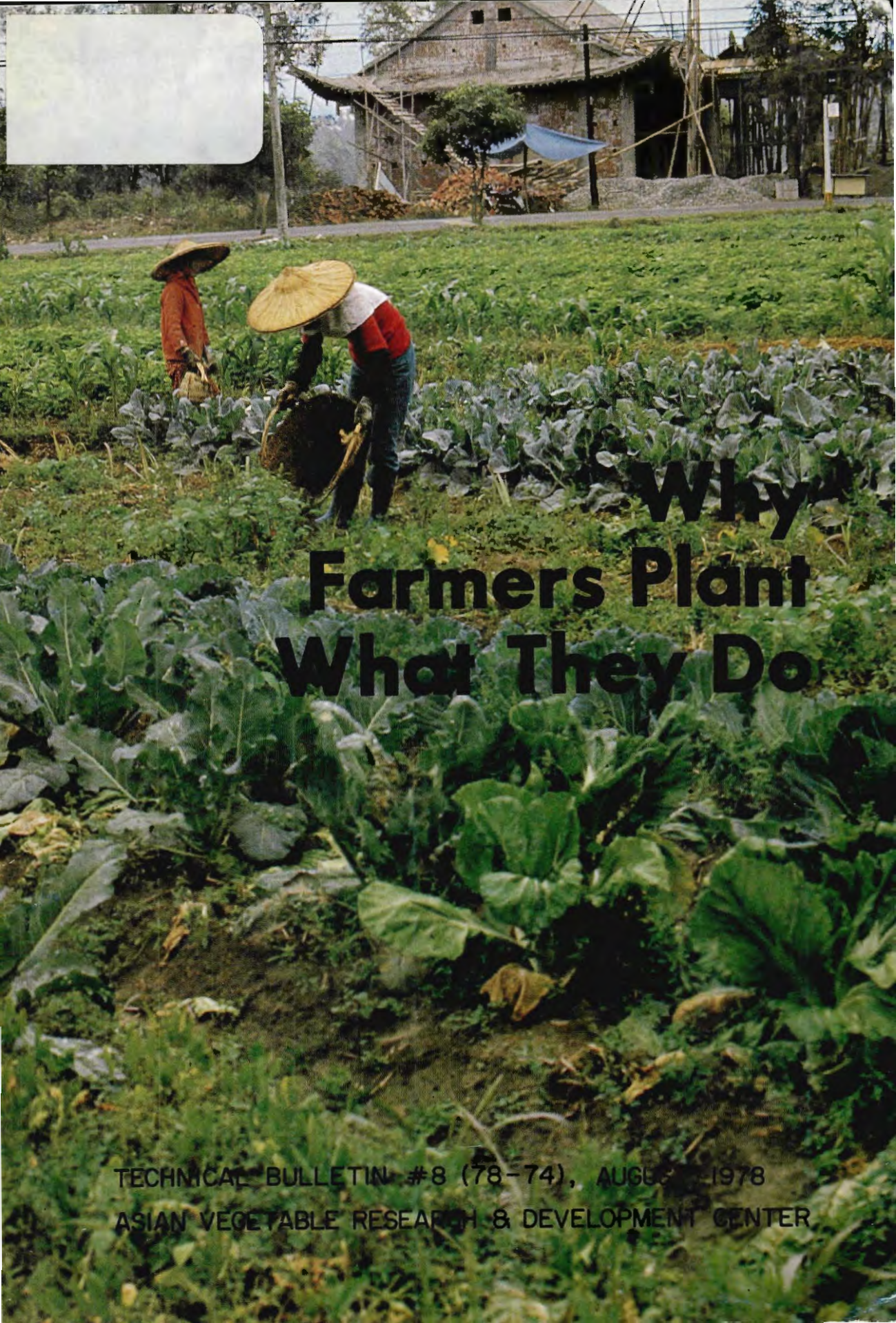

Why Farmers Plant What They Do

TECHNICAL BULLETIN #8 (78-74), AUGUST 1978
ASIAN VEGETABLE RESEARCH & DEVELOPMENT CENTER

Why farmers plant what they do: A study of vegetable production technology in Taiwan

by

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About this report

Data in this report are presented in metric units. Monetary values have been converted to U.S. dollars at the current (May, 1978) exchange rate.

