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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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The Potential of Mechanization for Crop Intensification in a Rainfed Area - Iloilo, Philippines

by

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The Consequences of Small Rice Farm Mechanization Project is a cross country study of the impact of engineering technologies on agricultural output, employment and income distribution The project, a centrally funded activity of the United States Agency for International Development, has two major components. The first is a series of case studies addressing specific topics relating to the application of mechanization. The majority of the case studies are funded through awards from the Agricultura Development Council to graduate and post-graduate research personnel in the Asian region. A second component is a three coun comparative study being administered by the International Rice Research Institute in cooperation with agencies in Thailand, Indonesia and the Philippines. This portion of the project consists of a series of stratified cross sectional surveys and daily recordkeeping activities at sites in the above countries. Details of the field design and research methodology are contai in the operations manuals noted on the last page of this report

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THE POTENTIAL OF MECHANIZATION FOR CROP INTENSIFICATION IN A RAINFED LOWLAND AREA - ILOILO, PHILIPPINES

James Chapman*

Methods of increasing total farm output and income in rainfed areas often include developing new technologies which facilitate more intensive farming. Crop intensification implies an increase in the number of crops that can be consecutively planted and harvested on a field during a growing season. Research concerned with the development of new cropping patterns acceptable to farmers involves detailed study of site-related agro-climatic, bio-physical and socio-economic environments (Zandstra, 1976). Methods of increasing cropping intensity include modification of crop establishment and management techniques, and the use of modern early maturing, high yielding rice cultivars.

Research carried out in Iloilo Province in the Philippines by staff members of the IRRI Cropping Systems Program has led to the identification and development of new cropping patterns with the potential for increasing farm production and income . Historical cropping practices in Iloilo include the planting of rice as a single crop or rice followed by a drought-tolerant upland crop such as mungbean or cowpea. One of the more promising new patterns involves the planting of two rice crops during a single cropping season. The double rice crop pattern has

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been adopted by a large proportion of farmers in the irrigated areas of Iloilo, while the incidence of adoption in the rainfed areas has been lower and less stable. Discussions with farmers owning or operating rainfed land reveal that the desire exists to adopt the double rice crop pattern. The results from these discussions, and from cropping pattern trials conducted on farmers' fields by the Cropping Systems Program, have led to the identification of factors affecting the adoption of the new rice cropping patterns introduced in the area (Magbanua et al 1978; Roxas et al 1978).

It has been suggested that the mechanization of certain farm operations can facilitate the adoption of more intensive cropping practices in rainfed areas (McMennamy and Zandstra 1979). In this paper, a description of the factors limiting the adoption of intensive rice cropping practices is presented, followed by an examination of the economic feasibility and expected benefits of the mechanization of land preparation operations in the Iloilo rainfed lowland area.

Environmental factors affecting rice cropping intensity

The development of modern rice varieties has significantly increased the potential for increased cropping intensity in rainfed areas. Where rainfall is sufficient, two rice crops can be successfully grown using new rice varieties which mature in three to four months. In Iloilo, the adoption of modern early maturing varieties (EMVs) has notably increased in recent years (Fig. 1). Farmers in the area cite the increased potential for multiple cropping as their principal reason for adopting EMVs such as IR-36.

While the adoption of modern varieties has increased, the practice of planting two crops of rice appears to be limited and unstable in rainfed areas. The incidence of double rice cropping has varied over the years 1974-79 (Table 1). During the 1974-75 cropping season,[1/] when the Cropping Systems Program first began work in Iloilo, only 5% of the total land area of surveyed farms was planted with 2 rice crops. The adoption of EMVs enabled farmers to plant two rice crops on 3% of the total cropped area by the 1976-77 season. The proportion of land planted with two rice crops declined sharply during the 1977-78 season, and rose once again in 1978-79 to nearly equal the 1976-77 figure. In 1976, a large portion of the Iloilo rice lands came under irrigation. In these newly irrigated areas, multiple rice cropping has been nearly completely adopted (Table 1).

The leveling off or decrease in the adoption of double rice cropping in the rainfed areas is due to a number of factors. The most important factor in the minds of Iloilo farmers is the uncertainty of water supply. This uncertainty is caused by unstable yearly rainfall patterns, which affect soil moisture conditions and therefore crop yields (Roxas et al 1978). Monthly rainfall patterns for the crop seasons of 1976-79 are presented in Fig. 2. Farmers were able to establish their first rice crops in the latter part of May to early June during the 1976-77 and 1978-79 seasons, but not until late June to mid-July in 1978. Sufficient moisture to support second rice crops planted in September or October was available during the 1976-77 and 1978-79 seasons. Rainfall during the latter part of the 1977-78 season dropped sharply with no resurgence in the ensuing months. Farmers with first rice crops planted late in 1978 observed fields drying up by October of the same year. Many farmers

were therefore unable to establish second rice crops, and many of the crops that did get planted yielded poorly.

Another environmental factor which influences rice cropping intensity is landscape position. The position of a field in the topographic sequence modifies the effects of rainfall by affecting the amounts of soil mositure avaiable to the rice crop. Paddy fields in sloping areas lose water through seepage and percolation, evapotranspiration and through surface drainage (Moorman and van Breeman 1978). Flat plain or plateau areas surrounded by slopes receive water from slope surface drainage as well as from rainfall. Moreover, the rates of seepage and percolation and surface drainage are lower on plain and plateau areas than on slopes due to the reduced effects of lateral gravitational pull and closer proximity to water tables. Soil types modify the effects of landscape position by retarding or increasing the rates of field drainage. Heavy soils are more efficient at retaining moisture, and are usually found on the lower portions of plains and plateaus. Therefore, the effective rice cropping season is usually longer for fields in plain or plateau positions where greater amounts of moisture are available for crop growth over an extended period of time.

Among the socio-economic factors cited by Iloilo farmers as important in influencing cropping patterns are labor, power and cash availability (Roxas et al, 1978). Fields are normally prepared for planting by the farmer, with a carabao (water buffalo) as the source of draft power. Since all farmers in an area are subjected to similar climatic conditions, land preparation activities take place at about the same time on rainfed farms with similar hydrologic characteristics. Due to the peak in demand, the local supply of labor and power for hire is severely limited when farmers need it most. Cash availability is an important factor related

material input purchase and use. It is not directly related to land preparation per se since farmers rarely hire labor or power for this purpose. Non-farm and off-farm activities do not, in farmers' minds, represent significant constraints to increased rice crop intensification.

Given the information available regarding current cropping practices in Iloilo and the socio-economic and agro-climatic conditions affecting farm operations, one can appreciate the desirability of technologies which reduce the time necessary for land preparation and planting at the beginning of the cropping season or between crops during the season.

