type such as corn mungbean intercropping give certain advantage. First, we can not always increase the yield of corn by keep increasing plant density or narrow down the row width. Corn exhibit the optimum leaf area index, thus row spacing can only be decreased up to the certain point inwhich mutual shadding will not be occurred. However, corn field may be infested with weeds if row spacing is not that close or if corn growth is in that early stages particularly when it was grown in the early rainny season inwhich moisture supply is ample. The establishment of mungbean crop may reduce weed infestation by the shadding effect mungbean plants gave to weeds and by other competitive effects. Mungbean does not compete with corn in term of light due to the different in height of their leaf canopies.

The second advantage of intercropping mungbean with corn is the efficient use of space in between corn rows, for the production of mungbean crops. In term of solar energy utilization, intercropping resulted in a better light energy interception. The third advantage of growing crops having the same maturity such as mungbean and sweet corn is due to better control of products to meet the level of market demand. In the area of Bangpae in Central Thailand region, the demand for sweet corn in the local market is not high. Farmers prefer intercropping three or four rows of mungbean in between two corn rows so that the corn production per unit area is not high and they would not have difficulty in selling products. In the meantimes farmers can also sell their mungbean crops in the market as well (Pookpakdi, 1980 b).

II. Short season crops intercropped with long duration crops at the early growth stage

The example of this type of intercropping is when mungbean or peanut are planted with cassava or sugarcane. The growth of cassava and sugarcane are long such as 10 months and one year respectively. Due to their size and maturity, cassava and sugarcane require wider row spacings in which the space between rows normally are left uncovered from leaf canopy during their early growth especially during the first three months. Weed infestation normally occur in cassava and sugarcane fields if nothing is intercropped. Planting mungbean or peanut in between rows of cassava and sugarcane keeps controlling weeds as well as increase the efficiant utilization of land. Mungbean or peanut can be harvested before cassava or sugarcane leaf canopies start to shade legumes. The practices of intercropping cassava with peanut or mungbean is widely adopted by north eastern farmers in Thailand and the farmers in transmigration areas in Sumatra and Kalimantan islands of Indonesia (Pookpakdi, 1980 c).

III. Intercropping field crops with fruit trees or plantation crops

The practices of intercropping field crops with fruit trees and plantation crops is widely practices in several orchard areas and in the rubber plantation particularly in the Southern Thailand. Planting field crops in between plantation crops provide farmers with additional incomes or initial incomes especially when the fruit trees and plantation crops are small and products can not be harvested at that stage. Normally field crops which are grown in between trees are those which gave farmer high prices in the market. The examples are sweetcorn. In some areas where irrigation supply is ample, vegetable crops such as sweet peas, tomato and cabbage can be intercrops in betweens rows of fruit trees.

Properties of intercropping combinations

Among the cropping system, intercropping involved mostly in the competitive effects between both crops. The management for successful intercropping is to reduce competition as much as possible. Intercropping is possible both in space (differences in root depth, canopy, etc.) and in time (duration). In a biological system, space and times factors are difficult to separate, for as the plant grow the space requirement varies (Krishnamoorthy, 1980). Basically, the peak demand for moisture, nutrients, and light by the components crops should not coincide. Krishnamoorthy (1980) estimated that atleast there should be the differences of 45 days in duration between two crops for the demand of moisture and nutrients. In addition, both crops should draw moisture and nutrients from the different soil depth.

Morphologically, the growth habit of both crops and plant height should be different in order to avoid light competition. Intercropping corn and mungbean is good example for reducing light competition. The nature of corn leaf is more erected and narrow, then, allowing more light to penetrate under the canopy of corn. Mungbean leaves can intercept radiation underneath corn canopy by their nature of broadleafness. In this manner, light competition is generally reduced.

The production advantage of intercropping combination was found when mungbean was intercropped with corn in comparison to corn and mungbean being planted alone (Herrera and Harwood, 1973). The advantage of intercropping is greatest under low management with the increase being as high as 400 percent. At high management, the advantage is normally 30-40 percent for well matched crops. (Table VI) In this case, the concept of Land Equivalent Ratio is use for determining total productivity of crops growing in combination as well as when they are grown alone as sole crops.

Land Equivalent Rato (LER.)

The land equivalent ratio is the total land required, using a monoculture of each crop at the same level of management to give production of each crop equivalent to that of one hectare of intercrop. In an intercrop system, the yield of the component crops (Y_{ij}, Y_{ji}---) will be different from the yield of sole crops (Y_{ii}, Y_{jj}---) LER. is the ratio of yield of a crop in an intercrop system to its yield as a sole crop.

Example LER. $= \frac{Y_{ij}}{Y_{ii}} + \frac{Y_{ji}}{Y_{jj}}$

In the system inwhich mungbean is intercropped with corn, if LER. of 1.56 can be obtained, it can be expressed as if an additional 56 percent of land has been brought under cultivation. In this sense, the LER. of intercrop system has a meaning similar to cropping intensity of a sequence crop system.