A double asterisk (**) means significant at the 1% level; a single asterisk (*) means significant at the 5% level; and a cross (†) means significant at the 10% level.

Information and conclusions reported herein are solely the responsibility of AVRDC. Additional copies of this report may be obtained by writing The Office of Information Services, P.O. Box 42, Shanhua, Tainan 741, Taiwan, R.O.C. Please quote the publication number.

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Peter H. Calkins

CHAPTER ONE: INTRODUCTION

In planning for the economic development of a developing country's agriculture, it is important to understand the decision-making processes of the farmers who will become the agents of change. All too often, development plans are based solely on regional or national statistics which suffer from poor data collection techniques and the very fact that they must remain averages. Thus they fail to pinpoint the strengths and weaknesses on individual farms dependant on farmer attitudes and decision-making ability. Then, failing to reflect the realities of the local agricultural situation, the development plans collapse, go astray, or succeed marginally. This study will measure these strengths and weaknesses in detail on progressive vegetable farms in southern Taiwan in order to provide a methodology for assessing agricultural development plans.

We chose progressive farms--defined as those with high levels of input intensity and profits--in the belief that those farms with the most successful management within a given agronomic environment have the greatest lessons to teach. Vegetable farms were chosen because, while there is abundant research associated with the introduction of high-yielding varieties of rice, wheat, and/or maize, little research attention to date has been given to the benefits and risks of adopting high-yielding vegetable varieties.[a] We chose Taiwan because it has a tropical location and a range in irrigated and non-irrigated environments similar to those found in other tropical countries.

This study first focuses on the process of adopting selected crops designated for technological improvement by the Asian Vegetable Research and Development Center (AVRDC). These crops--tomato, Chinese cabbage, white potato, sweet potato, soybean, and mungbean--were chosen because of their contributions to income, and their ability to supplement the rice diet with appropriate vitamins, minerals, and plant proteins.

The second focus is the broader question of how farmers make decisions to grow what they do. Unless we first understand why farmers plant vegetables and other crops, there is no way to identify and/or provide vegetable production technology appropriate to their conditions. How do farmers value off-farm work, the evenness of on-farm labor use, the full utilization of resources, the risks involved in embarking on new cropping systems, and the extra capital needed for technological improvements? We hope to answer these and other questions in this study.

Our objectives are to:

1) identify and describe irrigated and non-irrigated agricultural production areas in southern Taiwan, and the general factors which

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[a]We define vegetable crops to include the fruit (tomato), leafy (cabbage), bulb (onion), and the flower (cauliflower) types. Leguminous and root crops, such as mungbean and sweet potato, will be analyzed as field crops.

determine their cropping patterns;

2) measure for 18 sample farms in the 2 areas the role of vegetable cropping in overall production patterns, and the relative profitability of target vegetables and their competing crops;

3) identify the Taiwan farmer's decision-making criteria, and quantify them for 6 farms of different sizes and productive potential;

4) utilize these decision criteria to determine whether further improvements may be made on each of the 6 farms; and,

5) develop and apply a methodology for low-capital research projects (which lack computer facilities) that measures the present and potential roles of selected crops for farms in Taiwan and the tropics.

By adopting a holistic approach, the present project differs from many multiple cropping studies conducted in various countries. The unit of analysis for these studies is the individual plot. The studies measure the increased agronomic and economic returns which may be derived from an improved rotation system. As such, they seek to develop pure packages of technology, and are often based on a designated grain crop as one step in sequential planting.

On the other hand, we address the entire farm as the unit of analysis and seek not to identify optimal levels of inputs and specific crop sequences (although these are recorded in passing), but the underlying principles of farm decision-making behavior and how vegetable crops fit into the conflicting priorities which the farmer must balance.

Figure 1 shows a conceptual model of the farming systems studied. In addition to a crop component, we include livestock, household, and off-farm components; the latter are particularly important in the case of small farms. Each component has flows and interactions with the others, notably capital infusions from off-farm employment, and the exchange of fertilizer and feed between livestock and crops. A farmer must balance all his limited productive resources among these four components in trying to achieve his goals.

