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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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Impact of Cropping Pattern Technology on Income, Employment and Production: A Case Study on Expanded Crop Production in Lampung

by

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IMPACT OF CROPPING PATTERN TECHNOLOGY ON INCOME, EMPLOYMENT AND PRODUCTION: A CASE STUDY ON EXPANDED CROP PRODUCTION IN LAMPUNG[1/]

Rusdian Lubis[2/]

INTRODUCTION

In common with many developing countries, the race between food production and population growth is one of the major problems facing Indonesia. In 1977, the population was estimated at 143 millions (CBS, 1977), and to be increasing at a rate of 2.1 percent per annum. The production of rice - the staple food - increased at 2.3 percent per annum during the period 1974-77.

This food supply problem is aggravated by an imbalance in the distribution of population between Java and the Outer Islands. About 64 percent of the population live on Java, with less than 7 percent of the total land area. The population density of Java is 575 persons/km^2 while that of the Outer Islands is only 22 persons/km^2. This has influenced the government of Indonesia to support the transmigration of farmers to the Outer Islands.

There is a need to develop farming systems for the transmigration areas of these Outer Islands. They should be based on technology which will increase income, provide employment, and stimulate economic development through the production of additional food.

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The World Bank (1974) noted that there were 37 million hectares of land in Indonesia which could be used for food and non-food crops. These areas were dominated by alang-alang grassland and secondary jungle. In Sumatra alone, there are 18 million ha. mainly characterized by red-yellow podzolic soils, with a good potential for food crop production (Suryatna and McIntonsh, 1976). With an average rainfall of 200 mm/month during 6 months, and 50-100 mm/month during the rest of the year, this area can be continuously cropped. Viable yields may be obtained if fertilizer is applied.

Research designed to identify profitable and ecologically sound cropping patterns has been conducted, by the Central Research Institute for Agriculture (CRIA) in cooperation with IRRI, in Lampung Province. Three cropping patterns developed for dry land areas are shown in Figure 1. While these "Introduced Cropping Patterns" (ICPs) are more labor intensive, and use more inputs (fertilizer, pesticides, and lime), than patterns presently followed by farmers (FCP) in Lampung, they produce significantly more food. It is possible that the ICPs can be incorporated into production programs to be adopted by farmers in Lampung. Altenatively, some of the components could be used to improve the farmers' patterns and raise their production above the present level. In the long run, these cropping patternswill have an impact on the allocation of farmers' resources, farm income, production, labor use and employment opportunities.

Research is needed to identify the "optimal cropping pattern", given the available farm level resources and management in order to assess the impact of these cropping systems technologies on resource allocation. Linear programming was selected as a suitable analytical tool for this purpose.

RESEARCH PROBLEM

The objectives of the research were to quantify the levels of resource use, and to identify the factors constraining output. Optimal plans were first derived for combinations of farmers' existing cropping patterns. Subsequently the specification was extended to also include the introduced cropping patterns and new optimal plans were computed. The potential incomes and demand for inputs, under the introduced cropping patterns, were evaluated by sequentially eliminating the contraints to production.

METHODOLOGY

Production Model

Plant growth and yield (Y) are influenced by environment (E) and management (M). The environmental factors may be classified as either physical, including soil, water and solar energy, or non-physical, including institutional and socio-economic factors such as labor availability and the marketing system. Management focuses on attempts to manipulate the environmental factors in order to achieve a particular objective (Beek and Benneme, 1972; Harwood, 1974).

The impact of management and environment on yield may be represented as

$$\bar{Y} = f\ (\bar{M}, \bar{E}) \qquad (1)$$

Evaluation of the relationship needs to focus on the interactions between $\bar{M}$ and $\bar{E}$. Environmental factors will largely influence the management

vector that gives optimum returns (Zandstra, 1976). Consequently, recommendations must be specific to each management and then environmental vector and yield may be represented by:

$$\bar{Y} = f\ (\bar{M}|\bar{E}_i) \qquad (2)$$

To identify the yield associated with the optimal plan applicable to a given management system and production environment, a method of allocating scarce resources is needed. Linear programming is one tool for solving such an allocation problem (Barker, 1977).

The Technique: Linear Programming

Dantzig (1943) developed the simplex method for solving linear programming problems. This has been used widely for optimum allocation of resources in farm planning. The most common objective in farm management planning is maximization of net returns, subject to a set of constraints on the available resources and possible cropping patterns. The objective function, resource constraints and activities can be expressed mathematically as:

Maximize $z = c'x$

Subject to: $Ax \lesseqgtr b$

and the restrictions $x \geqslant o$

Where:

c is the vector of unit net returns for the cropping activities;

x is the vector of activities

A is the matrix of input output coefficients; and

b is the vector of constraint levels (RHS).

DESCRIPTION OF STUDY AREA AND SOURCE OF DATA

General Information

Central Lampung, the transmigration area selected for this case study, was first settled in 1954. Various surveys and field experiments have been conducted there by Bogor Agricultural University, CRIA-IRRI and other institutions.

The well-developed transportation network has facilitated regional development. The main road in Lampung passes through the area and connects the two main port cities in South Sumatra, Tanjungkarang and Palembang. The irrigation network, drawing water from the Way Seputih and Way Abung Rivers, is adequate for production of rice and upland crops.

Population, Climate and Soil

The population of Central Lampung was reported as 1.2 million in the 1974 census. The population growth rate, 6.6 percent/annum, is higher than the national rate due to the transmigration of people from Java and Bali. Population density is 474 persons/km^2.

Rainfall averages 1874 mm/annum with July the driest month and December the wettest. The mean daily temperature ranges from a maximum of 27.5°C to a minimum of 22.2°C.

Red-yellow podzolic soils predominate and the topography ranges from rolling plains to hilly. Most of the area is covered with alang-alang grass and shrubs. The soil is relatively low in nutrient content, has a low pH and is susceptible to erosion.

Farming System and Area of Study Sampled

The data for the study were drawn from a baseline survey, farm record keeping, and a supplemental survey. The baseline survey was conducted by CRIA, during August and September, 1975, to obtain information for planning cropping pattern research. The area was categorized by length of settlement, water-irrigation system and agronomic conditions. In Category I, land has been opened for more than 10 years and is irrigated for six months/year. Farmers grow lowland rice and upland crops. In Category II, land has been opened between 5 and 10 years, but is not irrigated. Rainfed rice and upland farming predominate. Category III is a newly opened area without irrigation. Farmers grow predominantly upland crops. Detailed descriptive information is presented in Tables 1-4. This includes farm size, household size, level of technology and crop, costs and returns.

The existing pattern of agriculture is subsistence oriented. Little fertilizer is applied and both cash costs and yields are low. The return from the crops is less than the total expenditure of the household. Labor demand is concentrated in a few peak periods during the year since the systems are essentially monoculture. Total caloric output is less than yearly family requirements.

The characteristics of the ICPs, as grown by CRIA in the experimental plots, are presented in Table 5. The ICPs use much higher levels of inputs, require higher cash costs, and generate greater net returns. For the purpose of the simulations the farmers were assumed to reduce

the levels of inputs used to 75 percent of the levels employed in the experimental ICPs, since they would be unlikely to be able to afford, or willing to use, such high input levels.

The data in Tables 1-5 were used to define the basic input-output matrix used in the LP simulation.

Farm recording data collected by CRIA during 1975-1977 were used to supplement the baseline survey data with more accurate social-economic information. In addition, a supplemental survey was conducted by the author from December 1977 to February 1978.

THE STRUCTURE OF THE BASIC TABLEAUX

Three basic tables were constructed, based on the three categories in the study area. Each of these comprised:

1) A vector of resources available (RHS) for lowland, upland, hired labor, family labor, animal power and fertilizer.
2) Vectors of input-output coefficient for the various activities, including crops, labor hiring, animal power hiring, marketing and man-animal labor substitions; and
3) A vector of net returns for the activities.

A schematic representation of the tableaux is shown in Figure 6.

The Simulation

Optimal solutions were obtained for each of the three base situations and compared to the current farming system. Sentivity analyses were conducted on the basis of information from the study area to determine the impact of relaxing selected constraints, of price

changes, of machine availability and of increased wages. Further runs were implemented to evaluate the impact of the ICPs.

RESULTS AND DISCUSSION

Optimal Cropping Patterns for Category I

The optimal cropping patterns for Category I are shown in Table 7. Given the farmers' existing resources, the optimal pattern (column 2) is a combination of LLR (19%) and LLR-LLR (57%) in the lowland and ULR+Cv (19%) in the upland. This pattern is quite similar to the farmers' existing cropping pattern (column 1). The solution is only marginally changed by relaxing the fertilizer and power constraints (column 3), or if the ICP is introduced into the model with existing resource constraints (column 4). If the fertilizer and power constraints are relaxed (column 5), the ICP with C+ULR+Cv+Pt+(C-Rb) will enter the program and will dominate the dry-land area. Increases in price (column #6), machine use (Column 7) and labor wage (column 8) do not affect the cropping pattern. Cropping pattern returns in Category I are less than expenditures (Table 10), suggesting the need for improved technology.