The work of the Upland Crop Improvement in Thailand has reported a substantial improvement of yield of the component crops and LER. of the systems (Upland Crop Improvement Project, 1980). Thirty percent increase in yield of mungbean and soybean has been achived by adopting a hill spacing of 10 cm. instead of 20 cm. when intercropped with cassava. By doubling the plant density and pairing the rows of both the component crops. LER. of 1.60 has been obtained for kenaf-mungbean and kenaf peanut intercrop system.

RELAY PLANTING

Relay planting is the intercropping of one crop in another before the first crop is harvested, that is, when the second crop is planted in the standing of the first crop when the first crop is about to mature. In this practice, there is a short overlapping period between crops and for the farmer, means a several days gained. This practices become especially important in fitting the multiple cropping pattern into the growing season that is available to the farmer. It also has the advantage of enable him to plant his following crop before he becomes too preoccupied with harvesting and processing of the first crop.

The practice of relay planting may impose certain competition on both crops. Depending on the tolerance to shade, the second crop may be planted 10 to 30 days before the harvest of the first crop. Krishnamoorthy (1978) pointed out that the first crop should reach the physiological maturity before the second crop is planted. (Figure VI) Usually, relay crop is planted without any tillage. However, if the planting of the relay crop require certain land preparation, alternatively, the row spacing of the first crop should be such that tillage of interspaces would be possible even in the standing of first crop.

The hardship of relay planting which require intense labor and proper planting techniques limit relay planting not to be practiced widely in construst to intercropping and sequential cropping. Relay crops has to be planted in such a way that the farmers would disturb the stand of the first crop as less as possible. Taiwan is the country which demonstrate the successful adoption of relay planting due to the small farm holding areas and ample labour sources. Due to the competitive effect of relay planting to crops, research techniques has to be developed to find out low shadding tolerance any crop species posses.

Table VI Peso return [a]/per hectare for corn-mungbean intercropping averaged over plant population after deduction the cost of nitrogen fertilizer (Herrera, 1973).

Crop	Nitrogen level (kg/ha)					
	70		180		270	
	No weeding	Butachlor 1.5kg ai/ha	No weeding	Butachlor 1.5 kg ai/ha	No weeding	Butachlor 1.5 kg ai/ha
Corn alone	923	2280	1725	2133	2050	3509
Mung alone	2488	2533	1977	2591	2193	2870
Corn & mung	3588	3423	3492	3581	4216	4525

a/ Corn = 0.79/kg Mungbean = 2.25/kg.

Moreover, the study on yield reduction due to its competitive effect when relay crop is planted needed to be explored in order to design the suitable relay planting scheme. Some of the results of the study involving competitive effects between crops in the relay planting are shown in Table VII and VIII

The work of Taichung District of Agricultural Improvement Station (Food and Fertilizer Technology Center, 1974) reported that the best time for sowing or transplanting the relay crops between the rows of rice is immediately after draining the irrigation water from the field for the last time, that is usually about two weeks before harvesting the rice crop. The Chinese scientists also reported the yield reduction of rice crop due to certain competitive effect of the relay crop and the disturbance of stand when planting relay crop such as 1-2 percent reduction when wheat was relay planted in rice, 5-6 percent decrease if sweet potato was relay planted. It was also found that the relay crop had certain influence on the yield of succeeding rice crop and cause the yield reduction of the following rice by 7 percent if wheat was relay planted, 4.7 percents if flax was relay planted. The reduction of yields of the follow-up crop was due to the drop in soil fertility. Vegetable, if uses as a relay crop and the least effect on the yield of the follow-up crop of rice because fertilization of vegetable was usually maintained at high level. Food and Fertilizer Technology Center (1974) also reported that, farmer in Taiwan adopted

Table VII The effect of relay planting on rice yield when the relay crops were planted in the field before harvesting rice (IRRI 1972)

Crop	Length of overlap (days)	Rice yields (t/ha)
Rice alone		4.01
Rice and corn	21	4.28
Rice alone		4.12
Rice and sorghum	21	4.33
Rice alone		4.03
Rice and sweet potato	30	3.95
Rice alone		3.43
Rice and soybean	21	3.91
Rice alone		3.97
Rice and cowpea	21	3.63
Rice alone		3.76
Rice and mungbean	21	3.55
Rice alone		3.38
Rice and radish	21	3.23