Time budget analysis has shown that total land preparation time can be reduced by 37% when animals are replaced by power tillers (McMennamy and Zandstra 1979). The possibility exists for a favorable impact of mechanization on cropping intensity and ultimately on farm incomes. In order to evaluate the potential benefits of power tillers, information about prices and the appropriate technical coefficients was incorporated into a formal analytical model which allows the choice of land preparation technique to be made according to specified optimization criteria.

Model description

A linear programming (LP) model was selected as the framework for the analysis of the problem. Linear programming has been extensively used as a means of studying and evaluating the allocation of resources to various activities on small farms in less developed countries (Hardaker 1979). The advantage of the approach is that the allocation of resources is made according not only to their profitability, but also to their availability to the farmer through ownership, purchase or hire.

Linear programming has been used to explicitly model whole farm systems, where resource use in non-farm, off-farm and household activities is taken into consideration along with farm production activities (Jayasuriya 1979, Sektheera 1979). Such models take into account the basic interrelationships that exist between all production and consumption activities in the farm household through their dependence on a common resource base. When a large number of interdependent activities are included in a formal mathematical model, large amounts of data are required on farm-household relationships. The model presented here does not examine the whole farm system explicitly, but rather is focused on a portion of the system which is directly concerned with the production of rice. Nevertheless, other factors were taken into account in a qualitative sense and became part of the structure of the model. Limitation of the problem scope was necessary in order to reduce the complexities of the modelling process, but still arrive at a reasonable approximation of reality.

The broad outline of the model used in this study is presented in Table 2. The various activities, most of which are rice production activities, are designated as columns. The rows represent the resources available for rice production, which include labor, land, draft power and cash. Land is classified according to landscape position, representing sideslope and plain-plateau classifications. Each resource is defined in terms of a flow over a specified time span. During the period of the year that rice can be grown, resource requirements are specified weekly. Time intervals are longer when no critical activities on rice fields are feasible.

Production activities use resources as necessary from the time a field is first plowed until after it is harvested, whereupon the field is once again available for land preparation and planting. Normally, there is a two to three week delay between the harvest of the first crop and the planting of a succeeding crop. The delay, or turnaround period (TAP), is due to the necessity of time use for harvesting the standing crop (one week) and land preparation for the succeeding crop (one to two weeks). Rice production contributes yield to a crop balance row. The yield is net of the harvesters share, as harvesting is done by hired laborers who receive a portion of the total harvested crop as payment. Rice is removed from the crop balance for consumption and sale. The cash supply is augmented through the sale of rice from the crop balance. Options are included for the hiring of a limited amount of man + carabao labor or man + power tiller in order to increase the supply of land preparation labor and power to the farm when necessary.

In this manner, the model takes into account the basic set of technologies and resources available to farmers in the Iloilo rainfed areas. It was assumed that farmer had two major goals; a dominant goal of obtaining a minimum quantity of rice for family consumption (specified as a constraint), and a secondary goal of maximizing the net cash surplus. For specified levels of farm resources, technologies and prices, the LP model chooses the economically optimal combination of activities which maximizes the net cash surplus.

Resource requirements and availability

The requirements for and availability of resources are listed in Table 3. The average farm size in Iloilo is about 1.5 hectares (Roxas and Genesila 1977). Rice is grown on two types of land, sideslope and plain-plateau. The amount of each land type per farm varies greatly, but land in the plain-plateau position is most common in the study area. For most model runs, .5 ha of sideslope and 1.0 ha of plain-plateau were made available for rice planting. Farmers normally utilize two to three weeks for land preparation, including plowing, harrowing, leveling and repairing and clearing bunds and levees. For Iloilo farms, land preparation is the principal method of weed control. Each field is plowed and perhaps harrowed once, then left to stand for a week or more while new weed seeds germinate. Then the field is harrowed again in order to uproot the young weed seedlings prior to planting. The most common method of establishing a rice crop is the broadcasting of pregerminated seeds onto puddled soil. This technique is called wet seeding (WSR), and has replaced transplanting (TPR) as the principal establishment method due to lower costs and to the scarcity of transplanting labor in the community (Fig.5). Since seebed preparation is not necessary, farmers need not decide the planting date in advance and can establish WSR as soon as field moisture conditions permit land preparation. While the establishment of second rice crops could conceivably be hastened by transplanting aged seedlings, the practice is not common in Iloilo. Harvesting opportunities, which command an implicit wage two to four times that normally offered workers for transplanting, are abundant during transplanting times.

About two weeks after broadcasting, portions of the field where plant populations are excessively low are replanted. Soon after replanting, fertilizer is broadcast in one or two applications, and pesticides are applied as necessary. When weeds not controlled during land preparation reach sufficient height, handweeding is done.

The period from planting to maturity of an EMV such as IR-36 is approximately 110 days. The crop duration was set to 16 weeks (112 days) in the LP model. A rice crop planted in the second or third week after the beginning of land preparation would be harvested during the 18th or 19th weeks. Harvesting, even on the smallest farms, is done by labor hired from within the community or from nearby areas. Therefore, no family labor was required by the model for harvesting and threshing operations, while the total quantity of rice entering the crop balance was reduced by the one sixth share payment to harvesters and threshers.

Harvesting was assumed to be completed in one week, leaving the land free for subsequent tillage and planting. Land preparation using traditional techniques (man plus carabao) for a second rice crop can be completed in two weeks. The minimum turnaround period between successive rice crops is therefore a total of three weeks.

Though power tillers are not currently being used on rainfed farms in Iloilo, it is possible to estimate the potential benefit of their inclusion in the farmers' technology set. Studies conducted in other areas of the Philippines (Orcino and Duff 1974) have shown that power tillers can prepare wet land paddy fields roughly twice as fast as the traditional

carabao-drawn plow and harrow. In order to specify this new technology in the model, changes in the requirements for resources were made as shown in Table 4. The total amount of time required to prepare, plant and harvest a rice crop was reduced by one to two weeks per crop, reflecting the time-saving contribution of the power tiller. Since it is likely that most farmers would be custom-hiring rather than buying power tillers (at least initially), the resource requirement for land preparation was specified in terms of cash (pesos/ha). The TAP between successive crops was reduced from three weeks to two weeks. Use of the power tiller could reduce the total time required to grow two rice crops on the same field in one growing season by as much as four weeks.

Agro-climatic effects on rice yields. It has been determined that rainfall, landscape position, soil texture and timing of crop establishment play important roles in determining the viability and feasibility of a double rice crop pattern in rainfed areas. The assumptions made for the model regarding rice yields as a function of these variables are presented in Figures 3 and 4. Figure 3 presents the relationship between planting date and yields for three rainfall termination situations for rice fields in the plain-plateau landscape position. While the actual yield values used in the model are "ball park" estimates of yields obtainable on farmers fields, the underlying relationships (shapes of the curves) are based upon data collected in trials on farmers' fields in Iloilo during the 1978-79 cropping season.[2/]

Once the wet season commences, conditions are more or less homogeneous in terms of amounts of rainfall and the incidence of solar radiation. Therefore, the yield expectations are fairly constant. When the frequency of rains begins to decrease, solar radiation increases, with a positive effect on rice yields through increased plant photosynthetic activity. Due to the high moisture retention capacity of heavy soils in the lower, more level areas, moisture stress will not initially cause yield reduction to occur. Therefore, the net effect on yields will be positive. As the frequency and intensity of rainfall decrease, and solar radiation begins to hasten water loss through evaporation, moisture stress will begin to become a significant factor causing yields to decline. The rates at which yields increase and decline depend upon the particular rainfall pattern occuring during the growing season in question.