THE WORLD OF THE FARMER

Regardless of farm size, managerial experience, or productive resources, farmers throughout the world are made up of physical, psychological, social, and political components which identify them as human beings. Their farm operations are not machines which may be replaced by more efficient models or which, if left unchanged will replicate last year's results this year. This is not only due to the variability inherent in producing crops and animals, but also because of the frequent decisions unrelated to farm production which the farmer makes in his larger role as a human being.

The farmer has varying levels of concern. If we imagine him standing at the base of a three-tiered pyramid, the first step to his ultimate goals is labor, capital, natural environment, and management

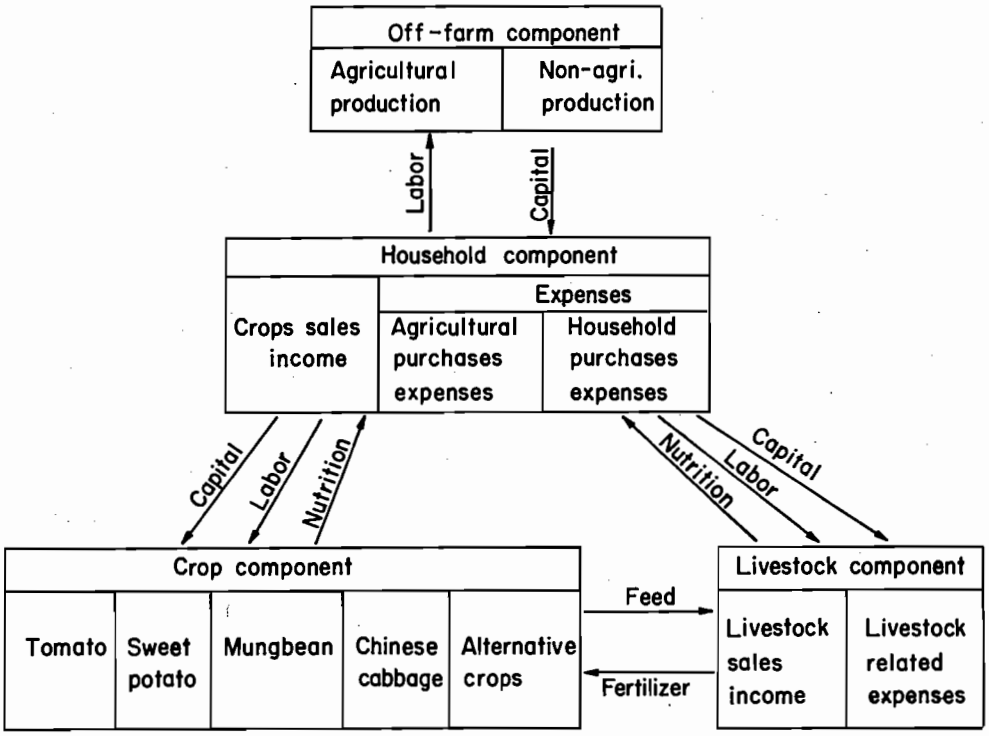

Fig. 1. Conceptual model of the farming systems studied in this project; AVRDC, 1978.

resources. These are the fundamental factors of his farm operation. But they may also be invested in non-agricultural pursuits and, thus, the farm competes with other possible uses of these four resources. The next step is full employment, adequate and growing income, and sufficient nutritional status to maintain himself and his family members. Having achieved these, the farmer may take the final step to wealth, social prestige, and even political power. Unless we understand this concept, addressing the farmer with an isolated change in his farm management may meet with failure.

For this study, we posit that the farmer endeavors to use his resources (step 1) to their best advantage. However, there is a time dimension involved. Given existing technology, farmers in the tropics have gradually developed cropping systems upon which they consider only marginal improvements each year. The management criteria they have considered include to:

1) fully utilize resources already owned on the farm;

2) if resources must be borrowed, invest in enterprises with a high rate of return (both expected and actual);

3) reject those enterprises which are too risky;

4) reject those crops with a limited market;

5) reject those crops which will suffer environmental consequences if grown by only one farmer; and,

6) other things being equal, choose crops with which the farmer already has experience.