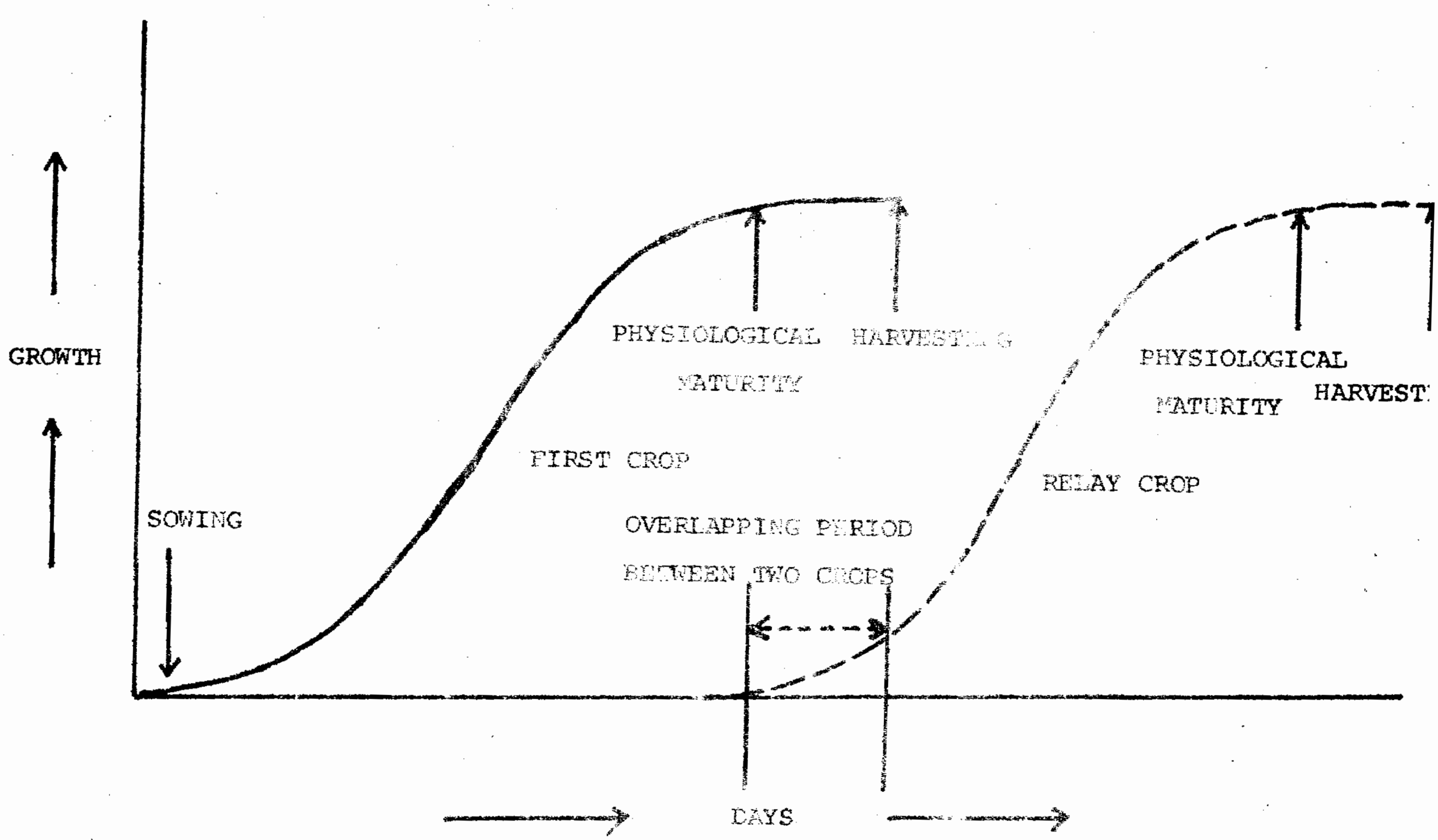
Table VIII The effect of relay planting into rice on the yield of relay crop (Multiple Cropping Research Report, 1976).

Day of overlapping	Grain yield (t/ha) [a]			
	Mungbean	Soybean [b]	Cowpea	Corn
0	0.80	7.01	0.70	3.12
7	0.60	5.63	0.61	2.40
14	0.11	4.87	0.44	1.10
21	0.12	3.54	0.35	0.84

a/ Mean of 4 replications

b/ Harvested as green pods

FIGURE VI DIAGRAM SHOWED THE GROWTH STAGE OF CROPS WHEN RELAY PLANTED WITH EACH OTHER (Adapted from KRISHNAMOORTHY, 1978)



relay planting technology even though relay planting may adversely reduced the yield of rice because the benefit gained from the use of this practices was consideraly greater than the less due to the competitive effect of the system.