The effect of landscape position on yield can be detected by comparing Figures 3 and 4. The yield curves for the sideslope position follow the same general trend as do those for the plain-plateau, except that yields decline sooner and at an increased rate. Water leaves paddy fields in sloping areas through surface runoff and seepage and percolation at high rates, thus exposing rice crops to moisture stress soon after the decline in rainfall. The positive effect of solar radiation is quickly overcome by the negative yield effect of moisture stress. Therefore, yields tend to fall sooner and more sharply on fields with light soils in sloping areas.

Model specification and results

Linear programming provides a single optimal solution. That is, it specifies a unique combination of activities and resource use which gives the maximum value of the objective function. Parametric programming is

used to investigate the sensitivity of the optimal solution to changes in the parameters of the resource availabilities, the technical coefficients and the objective function. Parametric analysis is able to provide information or the range of values of the parameters over which the optimal solutions are stable or changing, as well as the degree of change.

In this study, parametric programming technique were employed to explore the magnitude and directions of the effects of power tiller availability on rice production, cash surpluses[3/] and cropping intensity[4/] for a typical 1.5 ha rainfed Iloilo farm. Yield variability due to uncertain rainfall conditions was accounted for by developing separate submodels incorporating three states of nature (Figures 3 and 4). Each model contains figures which represent yields under specified rainfall conditions, a relatively late decline in rainfall intensity (Model 1), an intermediate or normal rainfall situation (Model 2), and a situation in which the rice-growing season is relatively short. (Model 3)

Power source and availability. A comparison was made of three power situations; animal power alone (A), animal power and power tiller (A + PT), and power tiller alone (PT) (Table 5). For the initial model runs, cash supply was set sufficiently high in order to prevent cash availability from becoming a limiting factor. The power tiller hire rate was set at the current Iloilo rate of ₱350/ha for completely prepared (plowed and harrowed) land. The cost of carabao maintenance was not included as a variable cash cost, since the costs of carabao maintenance remain basically constant whether or not the carabao is used to prepare land.

For Model 1, highest rice production was obtained with 100% power tiller use. However, due to the costs involved in hiring power tillers, the cash surplus for complete power tiller use was 10% below that surplus generated using only animal power. Due to the longer growing season, time

was sufficient to plant two crops on all land with or without a power tiller.

Rice production was again maximized in Model 2 with full power tiller use. Economic return, in terms of cash surplus, reach a maximum for the animal plus power tiller option, with power tillage hired for 25% of the total cropped area. Double cropping took place on all available land.

With an early rainfall termination such as that simulated in Model 3, the difference in production among the three power options became more pronounced. The proportion of land prepared with a power tiller increased to 40% when both animal and power tiller were available. Rice production with complete power tiller use exceeded that obtained with animal alone by 1.15 tons, but the differences in cash surpluses were slight even though the rice cropping index (RCI) fell to 167.

Cash availability. One of the more important factors limiting rice production and cropping intensity is the limitation placed on cash available to purchase material inputs and to hire necessary services. The effects of alternative cash availability levels were parametrically explored for two rainfall situations (Fig. 6).[5/] For Model 2, optimal amounts of rice output and cash surplus were obtained with a cash investment of ₱900. When additional amounts of cash were allotted to crop production, the extra amount was saved. No changes took place in activity selection or resource use. Twenty-five percent of the cropped area was prepared with power tillers. Optimal solutions obtained when cash was a limiting factor did not differ substantially from the unconstrained optimum, except when the cash supply was set to extremely low levels. Cash surpluses with no power tiller use reached 96% and 94% of the maximum for Models 2 and 3 respectively. Rice cropping intensity in Model 2 remained high with

animal power alone, but fell considerably when cash supply limited power use in Model 3.

When the rice growing season was shortened by an early rainfall decline, ₱1100 was needed to reach the unconstrained optimum. Lower levels of cash availability tended to reduce both the use of power tillers and rice cropping intensity. By reducing the cash expenditure to ₱600, 97% of the unconstrained optimal cash surplus could be obtained, while hiring a power tiller to prepare 10% of the cropped land. In this case, it was worthwhile to forego the planting of a second crop on part of the land in order to reduce land preparation time and improve yields on the remaining area.

Power tiller costs. It is evident from information presented in Table 5 that power tillers can contribute to significant increases in rice yields and total rice production. All or part of extra production, however, must be used to offset the extra costs of power tiller use. Optimal power supply combinations for the three rainfall situation models were parametrically determined for various power tiller hire rates (Table 7). Reduced power tiller hire rates predictably caused greater proportions of land to be prepared using power tillers (Fig. 7). However, the benefits in terms of increased production and income were not the same for all situations. For example, a ₱200 decline in the cost of power tiller hire brought about an increase in power tiller use from 0% to 42% for Model 1. However, total production and cash surplus increased by only 2%. The gains were similarly small in Model 2 (5%). The benefits from power tiller use were most evident in the results from Model 3. Production at the going rate was 9% less than production with reduced power tiller rates, while cash surplus was 13% less. A reduction of

₱100 in the hire rate placed 100% power tiller use as optimum. The intensity of rice cropping was affected only in Model 3 as power hire rates were increased by ₱200 over current rates.

Conclusions

The analysis presented demonstrates the potential of mechanized land preparation for increasing production, farm incomes, and rice cropping intensity in a rainfed lowland area. The value of the power tiller in production varies with weather conditions which affect rice yields. In general, although total rice production increased with the addition of power tillers to the system, the extra costs necessary to finance power tiller operation exceeded the derived benefits. Animal-powered and machine-powered systems were substitutable over a large range of cash availabilities and power hire rates, causing only marginal changes in rice production and net cash income.

Limitations of the analysis

Some of the results of this analysis are at variance with the observed farming practices in Iloilo. For example, Table 1 shows that current rice cropping intensities in Iloilo are far below those indicated as feasible under current conditions in the models. Since the models are not specified to handle variability in yields and in the technical coefficients, they assume risk-neutral behavior on the part of farmers. It is reasonable to presume that farmers will alter their behavior according to their subjective expectations with regard to rainfall patterns. Therefore, power tiller use would be favored if typical farmer expectations with respect to rainfall are pessimistic.