Many writers in agricultural development focus on the sixth criterion, and label the farmer "tradition-bound." An alternative hypothesis, which underlies this study, is that the farmer has arrived at a state where all marginal changes are judged on the basis of the sixth criterion, but that the entire framework of the farm is based more importantly upon the other five management criteria. Successful farms reflect these criteria; unsuccessful farmers should re-evaluate their cropping patterns in light of them.

When new technology becomes available, farmers respond in different ways, partly because of their perceptions of risk. Such perceptions are usually diagnosed as psychological, but in fact often depend upon the debt level, family size, experience, and resources available.[a] By choosing a sample of farms with varying resource and managerial configurations, we assess the role of risk in determining cropping patterns.

A NOTE ON CHANGES IN TAIWAN AGRICULTURE

Over the past 30 years agriculture in Taiwan has changed in 2 ways: from tenant farming to owner-operated commercialized farming, with most farm products for sale rather than for household consumption; and second, from labor-intensive to capital-intensive farming with an increased motive for investment and profit rather than for the highest yield per hectare.

Unlimited labor and unconditional growth in production no longer exist in Taiwan. With an increase in migration from the agricultural to the industrial sector, the multiple cropping index has declined and alternative employment has become more important to the farmer. Clothing, food processing, and other industries have been decentralized and their factories spread through the countryside to bring employment closer to the farmer and his family.

This new situation has prompted the government to institute several measures for accelerating rural development, notably improvements in irrigation facilities, transportation, and mass communications to convey market information to the farmer.

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[a]For further discussion of decision-making under conditions of risk and uncertainty, see reference 5.

STAGES OF THE FARMING PRACTICES RESEARCH PROJECT

We used a four-stage procedure in setting up the Farming Practices Project. First, to establish selection criteria for the remainder of the project, we conducted a pre-survey of seven townships in Tainan county. The townships were chosen in proximity to AVRDC to facilitate visits to the daily record-keeping farmers (Fig. 2). We then selected 63 farm families in the 7 townships from previous surveys conducted by the agricultural economics team. The total manpower requirements of this stage were 90 mandays for interviewing and analysis.