BIOLOGICAL ASPECTS OF CROPPING SYSTEMS

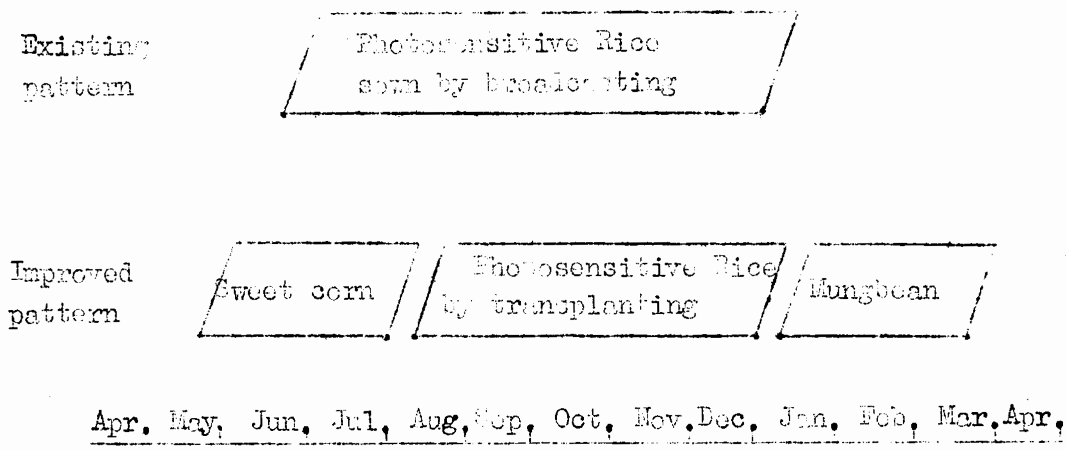
There are certain biological aspects which should be understood and considered before any type of cropping system will be practices. The impact of growing crops intensively in the same areas my varies depend upon the management system given by farmer. The benefit of the system such as the better control of pest and disease may be derived if proper sequential cropping or intercropping are being done. However, intensive crop management can cause gradual deterioration of soil fertility if fertilizer management are not propered.

The following biological aspects of the cropping systems should be considered as followed :

THE EARLINESS OF CROPS

As a rule of thumb, early maturing varieties are most suitable to use in any cropping system practices. However, the type of crop species which products can be harvested for green parts such as leafy vegetables, sweet corn and soybean harvested for green pods are also

Figure VII The adoption of growing three crop pattern by farmers in Bangpae District of Thailand from the existing pattern of one rice crop a year (Adapted from Pookpakdi, 1980 b).



suitable. The most obvious reason for using early maturing varieties and the growing of crops for fresh products is the shortness of growing time which will enable farmer to add other crops in the system. The farmers of Bangpae district in Central Thailand were able to grow sweet corn as crop before rice and mung bean as crop after rice in a sweet corn-rice-mungbean pattern instead of growing rice alone. By changing the rice growing method from broadcasting to transplanting, farmers are saved with approximately 70-80 growing day. Sweet corn which mature 75 days can be planted and harvested before transplanting rice. Similarly, mungbean can also be planted immediately after rice is harvested farming a three crops pattern in the rainfed area (Figure VII) (Pookpakdi, 1980 a).

In choosing the varieties for suitability in intensive pattern the highest yielding, long season types may not always be best suited for the purpose. For example, the greater portions of Indonesian corn area is intercropped with cassava, rice and several legumes. The traditional corn varieties used are early maturing, requiring 70-80 days. However, newly recommended varieties mature in 110 to 120 days. These varieties exhibit taller plant height as a result of long vegetative growth. These new varieties do not fit as well into intensive system. The gain in productivity resulting from the substitution into an intensive pattern of type which yield more in monoculture will be far less than would be indicated by a simple yield trial of corn varieties (Harwood, 1973).

Varieties should be choosen not only on the basis of earliness. However, the performance in the population should be considered rather than the performance of individual plant particularly in an intercropping system in which inter-specific competition is less than intra specific competition (Krishnamoorthy, 1978). In a sequential cropping, determinate growth habit is more desirable in certain crops particularly legumes. The indeterminate cowpea require stake due to their excess vegetative growth. This would result into extra cost of staking and several harvesting due to uneven maturity of pods. The change from indeterminate to determinate growth would limit the harvesting to one to two times. Although the yield over the period will be low but the reduction in cost of production would balance the reduction in yield. Moreover, farmer may be provided with an extra time for the planting of subsequent crops.

ADAPTATION OF CROP VARIETY TO ENVIRONMENT

The selection of varieties which should be suitable for the environment inwhich the system is subjected to, is mostly important. Now a day, the cropping system are practices in large areas of Asia inwhich irrigation is not provided. The varieties should be choosen on the basis of adjustable to the rainfall pattern. Chandrapanya, (1976) showed that planting early direct seeding of the suitable variety of rice into the moist soil from the middle of June to mid-July was possible to establish a rice crop which can withstand extended drought period and produce reasonable yield. After three years of researches in the rainfed areas of north eastern Thailand, the rice-mungbean cropping patterns was found to be suitable when the varieties suitable for early direct seeding method was used as its component (Pookpakdi, 1980 1).