It has been shown that results differ for different rainfall situations. Cumulative rainfall probability distributions developed for Iloilo by the Cropping Systems Staff (IRRI 1979) can be used to determine the likelihood of various rainfall patterns. This information can be used to strengthen the current models by permitting analysis of the results for each state of nature according to its probability of occurence.

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FOOTNOTES

1/ A cropping season (or crop year) is defined as a continuous time period in which sufficient moisture is normally available to support crop growth. In Iloilo, the cropping season extends from May to January.

2/ The data from which yield assumptions were based is a result of experiments carried out by Frank Bolton, Research Fellow in the IRRI Multiple Cropping Department.

3/ Cash surplus is the net return from rice sales above variable costs, after the family rice consumption constraint is satisfied.

4/ Rice cropping intensity is measured by the Rice Cropping Index (RCI). The RCI is equal to the sum of the areas planted to rice and harvested during a year, divided by the total cultivated rice area. The index is 100 if the total rice area is planted and harvested once during a year.

5/ The unconstrained optimum solution contained no power tiller use for Model 1.

Table 1. Percentage of cropland in various cropping patterns, by water management category. Iloilo, 1974-79.

Cropping pattern	1974-75	1975-76	1976-77	1977-78	1978-79
			Rainfed lowland		
2 or more rice	5	20	30	19	28
1 rice + 1 or more upland	11	28	43	30	46
2 or more upland	2	5	4	2	-
1 rice + fallow	82	47	21	48	25
1 upland + fallow	-	-	2	-	1
Rice cropping index (RCI)	105	121	132	120	128
			Irrigated		
2 or more rice			96	100	96
1 rice + 1 or more upland	-	-	-	-	3
2 or more upland			-	-	-
1 rice + fallow			4	-	-
1 upland + fallow			-	-	1
Rice cropping index (RCI)			196	200	195

Table 2. Outline of the linear programming model.

Resources \ Activities		Rice			Labor		Power			Cash surplus (₱)	RHS
		Production (tons)	Consumption (tons)	Sales (₱)	Family (days)	Hired (days)	Own carabao (days)	Hired carabao (days)	Hired power tiller (₱)		
Land (ha)	Side-slope	*									≤
	Plain-plateau	*									≤
Labor (days)	Family	*			*		*				≤
	Hired	*				*		*	*	*	≤
Rice balances (tons)		*	*	*						*	=
Consumption minimum (tons)			*							*	≥
Carabao availability (days)		*					*	*		*	≤
Power tiller availability (days)		*							*	*	≤
Cash supply (₱)		*		*				*	*	*	≤
Objective function										*	

* = relationship between resource and activity

Table 3. Requirements and availability of resources for wet-seeded rice production using traditional methods of land preparation.

Resource	Units	Operation	Requirement		Availability	
			Amount	# Weeks	Amount/ week	Amount/ crop
Land type 1	ha	-	-	18-19		.5
Land type 2	ha	-		18-19		1.0
Carabao	Animal-days/ha	Land preparation	13.4)	2-3	5.0	
Labor	Man-days/ha	Land preparation	13.8)	2-3	6.0	
Labor	"	Seeding	1.2)		12.0	
Labor	"	Replanting	3.0)		12.0	
Labor	"	Fertilizer and pesticide appln.	2.7)	1	12.0	
Labor	"	Handweeding	14.7	2	12.0	
Rice balance	tons	Harvesting & threshing	1/6 Y	1		∞
Cash	₱/ha		200			var

Table 4. Requirements and availability of resources for wet-seeded rice production using power tillers for land preparation.

Resource	Units	Operation	Requirement		Availability	
			Amount	# weeks	Amount/ week	Amount/ crop
Land type 1	ha			17-18		0.5
Land type 2	ha			17-18		1.0
Cash	₱/ha	Land prep w/ power tiller	350			∞
Labor	man-days/ha	land prep	4.2	1-2	6.0	
Labor	"	Seeding	1.2		12.0	
Labor	"	Replanting	3.0		12.0	
Labor	"	Fertilizer & pesticide app.	2.7	1	12.0	
Labor	"	Handweeding	14.7	2	12.0	
Rice balance	tons	Harvesting & threshing	1/6Y	1		∞
Cash supply	₱/ha		200			var

Table 5. Effect of power source on total rice production, cash surplus, power tiller use and cropping intensity.

Power source	Total product (kg)	% Max product	Surplus (₱)	% Max surplus	% area with PT	RCI
			Model 1			
A	7,412	94	5,760	100	0	200
A + PT	7,412	94	5,760	100	0	200
PT	7,850	100	5,200	90	100	200
			Model 2			
A	6,719	88	5,119	95	0	200
A + PT	7,250	95	5,362	100	25	200
PT	7,650	100	5,000	93	100	200
			Model 3			
A	4,950	83	3,409	96	0	167
A + PT	5,557	91	3,541	100	40	200
PT	6,100	100	3,450	97	100	200

A = Animal PT = Power tiller

Table 6. Effect of varying cash availability on total rice production, cash surplus, power tiller use and cropping intensity.

Cash supply (₱)	Total product (kg)	% Max product	Surplus (₱)	% Max surplus	% area with PT	RCI
			Model 2			
400	5,350	74	3,950	74	0	134
600	6 722	93	5,122	96	0	200
800	7,146	98	5,346	99	15	200
900	7,250	100	5,362	100	25	200
			Model 3			
400	4,450	80	3,050	86	0	134
600	5,042	90	3,442	97	10	168
800	5,309	95	3,509	99	21	190
1000	5,540	99	3,540	100	38	200
1100	5,557	100	3,541	100	40	200

Table 7. Effect of varying power tiller hire rates on rice production, cash surplus, power tiller use and rice cropping intensity.

PT cost (₱/ha)	Total product (kg)	% max product	Surplus (₱)	% max surplus	% area with PT	RCI
			Model 1			
150	7,675	100	5,887	100	42	200
250	7,536	98	5,772	98	19	200
350	7,412	97	5,760	98	0	200
			Model 2			
150	7,600	100	5,625	100	83	200
250	7,338	97	5,441	97	40	200
350	7,250	95	5,362	95	25	200
450	7,134	94	5,262	94	0	200
			Model 3			
150	6,100	100	4,050	100	100	200
250	6,100	100	3,750	93	100	200
350	5,557	91	3,541	87	40	200
450	5,426	89	3,462	85	25	200
550	5,001	82	3,412	84	2	171