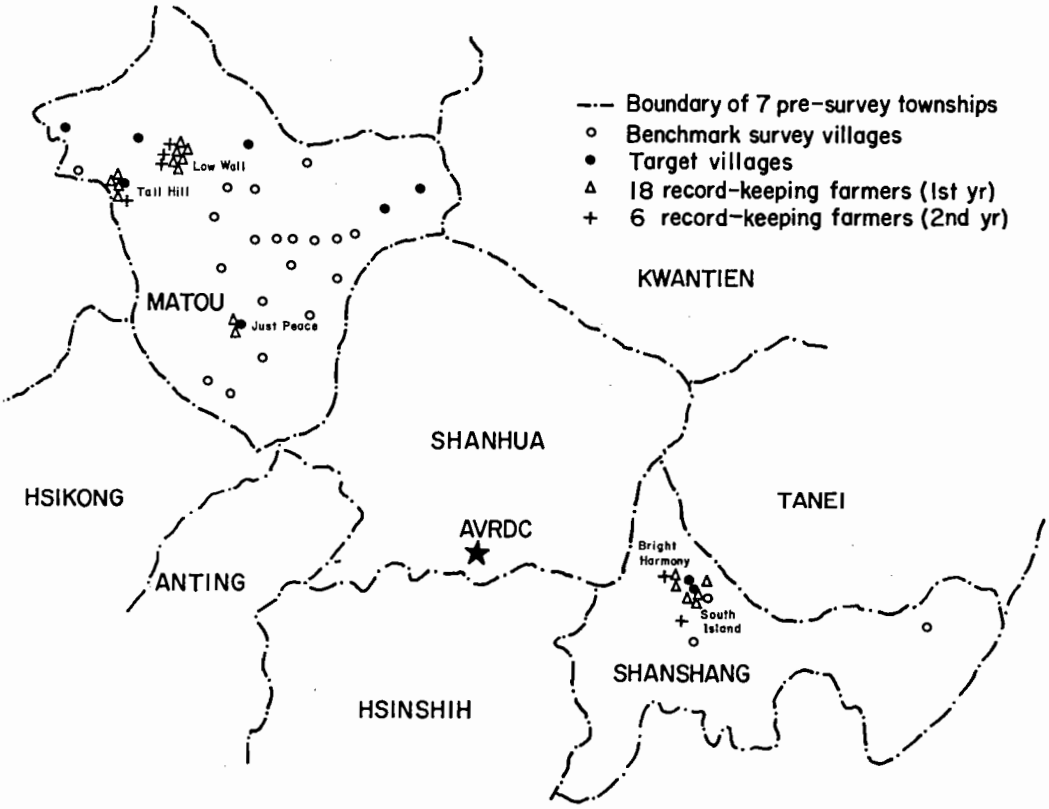

Fig. 2. Distribution of sample households in Matou and Shanshang townships; AVRDC, 1978.

The second stage was a benchmark survey of 130 farm families selected from farmers' association membership lists in two of the seven townships: Shanshang and Matou. We chose Shanshang because it best represented a less irrigated or "upland" area; Matou was chosen because it best represented a well-irrigated or "lowland" area. Lists of the farm population and area of cultivated land allowed us to select a systematic sample of 25 farmers from Shanshang and 105 farmers from Matou, distributed within each township in proportion to population in each village. We used 60 mandays to collect the interview data and make an initial distribution by farm size and cropping pattern.

During the third stage, we selected 18 farmers to keep daily records of all economic activities in the household for one year. These 18 farmers were chosen because they lived in representative villages within the townships (Low Wall, Just Peace, and Tall Hill in Matou; Bright Harmony and South Island in Shanshang), cultivated farms of representative size, grew vegetable and/or root and legume crops, worked at least half-time in farming, and had a family member literate enough to keep farm records. The first year required the full-time work of three and a half members of the survey team.

The fourth stage was selection of 6 of the 18 farmers to participate in the second, more intensive, year of daily record keeping. We selected progressive vegetable farmers in each of three farm-size categories, and one non-vegetable farmer with a medium-sized farm. Because fewer farms were involved, the second year required the full time work of 2¼ persons.

DATA COLLECTION

Figure 3 shows the project's data collection procedure . At its peak, we used only 4 full-time workers from AVRDC: 2 research aides and one research assistant each from the Departments of Agricultural Economics and Crop Management. The 18 farmers were interviewed first about their family size and household resources, farm layout, and long-term production enterprises. We recorded their responses in a Family Data Book. Subsequently, they maintained a diary of their agricultural production activities in a Daily Record Book, checked and tabulated each week by a research aide. An account of their cash flows was kept in a Purchases and Expenses Data Book. We set up an inexpensive meter to measure diurnal temperature variations and humidity in the irrigated and non-irrigated areas, and rainfall data were taken from secondary sources. The four full-time workers did all the tabulations with a desk-top calculator; occasional help came from emergency laborers if the coding fell behind schedule.

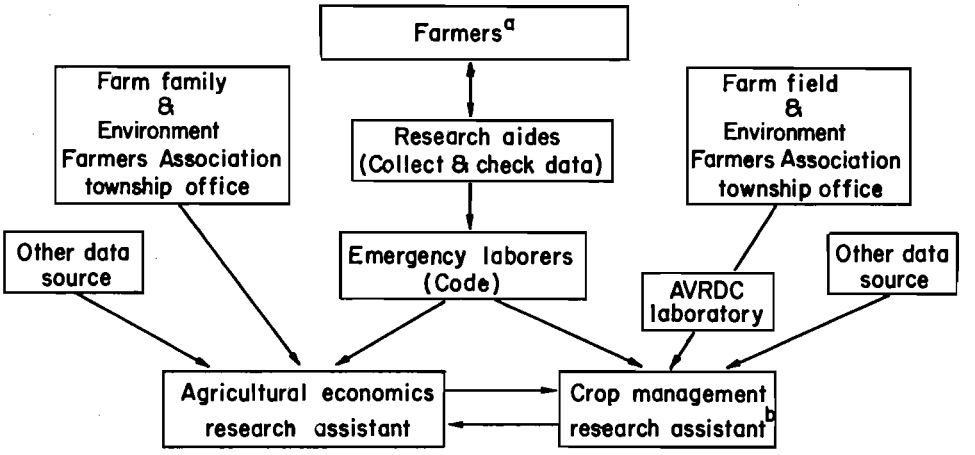

Fig. 3. Data resources and work responsibility, 1976-78; AVRDC, 1978.