Certain lowland rice production areas of the tropics such as Thailand, Burma and Bangladesh are considered as deep water area. Newly recommended high yielding varieties of rice sometime are differcult to replace the old traditional varieties. In the sweet corn-rice-mungbean pattern which farmer adopted as an improvement of cropping patterns in Thailand, the rice varieties used were still the traditional photosensitive varieties. (Cropping System Research Report, 1982) due to the fact that taller plant type of this variety could merge their stems and panicles above water level while the recommended varieties were short and frequently submerged underneath water level in the paddy field. Farmers also prefer to harvest photosensitive rice at the period inwhich the paddy field has already been dried down from flooding, due to its longer time in maturity. Growing non photosensitive varieties of rice took normally 90-100 days to harvest. In the period of harvesting, water stand in the field cause the problem of harvesting and crop processing to the farmers.

Table IX demonstrated the growth and height of different rice varieties in contrast to the depth of water level in the paddy field when varieties of rice were grown in a cropping patterns in Central Thailand (Cropping System Research Report, 1982).

SOIL FERTILITY

Soil fertility is one of the important factors which should be considered when intensive cropping system is practiced. Many soils of the tropics are inherently acid and relatively infertile in their native state and mineral nutrition is a principle concern for any cropping system. Fertilization practices for insuring adequate nutrients and their availability are even more rigorous when soils are multicropped. Oelsligle et al (1980) pointed out that during the cropping period, nutrients losses by leaching, removal in harvested crops or by run off and erosion usually deplete the available supply quite rapidly. Special attention must therefore be given to the dynamics of nutrient supply and nutrient availability under multiple cropping not only for assessing fertilizer needs but also in selecting the crops to be grown.

The information regarding the amout of nutrients which a given crop species require to complete their life cycle in necessary in considering the fertilization scheme for a cropping system. Cordero and Miner (1974), showed that the addition of phosphorus to rice grown on soils with 4 ppm of soil-test P (modified Olsen extract) gave no

Table IX The depth of water level, planting date, height and maturity of six rice varieties grown by transplanting methods

Varieties	Date of transplanting	Maturity (days)	Plant height at panicle emergence (cm.)	Water depth at panicle emergence (cm.)	Plant height at harvesting (cm.)	Water depth at harvesting (cm.)
R.D.1	25 Aug.	105	88.0 c	7.20	90.63 bc	2.50
R.D.9	25 Aug.	98	96.9 bc	3.75	98.75 b	4.75
R.D.19	25 Aug.	123	100.25 b	0.62	97.50 b	NONE
I.R.36	25 Aug.	98	73.00 c	0.45	79.38 c	4.75
Luang on	25 Aug.	112	157.00 a	0.30	158.12 a	NONE
Luang pra taew	25 Aug.	126	102.00 b	0.30	152.88 a	NONE
L.S.D. (0.01)	-	-	11.00	-	41.00	-

economic return, but when corn was grown on soils with the same soil test levels, phosphorus additions was necessary to make it an economic advantage. Increasing fertility levels in two cropping patterns in Costa Rica caused an increase in yield of beans and corn, a moderate increase in yield of cassava, no change in yields of soybean and a decrease in sweet potato, (North Carolina State University, 1974). It would seem appropriate to apply fertilizer to those crops which responded to it and little or non to the non responding crops.

The rate of nutrients uptake vary with plant age, the period of maximum nutrient demand for one specie may not coincide with that of another. Within a given specie, the uptake curve for one element may differ from that of others (Lelsligle, et al. 1980). Dalal (1974) observed that dry matter production by pigeon peas in a corn-pigeon pea intercrop was less than one half of that of sole-cropped pigeon peas during the first 16 weeks. Once the corn matured, however, its competitive influence was reduced and growth of the interplanted pigeon peas between 16-24 weeks was sufficient to produce seed yields comparable with the sole crop.

When two or more than two crops are grown sequentially in a yearly rotation, the growing of green manure crop could be an advantage because it would still allow one each crop to be harvested once or twice per year. However, the beneficial effect of green manure are short lived and can be quickly ploughed under before the commence of the following crops. The disadvantage of green manure is the difficulty for farmer to follow the practices. Farmers in Asia still prefer to harvest some products out of the crops which are being grown. Thus the practices of planting other non green manure legume inwhich pods can be harvested, is more appropriate since benefit can derived from the increase in soil nitrogen and organic matter resulted from nitrogen fixation of legumes and the ploughing under of plants after pods had been harvested.