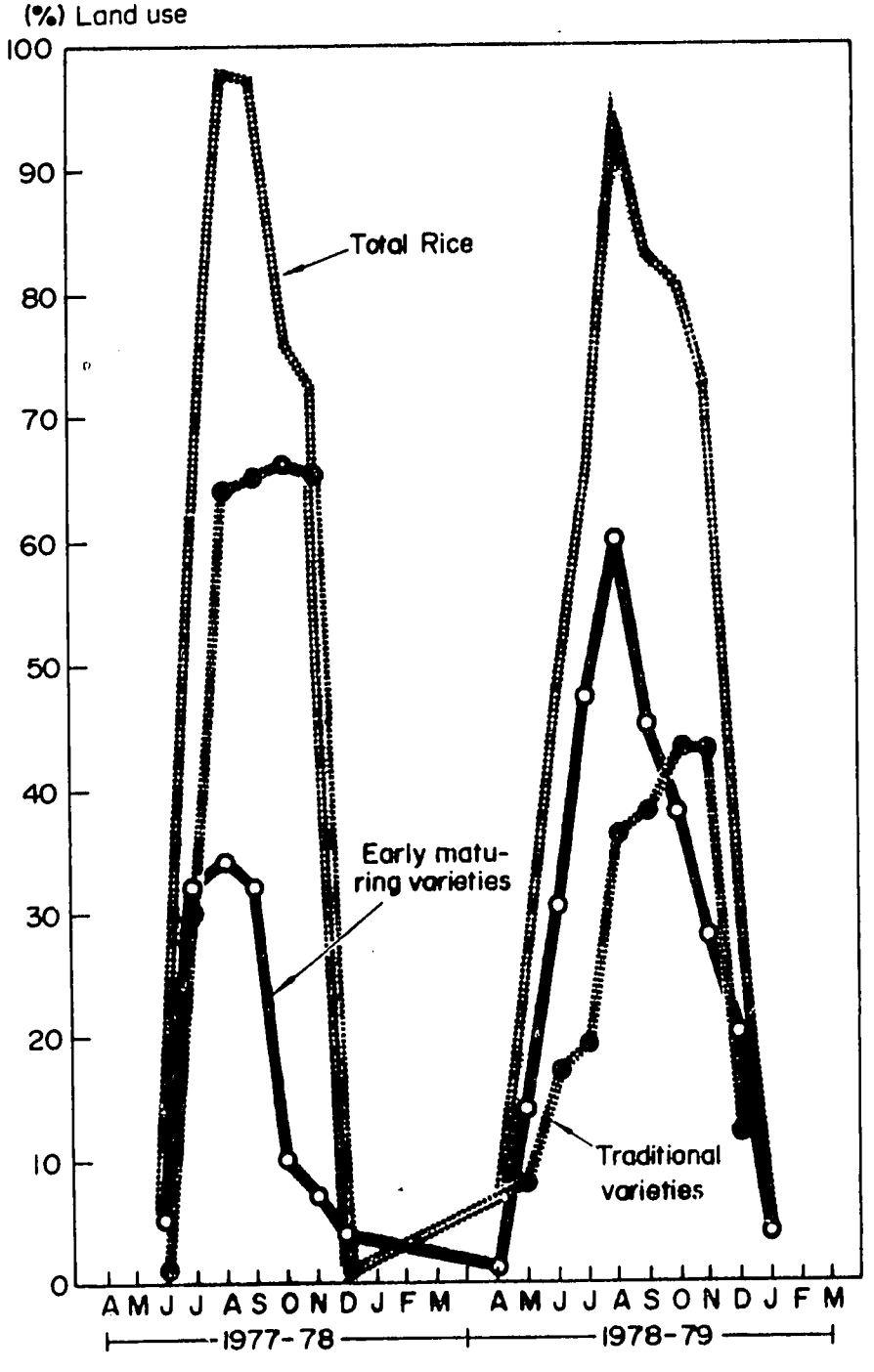

Fig. 1. Trends in adoption of early maturing rice varieties in Iloilo, rainfed areas, 1977 - 1979.

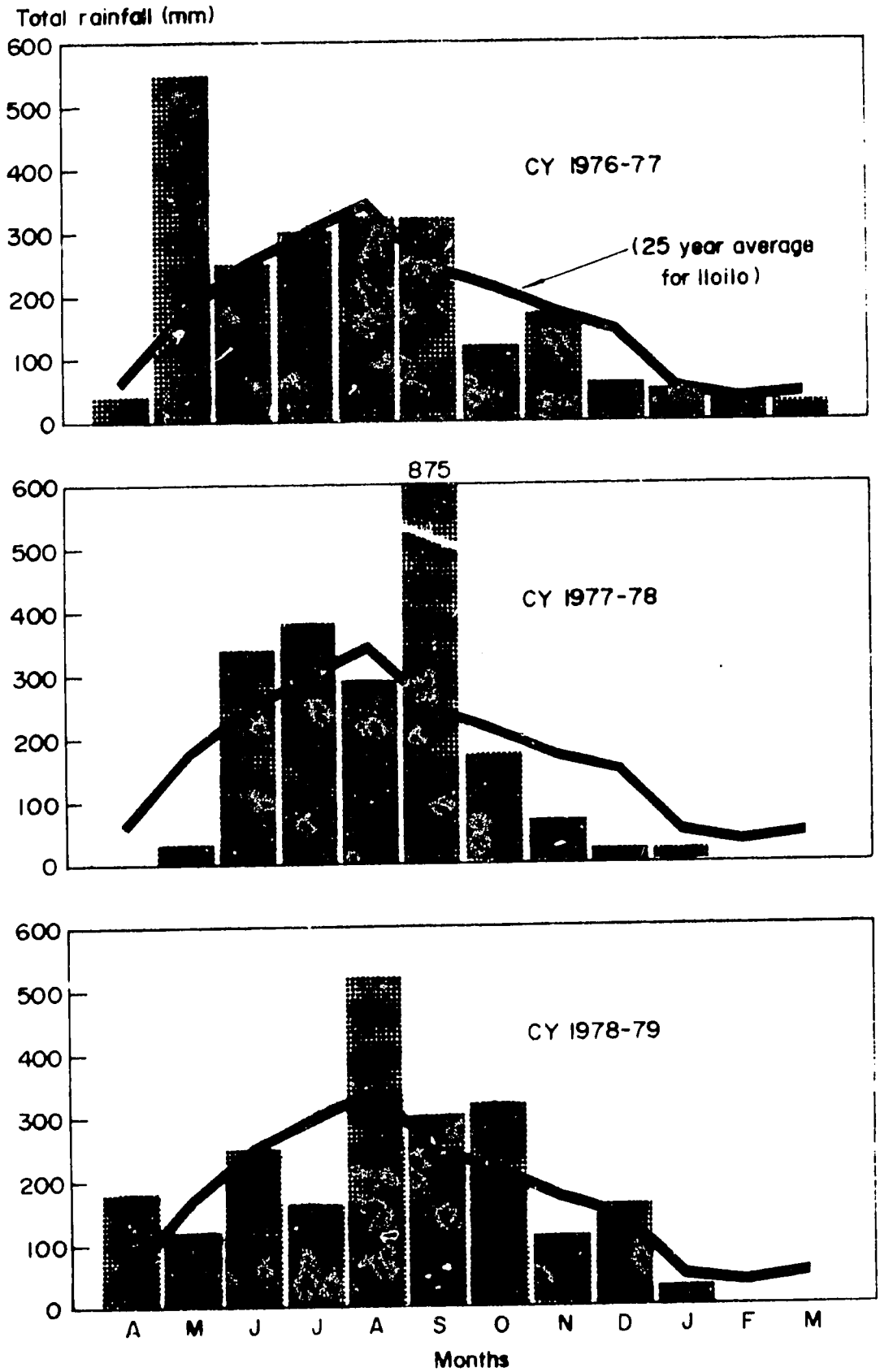

Fig. 2 Monthly rainfall patterns, Iloilo Outreach Site, 1976-79.