[a]Farmers provided information through Family Data Books, Daily Records, and Purchase and Expense Data Books; [b]we also collected temperature and humidity data.

FORMAT OF THE BOOK

Chapter Two deals with a description of the current environment for agricultural production in irrigated and non-irrigated areas of southern Taiwan, and the motivations, problems, and capital assets of farmers in each. Then, a cropping history of the planted area and the relative importance by farm size of selected vegetables and other crops is presented. Production budgets and regression analysis are used to demonstrate the most important determinants of yield and profitability in the target commodities.

Chapter Three discusses the six progressive farmers, the relative importance of their various farm management objectives, and how vegetable crops help them to achieve these objectives. A modification of linear programming is used to assess the current levels of success in reaching their stated objectives, and to determine whether any changes may make these 6 farmers more successful.

Chapter Four summarizes the results and conclusions. We emphasize the use which the methodology and results of this study may have for researchers, extension workers, and government planners in Taiwan and other countries of the lowland tropics.

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CHAPTER TWO: CURRENT VEGETABLE PRODUCTION TECHNOLOGY

Taiwan farmers are well-known for their successful, labor- and capital-intensive cropping systems. Because of short growing season, profitability, and popularity in the Chinese diet, vegetables have contributed greatly to the high levels of land use in Taiwan, which reached a peak average of 1.9 crops/ha per year in 1964.

THE PRE-SURVEY OF FARMERS IN SEVEN TOWNSHIPS ADJACENT TO AVRDC

We interviewed 63 farmers from 7 townships adjacent to AVRDC about their resources, cropping patterns, and constraints affecting farm improvement. Table 1 lists the most frequent responses from 43 of these.

We grouped the seven townships into three irrigation classifications: upland, with a large proportation of upland fields but no rotation or double-rice fields; low-upland, with a wide range of irrigation types; and, lowland, with a majority of rotation or double-rice cropping fields. We noted that as the irrigation potential declines, the size of the farm increases, showing that larger farms are needed to maintain adequate income. However, in lowland farms water is not a constraint. The farmers are exploiting water availability by experimenting with a wide range of vegetable crops, notably tomato and Chinese cabbage, which are the most perishable and have the highest water content.

Table 2 shows the relative importance of various agricultural problems for farmers in the three types of land classification.

Table 2. Farmer responses regarding major agricultural problems in 7 townships of Tainan County, 1976; AVRDC, 1978.

Major Agricultural Problems	Upland	Low/Upland	Lowland	Total
	(N=8)	(N=13)	(N=22)	(N=43)
Wind & rain damage	7	13	21	41
Labor shortage	5	12	22	39
Drainage	4	10	20	34
Pesticide - price	6	9	18	33
- quality	0	0	9	11
Serious disease damage	6	11	13	32
Inadequate roads	7	11	11	29
Irrigation	4	3	2	9
Poor soil quality	2	4	1	7
Seed source	0	3	3	6
Fertilizer shortage	0	4	0	4

Table 1. Farmers' resources, cropping patterns, and constraints affecting farm improvements in 7 townships of Tainan County, 1976; AVRDC, 1978.[a]

Township	Avg. farm size	Avg. of Parcels	Irrigation class: Double rice	Single rice	Rotation[b]	Upland	River-bed	Mountain	Most important reasons for using present cropping system	Species in which farmers would most like to see improvement	Cultivation technique which would provide the most profitable improvements
	-ha-		No. of parcels								
Upland Tanei (N=4)	3.2	5.0	0	1	0	17	0	2	Limited H_2O rotation	mango	improve soil
Shanshang (N=4)	3.3	7.3	0	1	0	26	1	1	Econ. factor[c]	tomato, mulberry, pumpkin	mechanize nematode control
Low upland Kwantien (N=6)	2.8	5.5	7	0	18	8	0	0	Limited H_2O	tomato, greenpea, soybean, seed melon, corn, ornamentals	mechanize improve soil
Hsinshin (N=7)	2.6	5.6	0	0	34	5	0	0	Limited H_2O rotation	tomato, radish, seed melon, carrot	mechanize
Lowland Anting (N=8)	1.5	4.9	0	0	35	1	3	0	Econ. factors[c] rotation	tomato, hot pepper, carrot, string bean, asparagus, watermelon	mechanize intercrop fertilize
Hsikong (N=6)	1.2	5.3	4	0	14	7	7	0	Limited H_2O	tomato, cabbage, carrot, musk-and watermelon	mechanize
Matou (N=8)	1.2	4.1	2	2	21	2	0	0	Econ. factors[c] rotation	tomato	mechanize diversify crops