In an intercropping practices, the rate of nutrients absorbtion is by far greater than the sole crops. Ibrahim and Kabesh (1971) found that the uptake of N, P, K and Ca was increased by 29, 33, 39 and 32 percents respectively over the monoculture. When corn and sugarcane are intercropped, Bhej and Kapoor (1970) found that an extra 112 kg N/ha and three extra irrigations were required to eliminate the competitive effect of corn on sugarcane. Chang el al (1969) also found a measurable effect of crops and fertilizer placement on recovery pattern for P and K after the application of such fertilizer. With the high demand of fertilizer in an intercropping practices, Oelsligle (1980) had suggested that the fertilizer source which is suitable for an intercropping are those which would release nutrients at the rate comparable to the nutrient demand of a particular crop. Slow-release materials would also make it possible to reduce the frequency of N applications and avoid some of the practical problem inherent in fertilizing any intensive cropping pattern.

Intercropping legumes with cereal is another possible way to supply nitrogen. Krishnamoorthy (1978) estimate that cereal would benefit from legumes approximately 30 kg/ha due to leaf shadding and stubble. Agboola and Fayemi (1971) reported that yields of four successive corn crops, each of which was fertilized with nitrogen fertilizer was comparable with corn yields from a corn-legumes intercrop without nitrogen fertilizer.

TILLAGE PRACTICES

Tillage practices for seedbed preparation and for weed control after planting crop in Southeast Asia setting is a major limiting factor in intensification of cropping (Harwood, 1973). The important major problem in tillage practices is the shortage of power where farmsize is small and a large proportion of products are largly consumed in the family. The small amount of surplus of products which farmers sell in the market is not enough to purchase a tractor or gasoline. Thus, the cropping system researches in many Asian countries seek the way inwhich tillage operation should be done as simple as possible using local farm equipments or animal powers, also the way inwhich tillage operation can be minimized.

The work of the Multiple Cropping Project in Thailand (Cropping System Research Report 1982) demonstrated the success of establishments of mungbean after rice has been harvested. Mungbean seeds were broadcasted at the rate of 54 kg/ha in the fields where rice stubble has been left. Ploughing was done only once using animal just to barely cover the seeds. Mungbean was planted in early January immediately after harvesting rice. The soil moisture level was ample for mungbean growth during the dry season where rainfall was not available (Pockpakdi, 1980 a). Single ploughing by animal provided good contact of soil and seeds for germination. Moreover, number of plough was minimal in order to reduce the loss in soil moisture during summer months.

The practice of minimum tillage in Thailand as described was not only aim for minimizing power but also conserve the soil moisture. Even in the irrigated areas, no-tillage or minimum tillage operations are practices in the multiple cropping for the benefit of saving times and powers for land preparations. The practices of planting soybean after rice in rice stubble culture in Taiwan was possible due to small land holding area and ample labour supply. In Southern Taiwan, soybean were sown beside the stubble directly after harvesting of second rice crops. Farmers use the tools similar to knife and strike a hole large enough to place 3-4 seeds at the base of rice stubble. The spacing of soybeans followed the spacing of rice stubble which were usually 22.5 x 22.5 cm. Sometimes, straw mulching had been practices in order to suppress weed growth and reduce evaporation as well as the suppliments of nutrients when straw was decays. The crops normally grown between October and January.

INSECT CONTROL

In multiple cropping system inwhich the growth of plants take longer period as crops are either sequentially grown or intercropped, the problem of pest become complex. As the level of managements and inputs such as fertilizer and weed control increased, the increased in insect and disease may be possible. Moreover, some of the newly high yielding varieties may be more succeptible to local insects than the native varieties, thus the need of chemical insect control will be essential. However, in many of the commonly used intensive pattern a high level of built-in stability towards insect population can be achieved. When crops are grown in a rotation manner as in sequential cropping, rotation aid in controlling many plant pests. Many insects are destructive to only one kind of crop. The life cycle is broken when crops which are grown are unfavorable to the development of the insect pest, thus sequential cropping is particularly effective in the control of insects. Cotton root-knot nematode can be reduced by the growth of immune crops in the cropping sequence.

Research in cropping system conducted by International Rice Research Institute in 1972 (IRRI, 1972) demonstrated the stability towards insect populations in an intercropping system. Increasing row spacing of corn from 1-m. row to 2 - m. rows reduce the corn borer (Ostrinia furnacalis Guenee.) population by reducing the suitability of corn for borer oviposition and increasing larval mortality. However, if peanut is intercropped between the rows of corn, further significant reduction in borer population has been observed. The addition of peanut gave still fewer insects by further influence on adult behavior and a probable effect on predator population (Table X). Raros (1973) also reported that reduced infestation by diamond-back moth, Plutella xylostella L. on cabbage intercropped in the tomato.

Table X Number of corn borer (Ostrinia furnacalis Guence.) per 100 corn plant in corn-peanut intercropping (IRRI, 1972)

40,000 plants/ha (1 - m. rows)		20,000 plants/ha (2 - m. rows)	
With peanut	Without peanut	With peanut	Without peanut
41	350	29	137

Plant-insect interactions of this type can also be found in other cropping pattern as crop are intensively grown. With intensive pattern, different crop may be grown in adjacent plots or in relay sequence will transfer of insect predator from crop to crop. Thus, the use of chemical control should be seriously considered otherwise, chemical would harm the insect natural predator and negate many of these existing pest control mechanisms.