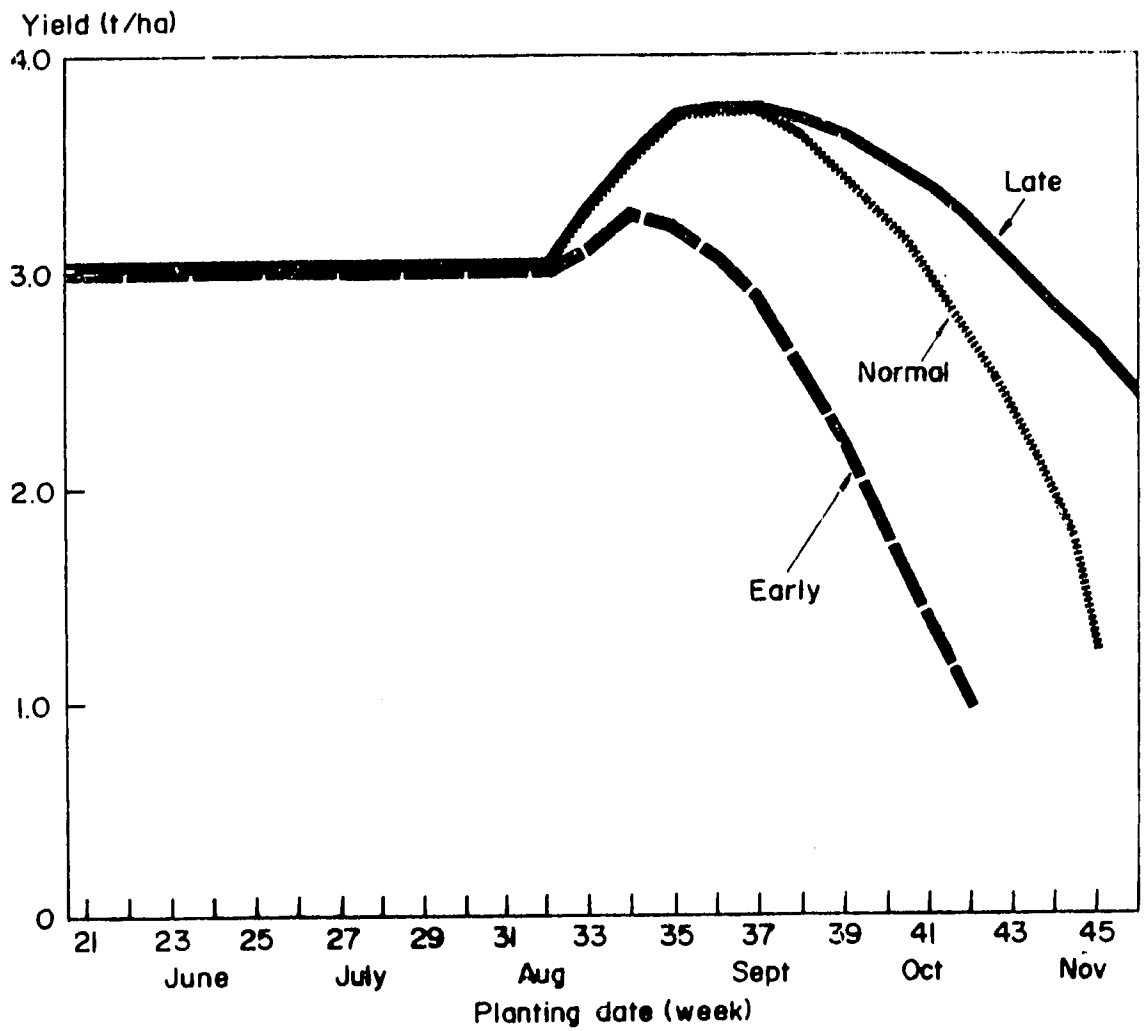

Fig. 3. Relationship between grain yield and date of planting for fields in the plain-plateau landscape position for three rainfall termination situations.