[a]Responses from 43 of 63 farmers interviewed; [b]2 crops of rice in 3 yrs; [c]High or stable profit, suits available inputs, etc.

We determined from farmer responses that the major differences existed between purely lowland and purely upland farms. Therefore, we selected only two townships for the benchmark survey. Matou and Shanshang were chosen because their cropping systems, water resources, soil fertility levels, and marketing structures best reflected the lowland and upland samples, respectively. Appendix I gives more detailed statistics on temperature, rainfall, soil, and elevation in the two villages.

THE BENCHMARK SURVEY

We interviewed 105 farmers in Matou and 25 in Shanshang. Initial consideration of the survey results for Matou showed that 25 farmers in Low Wall, Just Peace, and Tall Hill had more intensive farm operations in terms of labor and capital input levels than the remaining 80 farmers in Matou or the 25 in Shanshang. Farmers in these villages also grew the crops selected for special study by AVRDC. We selected these 25 progressive farms as target sites.

First, we asked farmers to state their primary goal in farming (Table 3). The largest percentage in all samples listed increased profit. The next most important goal in the Matou non-target and Shanshang farms was stable income each year, reflecting the desire to counter-balance profit maximization. The Matou target farmers, on the other hand, listed increased yield as the second major reason, showing their interest in technological innovation. Indeed, none of the Matou target farmers listed reducing labor requirements or expanding farm size, showing that they were interested in maintaining their man/land ratio and their high level of farming intensity.

Table 3. Farmers' rating of their primary farming goal, Matou and Shanshang, 1976; AVRDC, 1978.

Primary farming goal	Matou Non-target (N=80)	Matou Target (N=25)	Shanshang (N=25)
	----------%----------		
Increase profit from farming	48	52	56
Stable income each year	19	20	20
Increase production/ha	10	28	12
Reduce labor requirements	10		12
Expand farm size	7		
Others	4		
No response	2		

We then determined the attitudes of sample farmers towards various types of off-farm or specialized employment (Table 4).

Table 4. Preferences of Shanshang and Matou sample farmers for various types of work, 1976; AVRDC, 1978.

Type of Work	Matou Non-target (N=80)	Matou Target (N=25)	Shanshang (N=25)
	----------%----------		
Unskilled labor (farm, factory)	22	33	36
Non-agricultural business	20	22	20
Skilled	4	0	0
Cash enterprise (hog-raising)	1	8	4
Others[a]	5	4	12
None	40	33	28
No response	8	0	0

[a]government worker, craftsman, fruit and vegetable seller.

The farmers ranked serious agricultural problems differently by village (Table 5). Labor was a serious problem on the Matou target farms, a reflection on: (1) their slightly larger farm size and slightly lower labor/land ratios; and, (2) their much more labor-intensive use of holdings half the size of those in Shanshang. On the other hand,

Table 5. Percentage of sample farmers mentioning serious agricultural problems in their village, 1976; AVRDC, 1978.

Agricultural problems	Matou Non-target (N=80)	Matou Target (N=25)	Shanshang (N=25)
	----------%----------		
Labor shortage and high wages	29	56	40
Pests and diseases	19	24	40
Drainage	21	20	0
Natural damage (e.g. wind)	10	12	12
Low price of farm products	4	12	16
Irrigation water shortage	2	12	28
Pesticide quality and price	2	4	16
Transportation	4	8	12
Poor soil	8	4	0
Fertilizer distribution and price	4	0	12
Fluctuating income	6	4	0
Miscellaneous	15	16	32
None	8	0	8

Shanshang farmers emphasized problems of pests and disease, lack of irrigation, low price of farm products, and transportation and distribution. Their responses reflect the general situation in upland areas which lie away from major irrigation projects and, hence, have less road development and fewer farmers' associations. Matou target farmers show keener awareness of their problems than the Matou non-target farmers by emphasizing the problems of pests and diseases, low prices, and shortage of irrigation water and transportation. This is not because these problems and services differ substantially in degree of incidence or availability, but because of the greater frustration they cause to more progressive farmers.