Optimal Cropping Patterns for Category II

The optimal cropping patterns under farmers' existing resources (column 2) a combination of ULR+Cv (20%), ULR (23%), LLR (5%) and ULR+C-C (52%) is indicated. The pattern is slightly different from the farmers' pattern (column 1) although ULR+C-C is the major component. This pattern looks very promising, even if developed solely for upland.

Relaxing the fertilizer and power constraints (column 3) generates a system dominated by ULR+C-C in the upland and LLR in the lowland. If the ICPs are included (column 4), the optimal cropping pattern for the lowland is the pattern with farmers' resources, but the upland areas are dominated by ULR+C-C and the ICP pattern C+Sb-C+SP-Cp. In Category II, the introduction of machinery for land preparation (column 7), and increasing labor wage (column 8), does not affect the cropping pattern. Yet an increase in the price of outputs (column 6) results in the introduction of cassava (C+ULR+CvI+(Pt+CvII)).

Optimal Cropping Patterns for Category III

The optimal cropping patterns for Category III are shown in Table 9. Given the farmers' levels of resources (column 2), the results are very different from the existing farmers' pattern (column 1). The pattern changes drastically from a single crop, for example LLR, Cv, ULR and C, to a double crop, LLR-LLR, ULR+Cv and ULR+Cv-C. This pattern (column 2) is stable for Category III, land. With existing farmers' resources (column 4), only 10 percent of the area is planted to the ICP pattern C+Sb+C+Sb-b-Cp, when these are introduced.

A cropping pattern combination dominated by the ICP is selected when constraints on resource availabilities are relaxed (column 5).

Impact of Cropping Pattern on Net Return

In table 10, column 2, it can be seen that, with the exception of Category III, the net return from the optimal plan associated with the farmers' level of resources is less than the cost of the resources.

Farmers' returns can be increased by making more resources available and/or by introducing the ICP (columns 3, 4, and 5). The greatest increase in returns is for Category III which is exclusively upland.

Arc elasticities were estimated to determine the impacts of increasing farm prices of rice, corn and cassava by 60 percent, making a 5 Hp power tiller available, and increasing labor wage and animal hiring service by 66 percent. The arc elasticities are reported in Table 10.

Impact of Cropping Pattern on Employment

The impact of cropping pattern changes on employment can be divided into the impacts on total labor use (working day/ha/year), labor distribution (working day/month/year) and labor scarcity (reflected by the shadow price of labor).

Impact on total labor use. From table 11 total labor use with (column 2) and without (column 3) constraints is quite similar. With the introduction of ICP's (columns 4-9), total labor use increases tremendously for all categories.

The price, power tiller and labor wage variables do not greatly affect total labor use in the simulation. From table 11, a 1 percent increase in the price of rice, corn and cassava decreases total labor use by 0.12 percent in Category I and increases total labor use by 0.08 percent in Category II. Introduction of power tillers for land preparation decreases demand for labor by 0.05 percent in Categories I and III and increases it by 0.07 percent in Category II. An increase in labor

wage decreases labor use by 0.20 percent in Category I, by 0.03 percent in Category III and labor use in Category II by 0.03 percent.

Labor Distribution

In Figure 2, 4 and 6, labor use for the farmers' patterns is shown to be concentrated in the wet months of September through February. The land is fallow for almost 6 months and labor use is less than 10 working days/month. Labor distribution is improved with the introduction of the ICPs in the dry months (Figs. 3, 5 and 7).

Labor Scarcity

The biggest problem in developing an ICP was labor scarcity during the critical months of October through January, the land preparation period, and June through August, the harvest period.

Figures 2-7 suggest a scarcity of labor in Category II and Category III. These are relatively newly opened areas and there are few landless laborers available. Almost 90 percent of family labor is used on their own land. The shadow prices for labor are presented in Tables 12-14 for those months where at least one non-zero value was observed.

The optimal plan for Category I under existing cropping patterns, is constrained by availability of male labor in October, with a shadow price of Rp300 per day. For the other simulations labor was constraining in October through December, when it had a shadow price of Rp200-300 per day. However, when compared to the labor wage for man (Rp 300) and for woman (Rp 200), employing more labor input in these months would not be profitable.

In Categories II and III, labor shortages occurred in October and November with the peak demand for labor for cultivating. The shadow price of labor is Rp 300 to Rp 1,700 per day. This would be worsened if farmers were to combine their cropping patterns with the ICPs. In addition to a shortage of labor for cultivating the lowland, (September - December) a labor scarcity would also occur between June - August when labor is needed for cultivating prior to the second and third crops.

For all Categories of land, availability of animal power constrains the solutions. The shadow prices of animal power are generally in excess of the Rp 1000 per day hiring cost. Combined with the possibilities for substituting animal for human power during critical months, this suggests considerable potential for expanding the stock of draft animals.

Impact of Cropping Pattern on Resource Use

Impact of Fertilizer use

Adoption of the ICPs may have a tremendous impact on fertilizer use. Table 15 shows the fertilizer requirements when the ICPs are permitted without constraints of fertilizer and animal power (Columns 5-8) as compared to the fertilizer requirements when inputs and constrained (Columns 2-4). In Category I, where improved technology is used in the lowland, the fertilizer requirements doubles. Fertilizer requirement for Categories II and III are almost 5 and 30 times as great, respectively.

Increasing farm product prices tends to result in a decrease in fertilizer use due to increase in the area under cassava. Cassava is very responsive to price changes, but less responsive to fertilizer. The elasticities of fertilizer use with respect to farm product prices are -0.05 (Category I), -0.26 (Category II) and -0.22 (Category III).

Impact on Land Resource Use

The shadow prices, presented on Table 15, suggest that land is not a major constraint in the study area. This is largely due to the shortage of labor for land cultivation. For Category II and III areas, the government provided 2 ha., but only 50-75 percent could be cultivated. Relaxing the power constraint in combination with introducing the ICPs (column 5) will result in considerable intensification of land use. Large increases in the shadow price of land are observed. The cropping patterns in Category I and II seems more profitable than the cropping patterns in Category III because the existing level of technology in Category III is very low, compared to the other categories.

Impact on Production and Calories

The Total Production Ratio (TPR) is used to compare the total production with the total output of the farmers' existing cropping pattern. The calorific value of the output from the optimal plan is compared with the FAO recommended, minimum calorie requirement - 3900 kcal/annum for a family with 6 members - to determine the energy adequacy of the plan.

Total production, TPR and total calories are presented in Table 16. Total production for the optimal farmers' pattern is not very different from the existing farmers' pattern. However, when the constraints are relaxed and ICPs permitted (column 5), the TPR and calorie yield are increased by approximately 50%.

Table 18 also shows that the introduction of more diversified cropping patterns, such as those including soybeans in the ICP, will greatly increase the total calorific value of the output.

For Categories II and III, the optimum pattern with the ICPs and relaxation of the constraints will result in TPRs of 300 to 500 significantly improved calorific output (Table 15).

Power tiller introduction does not seem to have a significant impact on total production and calories yielded (Table 15). An increase of 1 percent in labor wage will decrease the total production by 0.10 percent (Category II) 0.05 percent (Category III) and increase it by 0.15 percent in Category I.

CONCLUSION

In summary, the introduced cropping patterns (ICPs) will improve farmer returns, employment and production. However, the ICPs also increase the demand for labor and require a very large increase in use of inputs (fertilizer, pesticides, etc.). Establishing guaranteed supply of these inputs will be a prerequisite for widespread adoption of the ICPs in Central Lampung.

From the simulation, Category III appears to be the best area for promoting existing ICPs, while in the two other areas,rescarch should be directed towards developing more appropriate technologies.

Although power tillers do not have a significant direct impact on production, income and employment, they appear to be needed to break seasonal labor bottlenecks, particularly during land preparation.

Government marketing and pricing policy seem to be potentially major factors in increasing income and stimulating production. In contrast, increasing labor wage does not significantly affect the requirement for labor.

This case study can not provide a comprehensive solution to the development problems of the area. Conditions in the area are extremely variable and more comprehensive studies are required to clarify many of the issues raised.

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Table 1. Socio-economic characteristics of the sample farm households, Lampung, 1977.

Parameter	Category I (old, irrigated rice + upland)	Category II (old, rainfed rice + upland)	Category III (new, upland only)
		Average	
Farm size (ha)	1.4	2.1	2.21
lowland	1.2	0.1	0.21
upland	0.2	2.0	2.0
Family size	7	6	7
Expenditures/year (Rp 1000)	292	230	120
Labor used (MD/ha/yr)	166	287	260

Source: CRIA Baseline Survey, 1976

Table 2. Characteristics of the cropping patterns grown by farmers in category 1, Lampung, Indonesia, 1975.