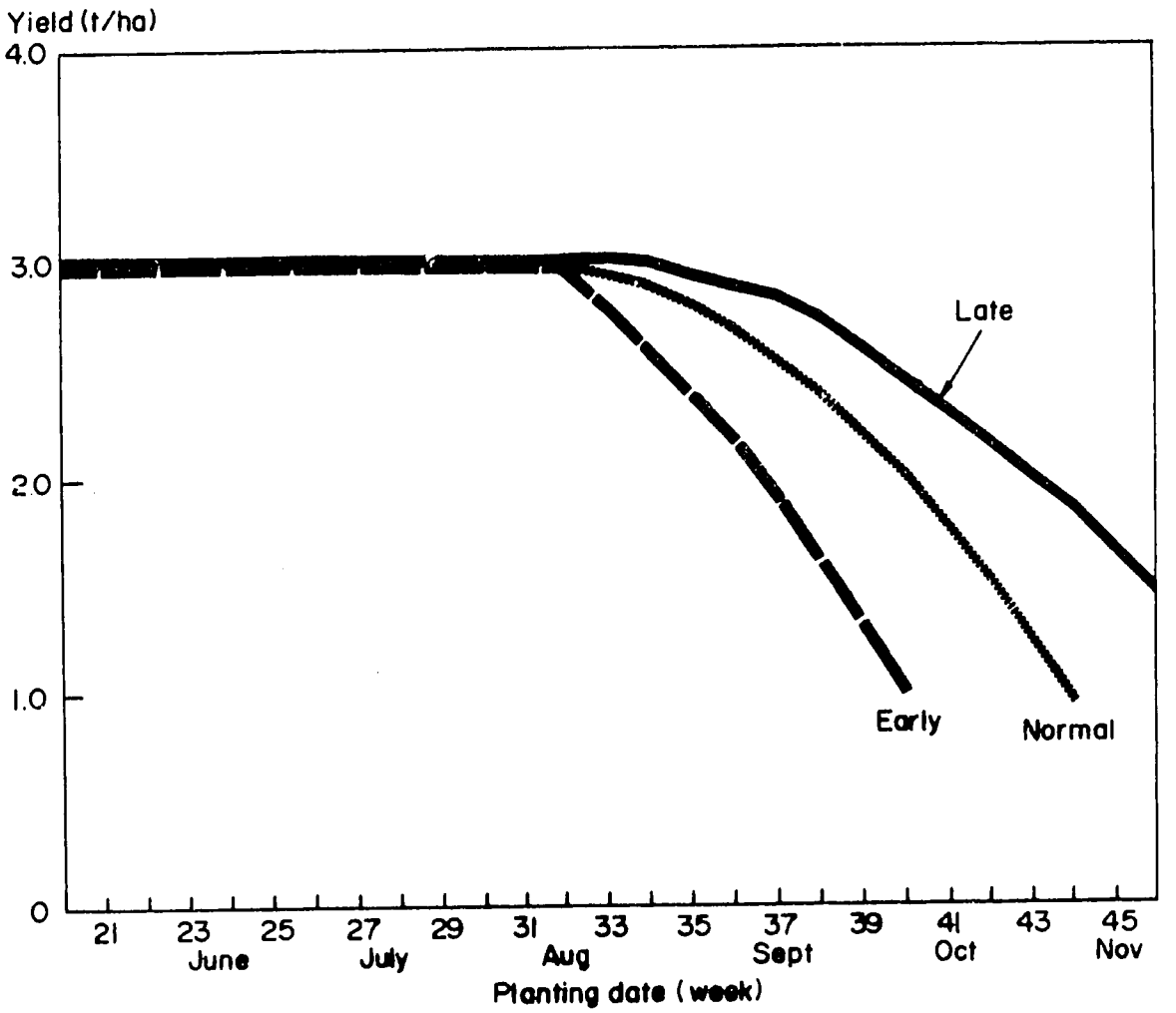

Fig. 4. Relationship between grain yield and date of planting for fields in the sideslope landscape position for three rainfall termination situations.

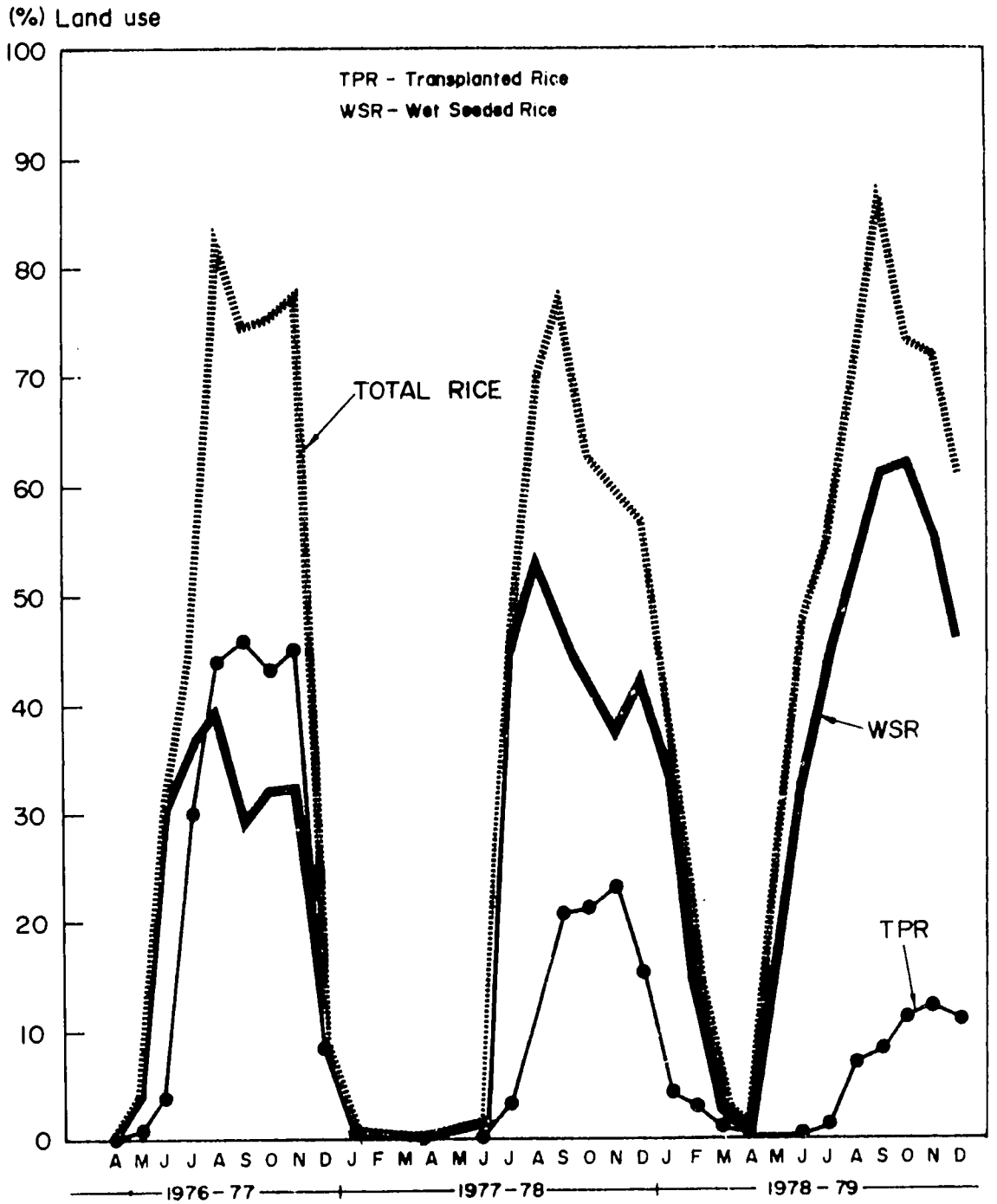

Fig. 5. Percentage of land utilization by method of rice crop establishment, Iloilo, 1976 - 1979.