Frequently, the practice of shorthening turn around time between crops by minimum or zero tillage practices has beneficial effect on insect control. In Philippines, the farmer's cultural practices of growing cowpea in zero tillage rice stubble culture reduce the beanfly (Ophiomyia phaseoli) population and damage cause by this particular insects especially when tall rice stubble are left in the field. Beanfly adults per plants were 0.3 and 3.1 under zero tillage rice stubble and conventional tillage no stuble respectively (IRRI, 1978). Ruhendi (1979) reported the amount of beanflies as high as 42 adults per 10 sampling dates in conventional tillage as compared to 20 adults per 10 sampling dates in zero tillage practices. The reduction in beanflies population in no tillage rice stubble could partly occurred because the present of high amount of natural enemy like spider in to no-tillage rice stubble plots.

The manipulation of plant-insect interactions by altering the planting pattern combined with a shift in a pest predator balance by selective use of insecticide could play an important role in Asian agriculture. In the tropics, farmers are facing complex assortment of insect pests because of greater diversity of tropical fauna. Their resources are perticularly less and technology to combat the insect problems are fews. Insect management practices not only chemical control but also plant resistant development, and biological control, should be adopted as well as cultural control practices in order to overcome insect problems in the cropping system.

WEED CONTROL

According to Bradfield (1968), weed control take more time than any other operation in multiple cropping. Reduction of the fallow can shortern the period during which weeds grow unimpeded. On the other hand, in the irrigated rice paddy areas in Southeast Asia, the tradition fallow during dry season help kill off aquatic weeds. Similarly, dryland weeds are killed by drowning in the wet stage as land has been flooded and puddle before rice are transplanted. Thus, a change in practices of different crops in a sequence may help reduce weed infestation.

Study at International Rice Research Institute (IRRI 1972) indicated that there was a shift in weed population towards annual grasses such as Digitaria sanguinalis and sedges (Cyperus rotundus) when crops had been grown in rotation and using herbicide for each of the crops. Normally grasses and sedge which were predominated as the result of crop intensification are more tolerance to commonly use herbicide and were more difficult to control by conventional tillage. However, these species were susceptible to shadding, thus increasing plant population in order to built up leaf area as fast as possible to control these type of weeds was found to be quite practical.

The problem of Alang-alang (*Imperata cylindrica*) infestation was reported in Indonesia. Indonesian farmers in the area of Sumatra where this specie of weed was common had adjusted their cropping patterns to achieve a high leaf area index throughout the growing season the shade this weed. This gave an effective control of this weed specie very well.

Disease Control

Up to the present, the control of disease in most field crop is limited to the use of resistant varieties and shifting the cropping pattern and management practices. Chemical control which is being available for many disease is still expensive for farmer, The Multiple Cropping Research Project in Thailand reported a successful control of downy mildew disease (*Scherospora sorji*) in glutinous corn by using fungicide called Rhidomil 25 WP for growing green corn before rice crop. However, the use of downy mildew resistant varieties was introduced for sweet corn grown before rice in corn-rice-mungbean pattern in Central Thailand (Cropping System Research Report, 1982).

By growing crop in the sequential manner, the control of disease was quite effective as similar to the control of insect pest. IRRI (1979) reported the present of Fusarium, Curvularis and Aspergillas of 22, 18, and 13 percents of the total microbial population in the upland soil inwhich continuous cropping are practices, this amount of organism could not been found in the soil when rotation cropping was done. It was speculated that continuous cropping causes the microbial balance to tip toward a specific organism which directly infects a crop or produces substances that inhibit crop growth of the plant which is grown in monoculture.

PRESENT PRACTICES IN CROPPING SYSTEM AS SHOWN IN ASIA

THE ASIAN CROPPING SYSTEM NETWORK

In the country throughout Asia, where one-half of all farm are less than one hectare and three-fourth are less than two hectares, crops is produced mostly on small farms. Rice appeared to be the most staple crop throughout the continents. Moreover, a small portions of rice land is irrigated, even in the irrigated area only a small fraction of land received the water all year round. In this particular area where rainfall is the only source of water for growth, farmers who cultivate the land are considerably poor, their land holding capacity are less and having high level of family members. These areas constitute approximately 70 percent of total Asia.