Pattern[a]	LLR	LLR - LLR	CV	ULR + CV	LLR - C
Percent of farmers	30	27	22	14	4
Farm size (ha)	1.46	1.41/1.32	0.68	0.57	1.0
Fertilizer used (kg/ha/yr)	162	207	0	0	208
Labor used (MD/ha/yr)	188	187	202	266	708
Production costs[b] (Rp 1000)	8	10	1	0.6	0.7
Returns over production costs (Rp 1000)	62	57	42	151	97
Yield (+/ha/yr)	2	3	10.5	1.3/10.5	1.5/1.1
Calorie equivalent (100 kcal/ha/yr)	42	60	111	137	42
Caloric surplus[c]	3	21	72	97	3
Total production ratio[d]	90	125	130	165	77

a/ LLR = lowland rice, CV = cassava, ULR =upland rice, C = corn, + = intercropped, - = followed by

b/ All inputs except fertilizer and labor

c/ Difference between minimum yearly requirement for a family of six persons and amount produced.

d/ $\sum_{i=1}^{m} hi/Hi \times 100\%$

where: h_i = multiple cropping yield (kg/ha/yr) of crop i.

H_i = monoculture yield (kg/ha/yr) of crop i.

Table 3. Characteristics of the cropping pattern grown by farmers in Category II, Lampung, Indonesia, 1975.

Pattern[a]	ULR + CV	CV	LLR	ULR+C-C	ULP+C-C	ULR
Percent of farmers	30	23	10	10	10	17
Farm size (ha)	0.76	0.6	0.8	0.94	1/1	1.21
Fertilizer used (kg/ha/yr)	-	-	88	-	180	-
Labor used (WD/ha/yr)	396	361	178	373	214	148
Production[b] costs (Rp 1000)	4	3	5	5	5	3
Returns over production[b] costs (Rp 1000)	37	16	84	27	111	15
Yield (+/ha/yr)	0.5/4	4	2.2	0.7/0.2	1.2/1	2.2
Caloric equivalent (100 kcal/ha/yr)	54	42	74	20	63	74
Caloric surplus	15	3	35	-19	24	35
Total production ratio[d]	66	42	97	45	144	97

a/ - d/: Footnotes as Table 2.

Table 4. Characteristics of the cropping patterns grown by farmers in category III, Lampung, Indonesia, 1975.

Pattern[a]	ULR + CR	CV	LLR - LLR	ULR	LLR	ULR + CV - C
Percent of farmers	32	23	14	10	10	10
Farm size (ha)	0.95	0.7	0.7	0.7	0.6	0.7 /0.7
Fertilizer used (kg/ha/yr)	5	-	65	2	53	-
Labor used (MD/ha/yr)	208	214	473	211	199	126
Production costs[b] (Rp 1000)	2	3	15	6	7	7
Returns over production costs[b] (Rp 1000)	69	30	100	20	14	117
Yield (t/ha/yr)	0.6/7	4	3	1	0.6	1.3/4.1
Calorie equivalent (100 kcal/ha/yr)	88	41	63	21	11	61
Calorie surplus[c]	49	2	24	-18	-28	22
Total production ratio[d]	100	41	136	46	25	145

a/ - d/: Footnotes as Table 2.

Table 5. Characteristics of the introduced cropping pattern (ICP), Lampung, Indonesia, 1976.

Pattern[a]	C+ULR+CV+ (Pt-RB)[f]	C+ULR+CVI +(Pt+CVII)[f]	C+Sb-C +Sp-Cp[f]	C+ULR+CV +(Pt-Rb)	C+ULR+CVI +(Pt+CVII)	C+Sb-C +Sp-Cp
Farm size (ha)	1.0	1.0	1.0	1.0	1.0	1.0
Fertilizer used (kg/ha/yr)	636	636	543	848	848	734
Labor used (MD/ha/yr)	614	530	484	819	707	645
Production costs[b] (Rp 1000)	69	72	109	92	95	144
Returns over production costs (Rp 1000)	388	302	487	518	403	649
Yield (t/ha/yr)	1.4/.6/12/ .7/.4	1/.7/20[e] /.3	.g[e]/.6/ 12/.5	1.8/.7/16 1/.5	1.3/.9/27[e] /.4	1.1[e]/.8 16/.7
Calorie equivalent (100 kcal/ha/yr)	238	273	226	318	365	302
Calorie surplus[c]	199	234	187	279	321	263
Total production ratio[d]	453	373	540	604	497	720

a/ ULR = Upland rice, LLR = lowland rice, CV = cassava, C = corn, Pt = peanuts, Sp = sweet potato, Cp cowpeas, Rb = ricebeans, Sb = Soybeans, + = introduced, - = followed by.

b/ - d/: Footnotes as Table 2.

e/ Total production

f/ Synthetic cropping pattern: ICP with 75% resource availability.

Table 6. Basic Tableau for Linear Programming Simulation.

Activity number	Cropping pattern N[a]		Hiring Man-labor 12		Hiring woman-labor 12		Hiring animal power 8		Hiring power til. 8[b]		Transfer man-animal 8[b]		Selling product 8	Buying fertili-zer 1	RHS
Code	LLR	ULR	Janman	Desman	Janwom	Deswom	Janapo	Desapo	Jantil	Destil	Jantra	Destra	Rice	Buyfer	
Costs (Rp)	-PC		-300		-250		-1000		-1500		0		+P	-70	Z[c]
Constraint															
Land															
Lowland	1														
Upland		1													
Labor															
Janman			-1												
Janwom				-1											
Desapo								-1							
Labor Hire avail.															
Totman			1												
Totwom				1											
Fertilizer														-1	
Product													1		

[a]According to category.

[b]According to simulation.

[c]According to simulation and category.

Table 7. Optimal cropping pattern results of simulation for category I.

Cropping pattern simulation[a]/ constraints relaxed	(1) FCP[b]	(2) Optimal FCP Existing resources		(3) FCP fertilizer, anim. power		(4) FCP+ICP Existing resources		(5) FCP+ICP fertilizer, anim. power		(6) FCP+ICP fertilizer, anim. power higher output prices		(7) FCP+ICP fertilizer, power tiller		(8) FCP+ICP Fertilizer, anim. power higher wages	
Size	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
LLR	27	.20	14	.34	28	.20	14	.26	19	.34	25	.34	24	.34	24
LLR - LLR	30	.80	57	.80	57	.80	57	.80	57	.80	57	.80	57	.80	57
ULR + CV	--	.20	17	.20	15	.20	17								
LLR - C	4							.14	9	.05	3	.05	3	.05	3
ULR + C	14														
CV	12														
C + ULR ≠ CV ≠ (Pt-Rb)								.20	15	.20	15	.20	15	.10	8
C + Sb - C + Sp - Cp														.10	8
Other	3														

[a]LLR = lowland rice
ULR = upland rice
CV = cassava
C = corn
Pt = peanuts
Rb = ricebeans
Sb = soybeans
Sp = sweet potato
+ = intercropped
- = following

[b]FCP = farmer's cropping pattern
ICP = introduced cropping pattern

Table 8. Optimal cropping pattern results of simulation for category II.

Cropping pattern simulation[a] Constraints relaxed	(1) FCP[b]	(2) Optimal FCP Existing resources		(3) FCP, fertilizer, animal power		(4) FCP + ICP Existing resources		(5) FCP + ICP Fertilizer, anim. power		(6) FCP + ICP Fert., anim. power, higher output prices		(7) FCP + ICP Fertilizer, power tiller		(8) FCP + ICP Fert., anim. power, higher wages	
Size	%	Ha	%	Ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
ULR + CV		41	20			.42	20								
CV	27														
ULR	18	.49	23			.53	25	.18	9	.72	32	.18	9	.35	17
LLR	10	.10	5	10	5	.10	5	.10	5	.10	5	.10	5	.10	5
C	10														
ULR + C - C	35	1.10	52	2.00	95	.25	12								
C + Sb - C + Sp - Cp[c]								1.24	59	.16	7	1.24	59	.95	44
(C+ULR+CV) ≠ (Pt - Rb)								.38	18	.52	25	.38	18	47	23
C + ULT + CVI ≠ Pt + CVII										.33	16				
C + Sb - C + Sp - Cp						.20	10	.20	9	.27	15	.20	9	.23	11
Other	10														

[a]ULR = upland rice
CV = cassava
LLR = lowland
C = corn
Sb = soybeans
Sp = sweet potato
Cp = cowpeas
Pt = peanuts
Rb = ricebeans