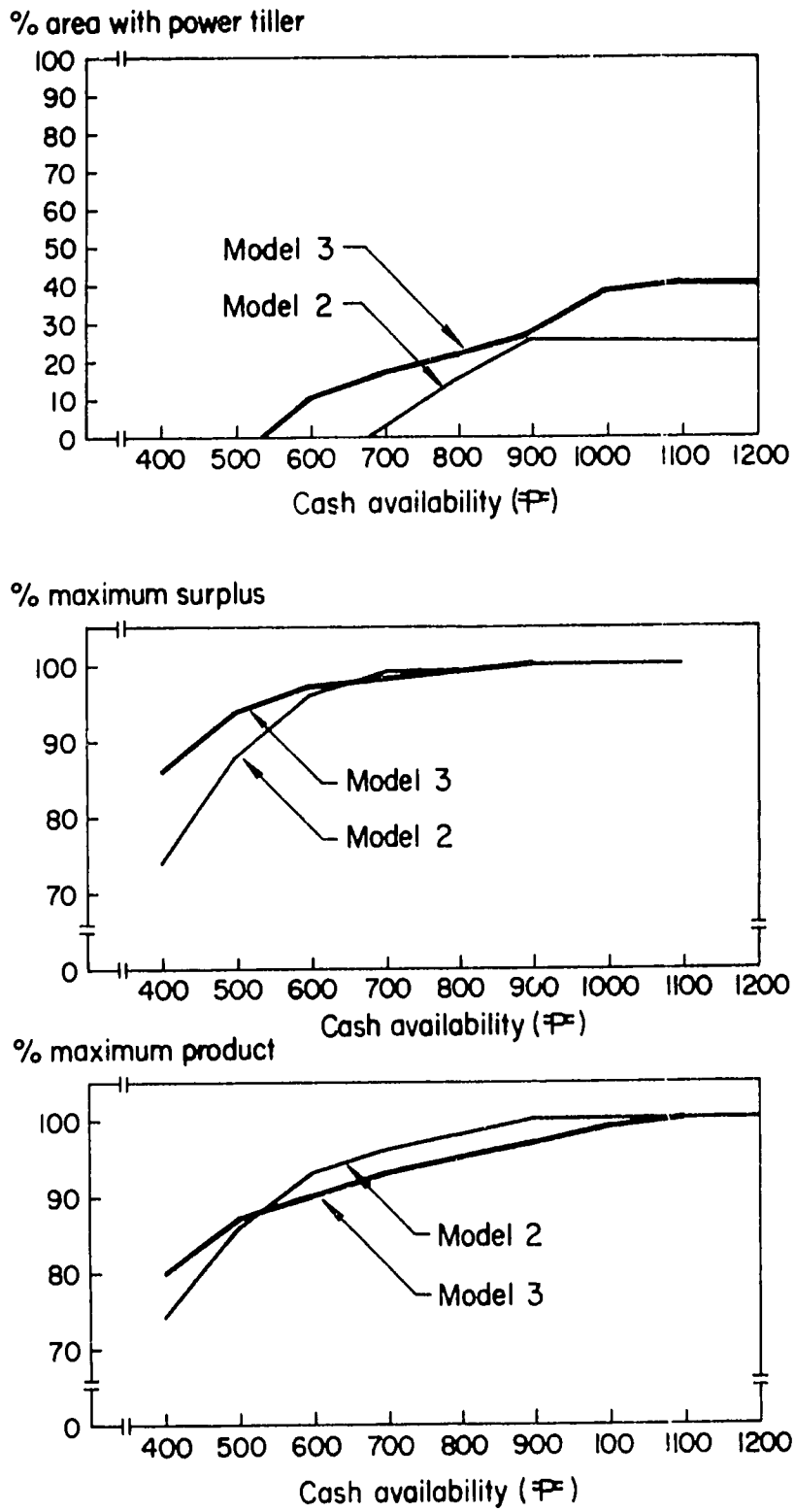

Fig. 6. Effect of cash availability on power tiller use, cash surplus and rice production.

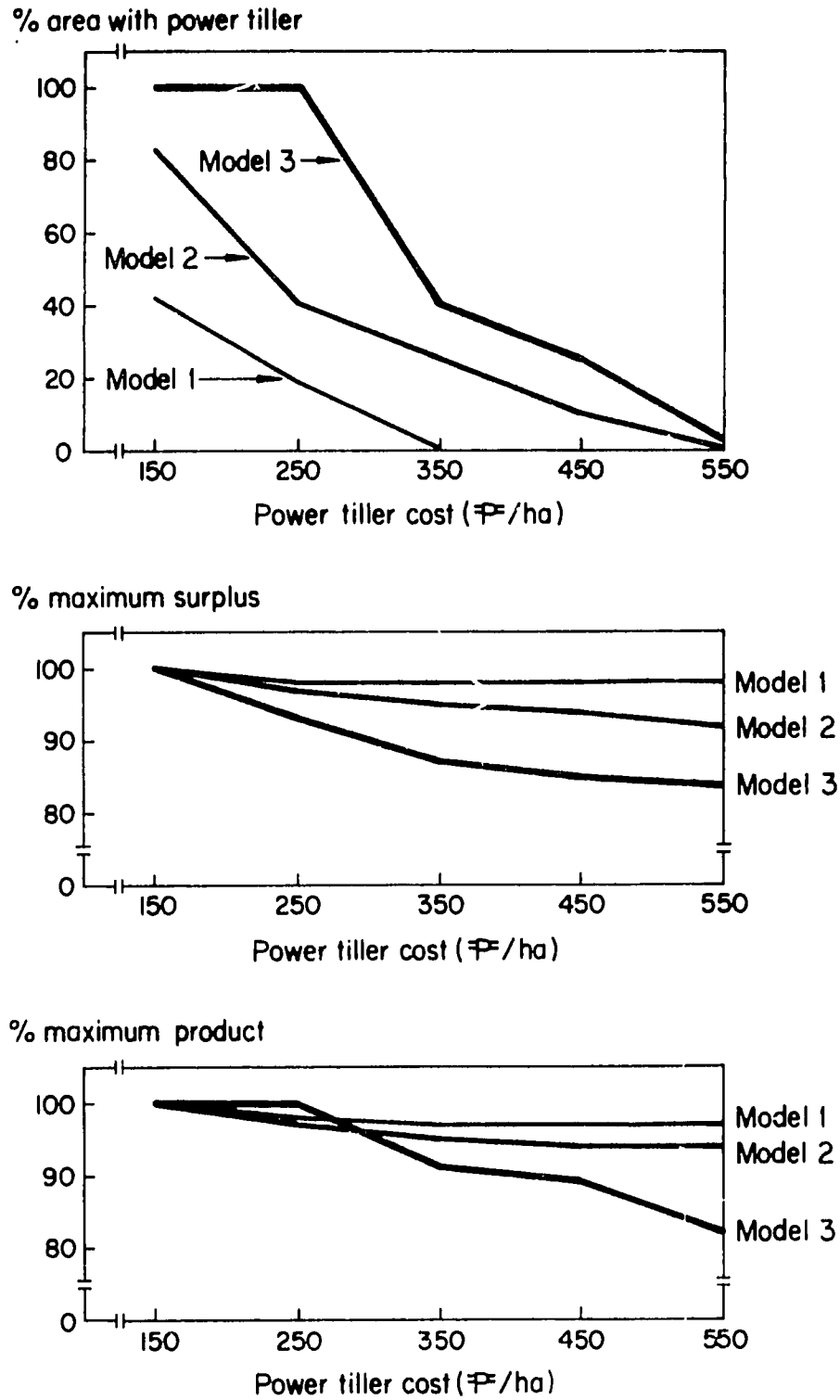

Fig. 7. Effect of power tiller hire rates on power tiller use, cash surplus and rice production.

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3. Gardezi, J.,A. Rauf, M. Munir, K. Altaf, Q. Mohd-ud-Din, and B. Lockwood. A Study of Mechanical and Traditional Wheat Threshing in Multan District, Punjab, Pakistan: Some Preliminary Results. October 1979.

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