The need of developing technology in cropping system to enable farmer to increase their products and incomes base upon their available resources become evidence for many Asian countries. As most of the areas in Asia are rainfed inwhich only one crop of rice is a staple food, the purpose of developing cropping system based on rice in the rainfed areas was necessary for most Asian countries to developed. Priority is given to the areas with potential for increased production during a crop season and for two crops or two or three crop a year (Carangal, 1976). Although major effects are concentrated to these areas, irrigated and rainfed upland crops are also given attention. Through the supports of various countries in Asia, The International Rice Research Institute in the Philippines organized the Asian Cropping System Network in 1975 inwhich the program leaders from the collaborating countries and the Institute meet annually and seek the ways inwhich cropping system research towards farmer adoption can be developed. Realizing that cropping system are highly specifics, thus, in order to develop technology for Asia, research has to be done in different environments. Technology developed from each site representing a specific agro-ecological zone will be extrapolated to other areas with similar ecological conditions.

LOWLAND RICE BASED CROPPING SYSTEM

Various countries developed their own cropping pattern based upon researches in their own countries and collaborative research between various member Asian Cropping System Network. In Indramayu district of West Java, Indonesia, the area has four wet months and five dry months with gradual transition from dry to wet and wet to dry. The existing crop was rice which was irrigated. The newly develop cropping system were two crops of lowland rice followed by soybean and two crops of lowland rice followed by cowpea.

In Thailand, apart from the cropping patterns of corn-rice-mungbean and mungbean-rice-mungbean which has been developed to replace the traditional rice monoculture in Central Thailand. In the Northeastern Thailand, the Ministry of Agriculture, Cropping System Project was able to developed the cropping pattern of yard-longbean - rice and rice - peanut. The farmer pattern represent field crop before rice and the latter is the pattern of growing field crop after rice (Pookpakdi, 1980 d). Results obtained in 1977 indicated the possibility of growing field crop before and after rice if the particular crops were planted immediately after the onset of rain in May. This northeastern area inwhich this cropping pattern had been developed is described as strictly rainfed and normally experience late drought period at the end of monsoonal season.

Consequently, the success in establishment of crops after rice depend on the immediate planting to make the full use of soil moisture. The risk in crop failure when grown after rice exist, if rainfall ceased much earlies in September.

In Nepal, although most of the lands are hilly and sloppy, rice based cropping system has been developed to replace the single planting of rice crop. In Pundi Bhundi, rice-winter crop-fallow, rice-rice-fallow and rice-fallow-maize were the pattern recommended to farmers. Nepal national program was successful in introducing varieties Taichung 176 from Taiwan in the system. The use of these varieties and improved technologies bring increases in total yield of the patterns from 39 to 62 percent and increase in rice production from 39.6 to 92.0 percent. (Cropping System-Agronomy Division, 1980).

The Sri Lankan National Program in Agriculture seek the possibility of developping two rice cropping system inwhich the first rice crop benefit their growth from the rainfall distribution. The second crop of rice depend entirely upon the available water from the small reservoir or so called "tank" which are scattered throughout the central portion of the country. Technology was developed to improve to cropping pattern in order to benefit most from the available water, the example was the development of early maturing rice variety called BG 750 or Batalagolar which mature in 75 days. Other components researches are conducted in order to improve the cropping pattern such as planting date and water management.

UPLAND CROPPING SYSTEM

Certain areas in Asia has been devoted to upland crop due to sloppy topographic conditions and upland in nature. However, the practices in cropping systems was still applicable eventhough they are not rice based sequential cropping. In the areas where cassava has been grown, intercropping of cassava with legumes such as mungbean and peanut was practices. (Pookpakdi, 1980 c) Several researches are being conducted in the Northeastern Agricultural University as well as Agricultural Experiment Stations to find out the most suitable management practices when legumes are intercropped with crops such as cassava and kenaf in the absence of irrigation (Chareonwatana, 1980). In South Sumatra island of Indonesia, corn,upland rice, peanut and ricebean were intercropped with cassava at the different stages of cassava growth, the purpose of heavy intercropping is not only to increase the production in newly open area but also to develop as high as possible of leaf area index to shade alang-alang weed (Effendi, 1980).

CONCLUSION

At present, cropping system is needed for the increase in crop production and income particularly for subsistence farmers who has limited amount of inputs and resources. A central proposition for cropping system research is that the productivity of different cultivars which are adjacent in time or space is different from that of the same plants in monoculture (Price, 1976). A scientific research is needed to capture the gain made possible by favorable interactions between adjacent crops.

Researches in multiple cropping are being conducted in different level. At the experiment stations, varieties are being developed, newly technology in crop and soil management are being tested. At a farm level a cropping patterns are tested in the farmer fields and farmers with their resource are one of the component of researches. Physical environments as well as socio-economic constraints of farmers are closely monitors. At the extension levels, procedures are being developed for proper and effective transfer of technology to farmers. Thus, the research in cropping system is entirely a multidisciplinary approaches aim for better well being of the farmers. This papers only presented an agronomic concepts and principles in cropping system, it only regards other socio-economic factors when necessary. The impact, concepts, and application of cropping system for socio-economic aspects can be differently ellaborated.

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