[b]FCP = farmer's cropping pattern
ICP = introduced cropping pattern

[c]Synthetic cropping pattern

Table 9. Optimal cropping pattern results of simulation for category III

Cropping pattern simulation[a]/ constraints relaxed	(1) FCP[b]	(2) Optimal FCP existing resources		(3) FCP fertilizer, animal power		(4) FCP + ICP Existing resources		(5) FCP + ICP fertilizer, anim. power		(6) FCP + ICP fertilizer, anim. power, higher output prices		(7) FCP + ICP fertilizer, power tiller		(8) FCP + ICP fertilizer, anim. power higher wages	
Size	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
LLR - LLR	14	.14	6	.14	6	.16	7			.24	11			.09	4
ULT + CV		1.25	56	1.25	56	1.02	46			.08	4			.56	7
ULR + CV - C		.75	33	.75	33	.75	33	.46	21	.75	33	.46	20		
LLR	10							.24	10			.24	11		
LLR - C	32														
CV	23														
ULR	12														
C	7														
C + Sb - C + Sp - Cp[c]								.97	43	.30	13	.97	43	.89	40
C + ULR ≠ CV ≠ Pt - Rb[c]										.38	18				
C + ULR ≠ CV ≠ Pt - Rb[c]								.37	17	.27	12	.37	17	.33	15
C + Sb - C + Sp - Cp						.23	10	.20	9	.21	9	.20	9	.22	9
Other	8														

[a]LLR = lowland rice
ULR = upland rice
CV = cassava
C = corn
Sb = soybeans
Sp = sweet potato
Cp = cowpeas
Pt = peanuts
Rb = ricebeans

[b]FCP = farmer's cropping pattern
ICP = improved cropping pattern

[c]Synthetic cropping pattern

Table 10. Impact of cropping pattern on total net return.

Cropping pattern simulation/constrainst relaxed	Optimal FCP Existing resources	FCP fertilizer, animal power	FCP+ICP existing resources	FCP + ICP fertilizer, animal power	FCP + ICP fertilizer, anim. power higher output prices	FCP + ICP fertilizer, power tiller	FCP + ICP fertilizer, animal power, higher wages
Category I	2	3	4	5	6	7	8
Total Net Return (TRN)[a]	247	275	247	305	520	332	330
Arc Elasticity (e)[b]					(1.1)	(.04)	(.15)
TNR/Expenditure (%)[c] Rp 294,000	84	93	84	104	177	133	112
TNR/optimum (%) farmers' pattern	100	111	100	123	210	134	134
Category II							
Total Net Return (TNR)[a]	204	267	215	690	891	713	608
Arc Elasticity (e)[b]					(.6)	(.02)	(-.25)
TNR/Expenditure (%)[c] Rp 231,000	88	115	93	298	386	308	263
TNR/optimum (%) farmers' pattern	100	130	105	338	437	349	298
Category III							
Total Net Return (TNR)[a]	288	288	399	636	839	655	572
Arc Elasticity (e)[b]					(.6)	(.01)	(-.21)
TNR/Expenditure (%)[c]	239	239	331	528	696	543	375
TNR/optimum (%) farmers' pattern	100	1^0	138	221	291	227	198

[a]In Rp. 1,000 /year

$$b_e = \frac{Y_2 - Y_1}{X_2 - X_1} \cdot \frac{X_2 + X_1}{Y_2 + Y_1}$$

e = arc elasticity
Y = income
X = price, power, labor wage

[c]Total net return as a percent of farmers' total expenditures

Table 11. Impact of cropping pattern on employment, Lampung, Indonesia, 1977.

Cropping pattern simulation/ constraints relaxed	Optimal FCP Existing resources	FCP fertilizer, anim. power	FCP + ICP Existing resources	FCP + ICP fertilizer, anim. power	FCP + ICP fertilizer, anim. power higher output prices	FCP + ICP fertilizer, power tiller	FCP + ICP fertilizer, anim. power, higher wages
Category I	2	3	4	5	6	7	8
Total labor use (MD/ha/yr)	216	231	216	328	309	296	303
	(100)	(106)	(100)	(151)	(141)	(137)	(135)
Arc elasticity (e)[a]					(-.12)	(-.05)	(-.20)
Family labor	204	219	204	315	298	285	281
Hired labor	-	1	1	5	-	-	11
Animal power	12	11	11	8	11	11	11
Tiller	-	-	-	-	-	.3	-
Category II							
Total labor use (MD/ha/yr)	224	190	300	378	401	436	384
	(100)	(84)	(133)	(168)	(174)	(172)	(171)
Arc elasticity (e)[a]					(.08)	(.07)	(.03)
Family labor	190	172	276	281	301	361	292
Hired labor	27	11	12	54	54	54	54
Animal power	7	7	12	43	46	-	38
Tiller	-	-	-	-	-	21	-
Category III							
Total labor use (MD/ha/yr)	171	185	260	351	350	328	357
	(100)	(108)	(152)	(205)	(205)	(191)	(208)
Arc elasticity (e)[a]					(0)	(-.05)	(-.03)
Family labor	158	163	212	279	278	272	285
Hired labor	5	13	38	38	38	38	38
Animal power	7	9	10	34	34	-	34
Tiller	-	-	-	-	-	18	-

$$\frac{Y_2 - Y_1}{X_2 - X_1}, \quad \frac{X_2 + X_1}{Y_2 + Y_1}$$

e = arc elasticity
X = labor requirement; Y = price, power, labor wage

Table 12. Shadow prices ('000 Rp/day) for labor and animal power for areas in Category I

Month	Type of activity	Optimal FCP existing resources	FCP fertilizer, animal power	FCP + ICP existing resources	FCP + ICP fertilizer animal power	FCP + ICP fertilizer, anim.power, higher output prices	FCP + ICP fertilizer, power tiller	FCP + ICP fertilizer, anim. power higher wages
	Col. no. 1	2	3	4	5	6	7	8
June	Male labor	0	0	0	0	0	0.3	0
June	Animal power	4	12	4	12	20	0	1.4
Aug.	Female labor	0	0	0	0	0	0.06	0
Sept.	Male labor	0	0	0	0.2	0.2	0	0
Oct.	Animal power	0	0	0	0	0	0.15	0
Nov.	Male labor	0	0.3	0	0	0.2	0	0.3
Nov.	Animal power	0	0	0	0	0.4	1	1.8

Table 13. Shadow prices (,000 Rp/day) for labor and animal power for areas in Category II.

Month	Type of activity	Optimal FCP existing resources	FCP fertilizer animal power	FCP + ICP existing resources	FCP + ICP fertilizer, animal power	FCP + ICP fertilizer, animal power higher output prices	FCP + ICP fertilizer, power tiller	FCP + ICP fertilizer, animal power higher wages
	Col. no.	2	3	4	5	6	7	8
Jan.	Male labor	0	0.1	0.1	0.2	0.2	0.2	0.3
Jan.	Animal power	0	0	0.6	0	0	0	0
Feb.	Male labor	0	0	0	0.2	0.1	0.2	0.3
March	Male labor	0	0.3	0	0	0.5	0	0
April	Male labor	0	0.2	0.2	0.2	0.2	0.2	0.3
May	Male labor	0	0	0	0	0	2	1.2
June	Male labor	0	0	0	0.2	0	0.2	0.3
June	Female labor	0	0	0	0.7	0	0.7	0.6
June	Animal power	0	0	0	1	0	0	0
July	Male labor	0	0	0	0.7	1.6	1	1.2
July	Female labor	0	0	0	1.7	1	0.7	0.7
Aug.	Male labor	0	0	0	0.7	1.6	2	1.2
Aug.	Female labor	0	0	0	1.7	1	0.7	0.7
Sept.	Male labor	0	0	0.2	0.7	0.2	0.2	0.3
Sept.	Female labor	0	0	0	0	1	0.7	0.6
Sept.	Animal power	0	0.2	1.5	0	0	0	0
Oct.	Male labor	0.3	0.3	0.3	0.2	0.2	0	0
Oct.	Animal power	1.7	0	1.5	0	0	0	0
Nov.	Male labor	0.3	0	0.2	0	0.2	0	0
Nov.	Female labor	1.7	0.2	0	0	0	0	0
Nov.	Animal power	0	0	1.3	0.2	0	0	0
Dec.	Male labor	0	0	0	0	0.2	0.2	0.3

Table 14. Shadow prices ('000 Rp/day) for labor and animal power for areas in Category III.

Month	Type of activity	Optimal FCP existing resources	FCP fertilizer animal power	FCP + ICP existing resources	FCP + ICP fertilizer, animal power	FCP + ICP fertilizer, animal power higher output prices	FCP + ICP fertilizer, power tiller	FCP + ICP fertilizer. animal power higher wages
	Col. no.	2	3	4	5	6	7	8
Jan.	Male labor	0	0	0	0.2	6.2	0.1	0.3
Feb.	Male labor	0	0	0	0.2	0.2	0.1	0.3
Apr.	Male labor	0	0	0	0.2	0.2	0	0.3
Apr.	Female labor	0	0	0	0	0	0.1	0
May	Male labor	0	0	0	2	2.4	0.2	1.6
June	Male labor	0	0	0	0.2	0.2	0.1	0.3
June	Female labor	0	0	0	0.7	0	0.7	0.7
June	Animal power	23	24	20	0	22	0	0
July	Male labor	0	0	0	0.9	1	0.8	1
July	Female labor	0	0	0.3	0.7	0.9	0.7	0.7
Aug.	Male labor	0	0	0	2	3	2	1.6
Aug.	Female labor	0	0	0.3	0.7	0.9	0.7	0.7
Sept.	Male labor	0	0.2	0.3	0.2	0.2	0.1	0.3
Sept.	Female labor	0	0	0	0.7	0.9	0.7	0.7
Sept.	Animal power	0	0	1.5	0	0	0	0
Oct.	Male labor	0.3	0.2	0.3	0	0.2	0	0.1
Oct.	Animal power	1.5	0	1.5	0	0.2	0	0
Nov.	Male labor	0	0.2	0	0	0	0	0
Nov.	Animal power	0	0	0	0	0.2	0	0
Dec.	Male labor	0	0	0.3	0.2	0	0	0.3
Dec.	Animal power	18	17	13	19	1	0.2	11

Table 15. Impact of cropping pattern on resource use, Lampung, Indonesia, 1977.

Cropping pattern simulation/ constraints relaxed	Optimal FCP Existing resources	FCP fertilizer, anim. power	FCP + ICP Existing resources	FCP + ICP fertilizer, anim. power	FCP + ICP fertilizer, anim. power higher output prices	FCP + ICP fertilizer, power tiller	FCP + ICP fertilizer, anim. power, higher wages
Category I	2	3	4	5	6	7	8
Total fert. use (kg/ha/yr)	167	169	167	298	291	290	282
	(100)	(100)	(100)	(178)	(176)	(175)	(169)
Arc elasticity (e)[a]					(-.05)	(-.01)	(-.11)
Shadow price (Rp 1000)	.9	0	.9	0	0	0	0
Land use (ha)	1.2	1.4	1.2	1.4	1.4	1.4	1.4
Shadow price (Rp 1000)	0	144	0	243	243	136	127
Upland (ha)	.2	.2	.2	.2	.2	.2	.2
Shadow price (Rp 1000)	185	185	185	381	663	527	529
Category II							
Total fert. use (kg/ha/yr)	100	172	134	544	481	544	516
	(100)	(172)	(134)	(544)	(481)	(544)	(516)
Arc elasticity (e)[a]					(-.26)	(0)	(-.10)
Shadow price (Rp 1000)	.6	0	.7	0	0	0	0
Land use (ha)	2.1	2.1	1.5	2.1	2.1	2.1	2.1
Shadow price (Rp 1000)	142	167	143	153	262	158	141
Upland (ha)	2.0	2.0	1.4	2.0	2.0	2.0	2.0
Shadow price (Rp 1000)	13	106	0	146	252	152	131
Category III							
Total fert. use (kg/ha/yr)	14	14	92	450	406	450	426
	(100)	(100)	(657)	(3210)	(2909)	(3210)	(3048)
Arc elasticity (e)[a]	-	-	-	-	(-.22)	(0)	(-.11)
Shadow price (Rp 1000)	0	0	.5	0	0	0	0
Land use (ha)	2.14	2.14	2.17	2.24	2.24	2.24	2.24
Shadow price (Rp 1000)	0	0	0	17	66	21	4
Upland (ha)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Shadow price (Rp 1000)	74	67	64	113	107	114	111

$$e = \frac{Y_2 - Y_1}{X_2 - X_1} \cdot \frac{X_2 + X_1}{Y_2 + Y_1}$$

e = arc elasticity
X = fertilizer use
Y = price, power, labor wage

Table 16. Impact of cropping pattern on production (100 kg/ha/yr), Lampung, Indonesia, 1977.

Activity	Optimal FCP existing resources	FCP fertilizer, animal power	FCP+ICP existing resources	FCP + ICP fertilizer, anim. power	FCP + ICP fertilizer, anim. power higher output prices	FCP + ICP fertilizer, power tiller	FCP + ICP fertilizer, anim. power higher wages
Col. no	2	3	4	5	6	7	8
Category I							
Rice	25	24	25	23	23 (0)[a]	23	23.6
Corn	-	.4	-	3.8	3.1 (-.43)	3	1.8
Cassava	17	15	17	-	23.8 (4.3)	22.6	11.9
Peanut	-	-	-	1.4	1.4	1.4	.7
Rice bean	-	-	-	.7	.7	.7	.4
Sweet potato	-	-	-	-	-	1.2	11.8
Cowpea	-	-	-	-	-	-	.5
Cal. equi. (100 kcal/ha/yr)	68	66	68	92	92	91	90
Cal. surplus	29	27	29	53	53	52	50
Total prod. ratio (TPR)	126	123	126	174	194	190 (.04)	188 (.15)
Category II							
Rice	9.7	13.3	8.3	5.5	13.6 (1.8)	5.5	7.9
Corn	5.6	10.2	1.8	8.9	7.4 (-.4)	8.9	8.4
Cassava	-	-	11.9	30	87.4 (2.1)	30	37.5
Peanut	-	-	-	1.8	3.1	1.8	2.2
Rice bean	-	-	-	1	1.3	1	1.2
Sweet potato	-	-	22.7	88.6	30.7	88.6	73.4
Cowpea	-	-	1.1	4.3	1.5	4.3	3.5
Soybean	-	-	1	3.9	.4	3.9	3.2
Cal. equi. (100 kg cal/ha/yr)	48	62	71	224	209	224	216
Cal. surplus	9	23	32	185	170	185	177
Total prod. ratio (TRP)	96	142	139	474	388	474 (0)	450 (-.1)

Table 16 (cont.)

Col. no.	2	3	4	5	6	7	8
Category III							
Rice	10	10	10.8	5.6	11.5 (1.6)[a]	5.6	7
Corn	3.7	3.7	3.7	9.3	9.4 (0)	9.3	9
Cassava	56	56	47.6	27.6	70.6 (1.9)	27.6	24.8
Peanut	-	-	-	1.7	2	1.7	1.5
Rice bean	-	-	-	1	.7	1	.8
Sweet potato	-	-	-	67.9	31.8	67.9	65
Cowpea	-	-	1.0	3.3	1.5	3.3	3
Soybean	-	-	-	-	1.4	3	2.8
Cal. equi. (100 kg cal/ha/yr)	92	92	88	190	191	190	184
Cal. surplus	51	51	49	151	152	151	145
Total prod. ratio (TRP)	132	132	148	406	356	406 (0)	395 (-.05)

[a] Values in parentheses are arc elasticities.

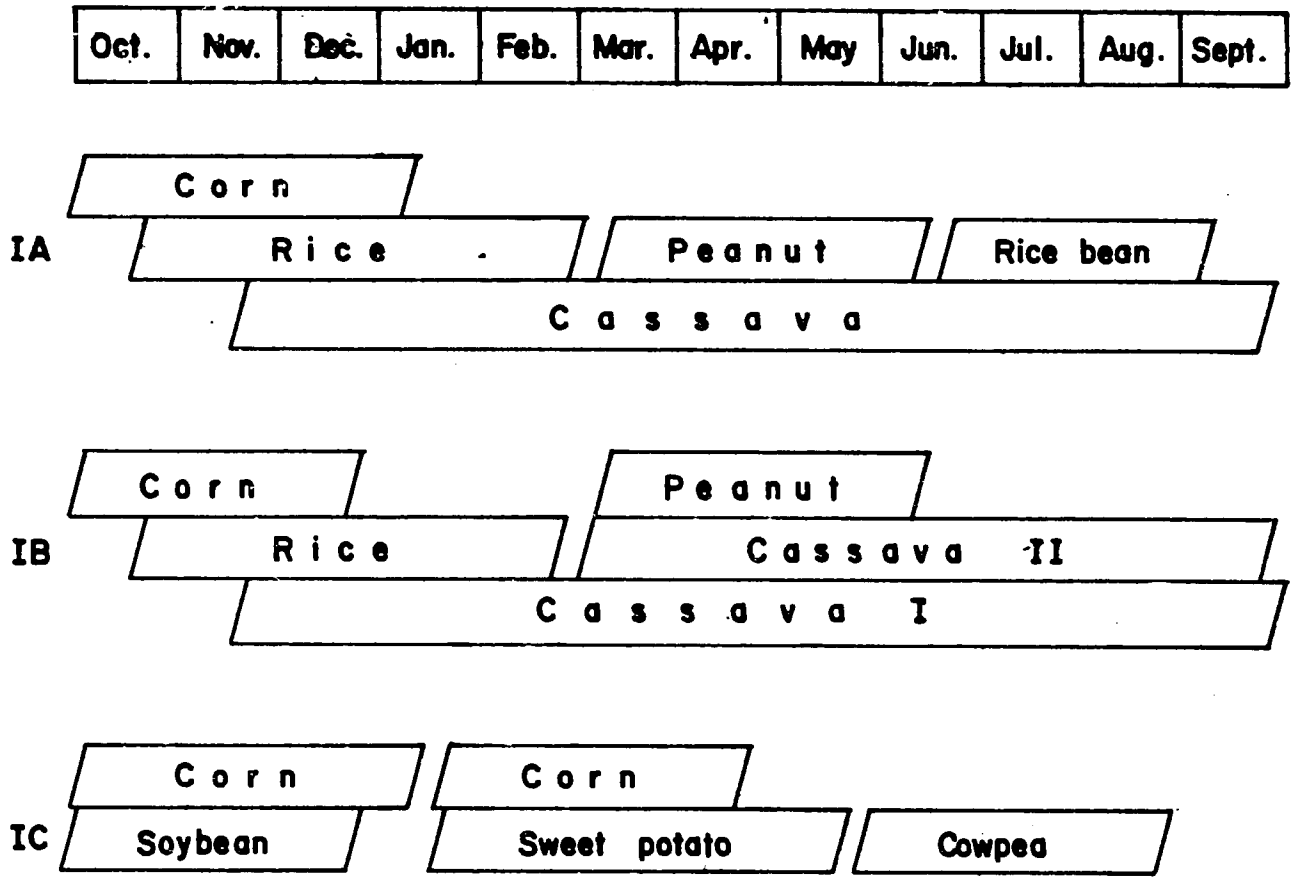

Fig. 1 Potential Cropping Systems for Lampung, Indonesia
Source: Report of the Sixth Cropping Systems Working Group Meeting, 1978.

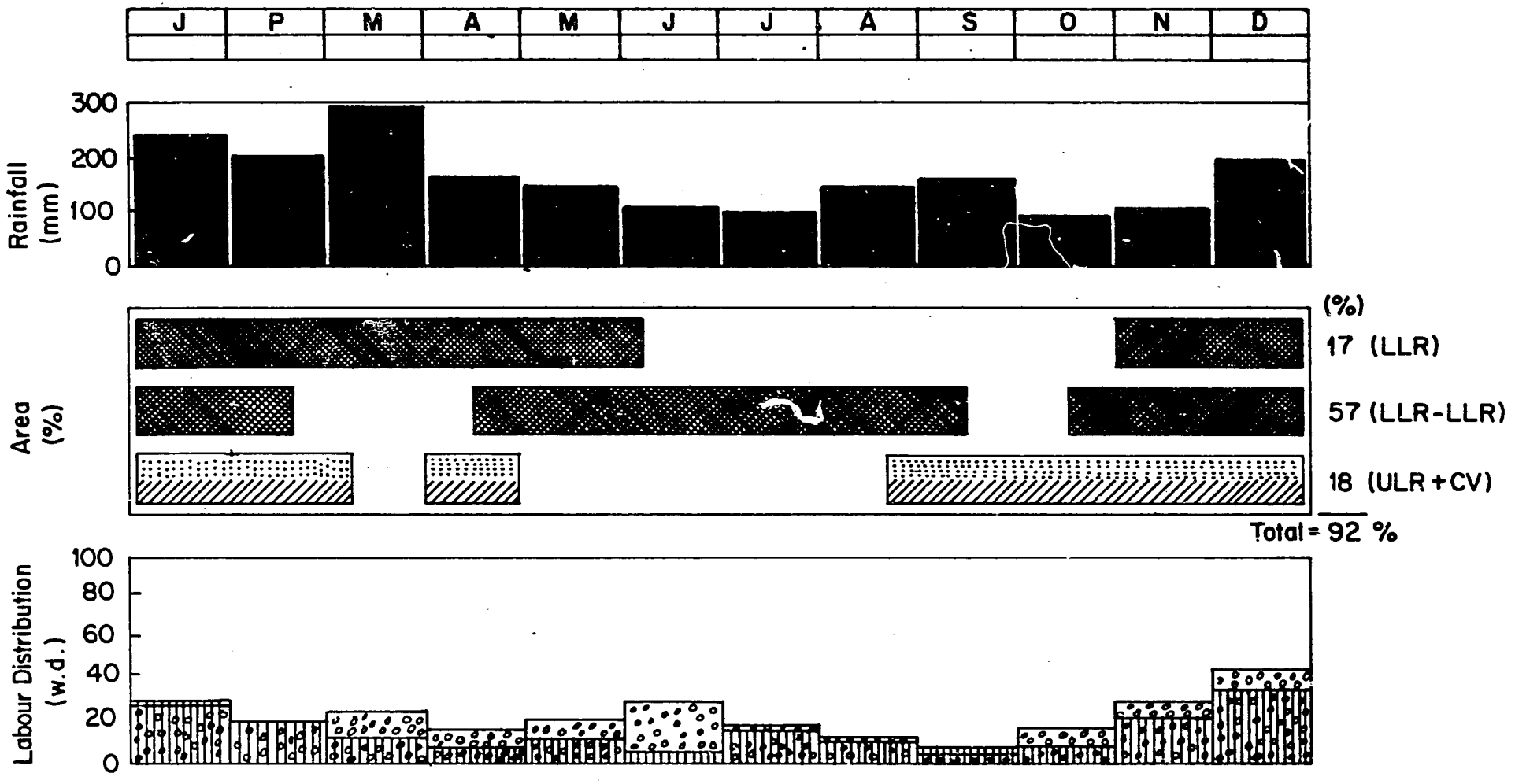

Fig. 2 Optimal Cropping Pattern : 1, 2 and 3
Category : I
Size : 1 Ha.

Rice
Gogo UL Rice
Cassava

Optimal C.P.
Farmer C.P.

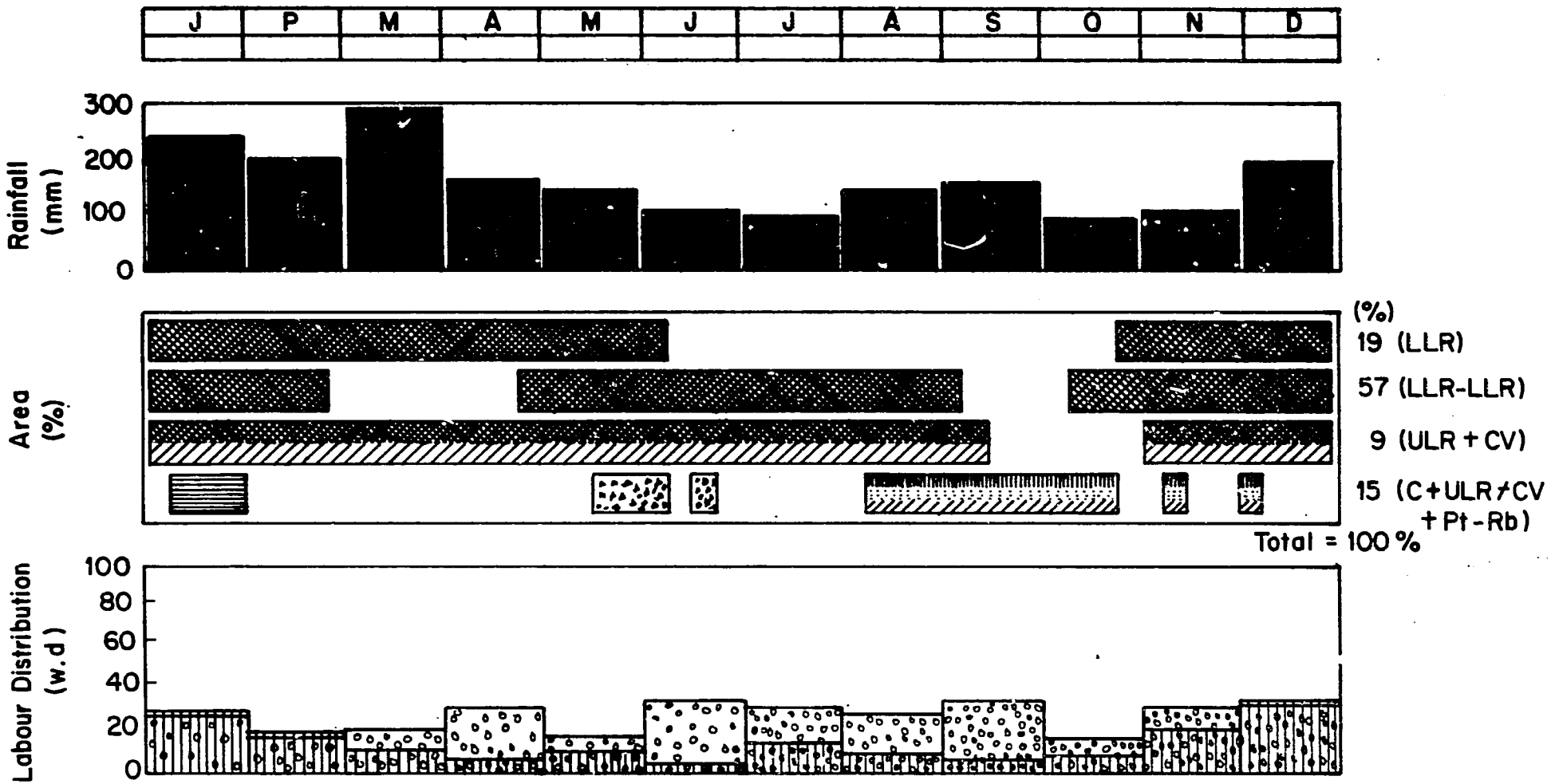

Fig. 3 Optimal Cropping Pattern : 4, 5 and 6
Category : I
Size : 1 Ha.

Rice
Gogo UL Rice
Cassava
Corn
Peanut
Ricebean
Optimal C.P.
Farmer C.P.

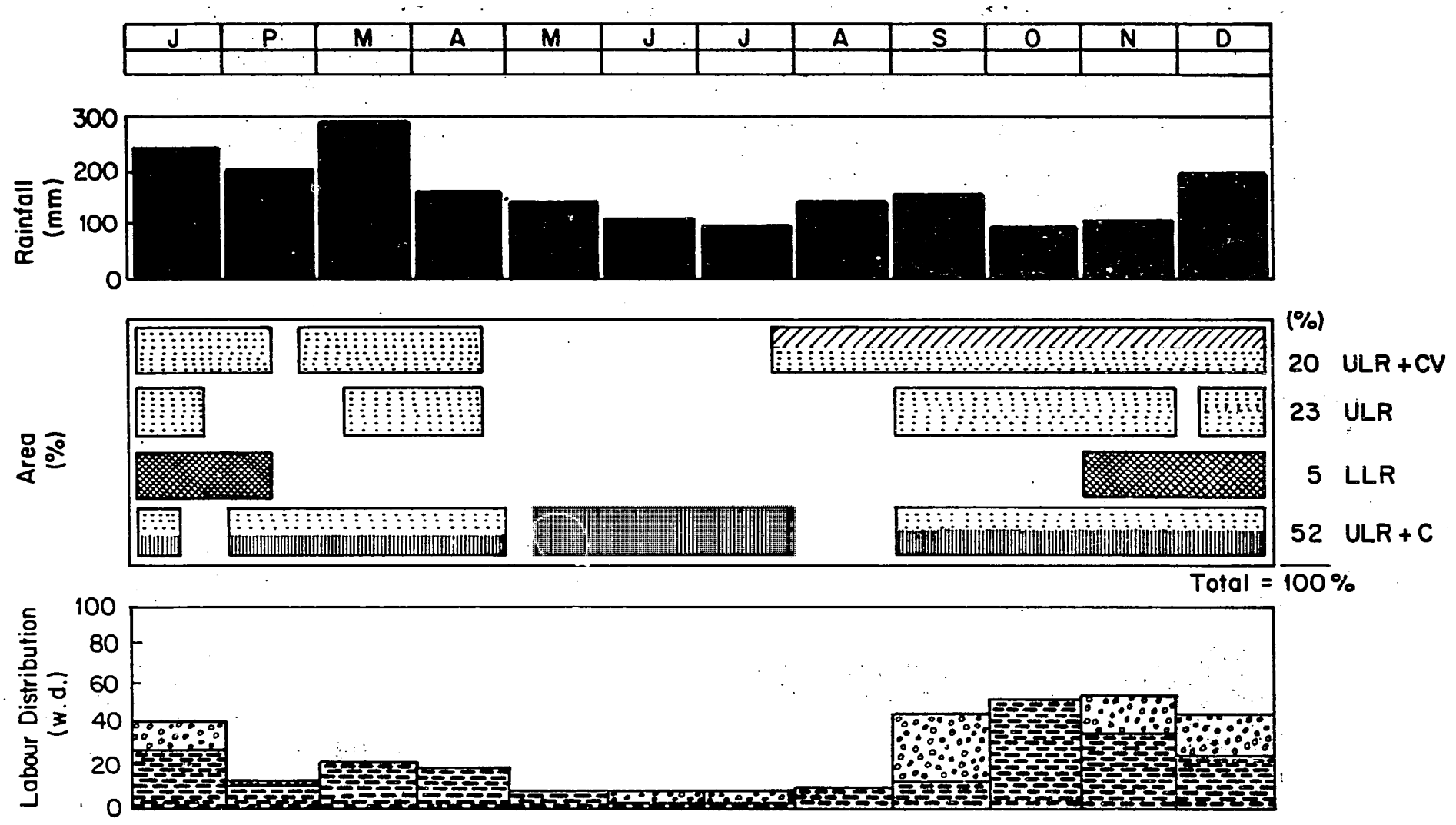

Fig. 4 Optimal Cropping Pattern : 1
Category : II
Size : 1 Ha

Rice
Gogo (UL Rice)
Cassava
Corn

Optimal C.P.
Farmers C.P.

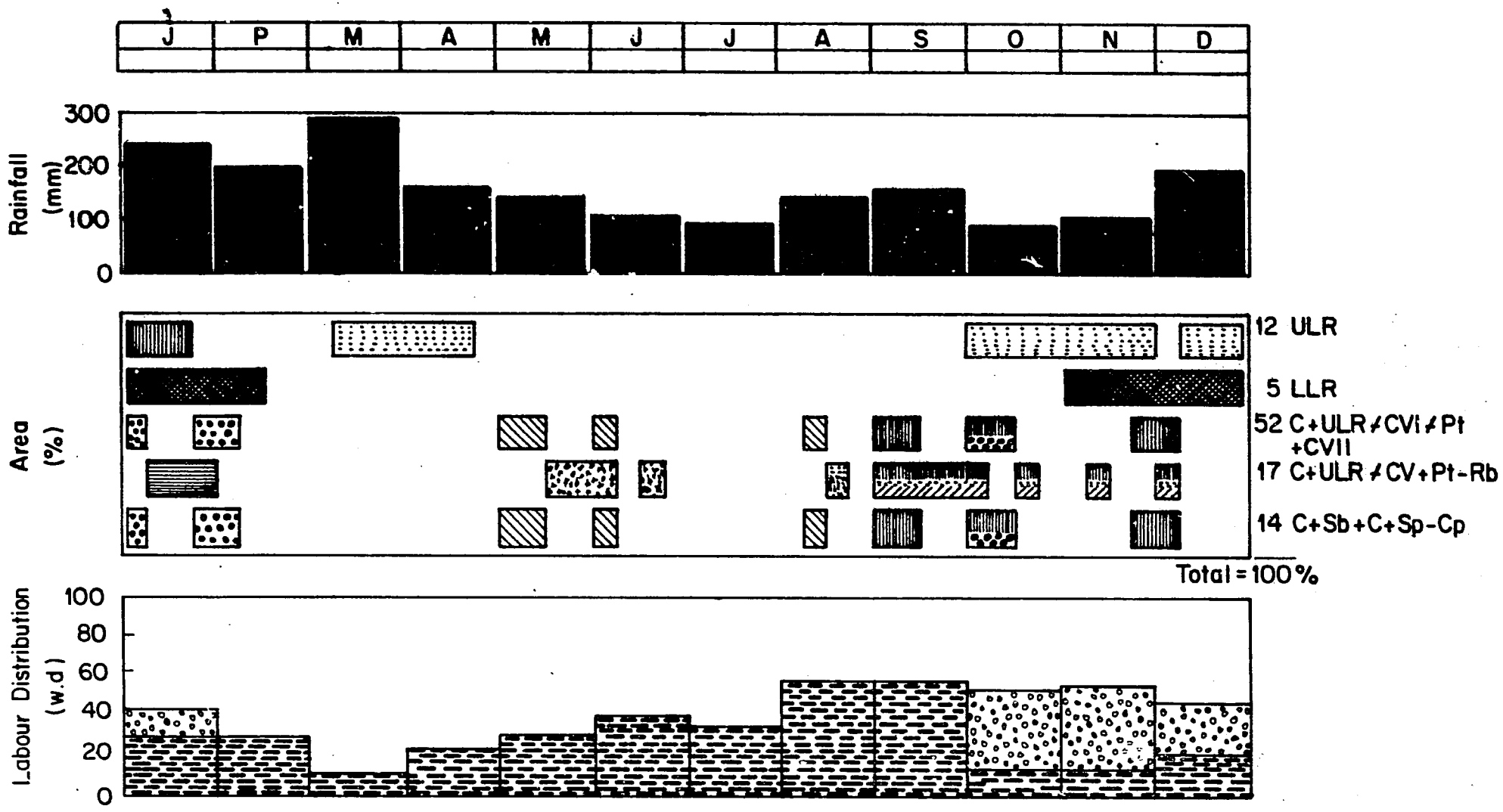

Fig. 5 Optimal Cropping Pattern : 4,6 and 7
Category : II
Size : 1 Ha.

Rice
Gogo (UL Rice)
Cassava
Corn
Soybean
Cowpea
Peanut
Rice bean
Sweet potato
Optimal C.P.
Farmers C.P.

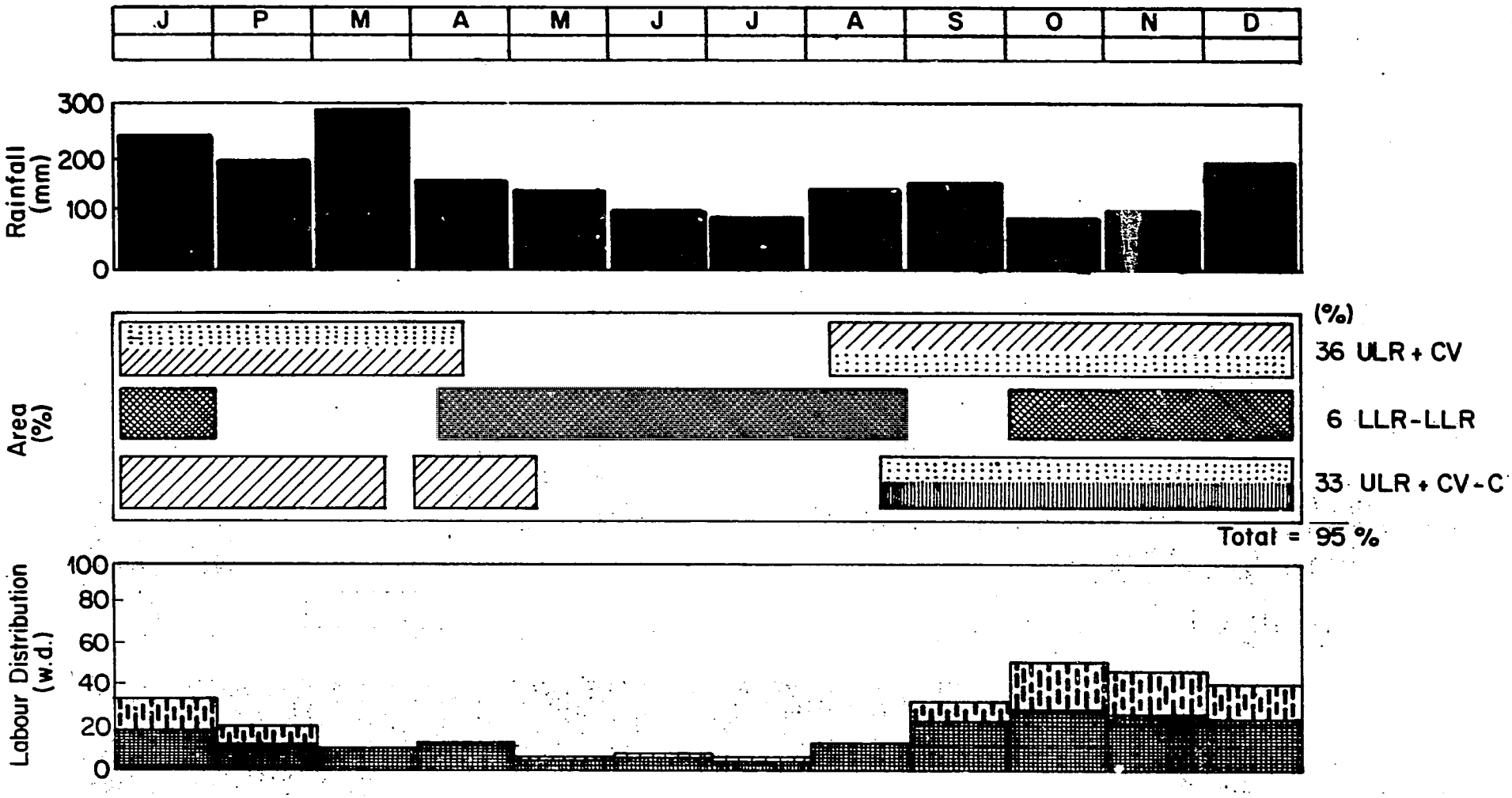

Fig. 6 Optimal Cropping Pattern : 1 and 2
Category : III
Size : 1 Ha

Rice
Gogo (UL Rice)
Cassava
Corn

Optimal C.P.
Farmer C.P.

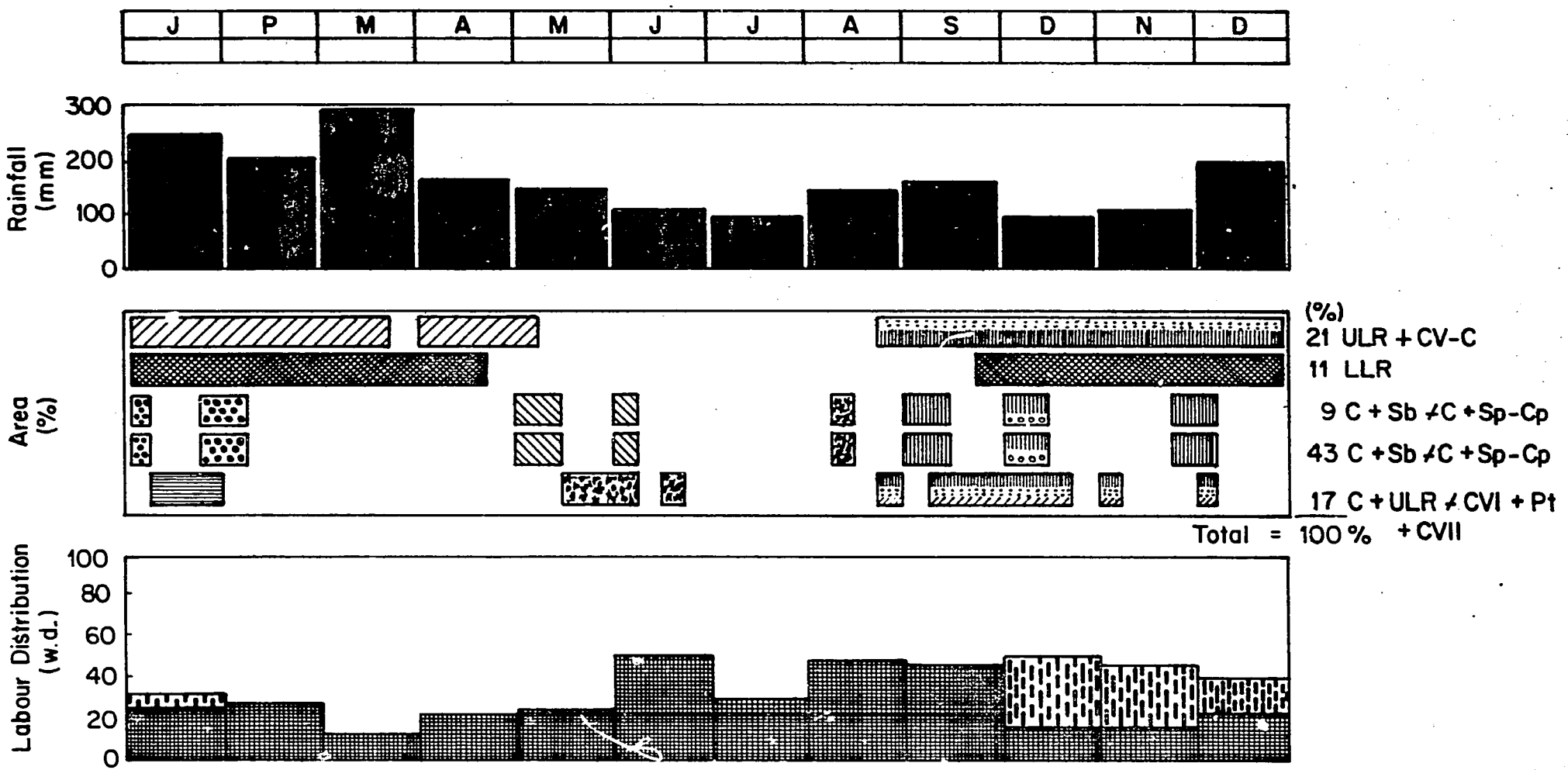

Fig. 7 Optimal Cropping Pattern : 4 and 6
Category : III
Size : 1 Ha

Rice
Gogo (UL Rice)
Cassava
Corn
Soybean
Cowpea
Peanut
Rice bean
Sweet Potato
Optimal C.P.
Farmer C.P.

CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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