Another indication of their progressiveness is the ownership levels of farm machinery (Table 6). Matou target farmers own more power-tillers and hand-sprayers than Matou non-target and Shanshang farmers. Matou target farmers have amassed enough capital to substitute motor-carts for other types of carts. They own fewer chopping machines because they have greatly reduced the area planted to sweet potatoes (the main crop for which such machines are used) in favor of intensive cultivation of higher-value vegetable crops.

Table 6. Ownership of different types of farm equipment, Matou and Shanshang, 1976; AVRDC, 1978.

Farm equipment	Matou		Shanshang
	Non-target (N=80)	Target (N=25)	(N=25)
	----------%----------		
Power tiller	5	20	12
Pumpset - electric	8	8	25
- diesel	56	60	40
Tractor	0	4	0
Motorcart (3 or 4 wheels)	1	4	0
Cattle cart	18	24	36
Hand cart	18	16	8
Sprayer - machine	8	8	8
- hand	76	88	64
Threshing machine	3	4	0
Chopping machine	9	0	0

Table 7 lists, for the 1975-76 crop year, relative crop intensity indices of selected crops and crop groups on farms of varying sizes in Matou and Shanshang.[a]

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[a]Vegetables as a group and specific crops - sweet potato, mungbean, and tomato - were included because we were interested in farmers' experience with one of AVRDC's objectives: improved vegetable production systems. We learned later that some farms also grew Chinese cabbage.

Table 7. Relative Crop Intensity Indices[a] of selected crops and crop groups on farms of 3 sizes in Matou and Shanshang, 1975-76; AVRDC, 1978.

Crop	Matou			Shanshang		
	Small[b] (N=62)	Medium (N=30)	Large (N=8)	Small (N=6)	Medium (N=10)	Large (N=9)
Sugarcane	29	37	36	23	47	41
Rice	22	24	17	6	n.s.	2
Sweet potato	7	9	4	0	0	1
Mungbean	2	1	2	0	0	0
Tomato	3	1	1	6	6	3
Vegetables	12	11	6	0	2	0
Fieldcrops	11	6	11	23	9	7
Fruit trees	9	6	17	41	28	32
Miscellaneous	5	6	7	3	9	13

[a]Defined as:
$\frac{\text{\% of ha - months cropped to a given crop or crop group}}{\text{\% of total ha- months cropped/year}}$ (see reference 19). [b]Small, 0.1-0.99 ha; medium, 1.01-1.99 ha; large, 2.0 and above.

The table shows that for rice, sweet potato, mungbean, and tomato the differences in cropping intensity between lowland and upland are greater than those between farm sizes. At the same time, however, sugarcane and miscellaneous crops show more differences by farm size, and vegetable crops and field crops show distinct differences on the basis of both classifications. To ignore either the differences between small, medium, and large farms, or those between lowland and upland areas would misrepresent the farm sample. Thus, we chose the 18 first-year farms to embody differences between lowland and upland conditions; small, medium, and large farm sizes; and varying intensities of vegetable and field crop production.

THE 18 FIRST-YEAR FARMERS

We reduced objective 2 (page 2) into four sub-objectives to facilitate the analysis of records from 18 farmers who recorded their daily economic activities during the crop year 1976-77. These were to:

1) determine long-term trends in planted area, and the profitability of various crops grown in Matou and Shanshang;

2) compare the profitability of various production technologies for the AVRDC target crops and a major alternative, cauliflower intercropped with limabean;

3) test hypotheses regarding special aspects of vegetable production technology, and the most appropriate level of each for given environmental conditions; and,

4) introduce wherever possible AVRDC target crops for yield and profit comparison with local varieties.

Table 8 shows the coefficient of variation and trends in year to year levels of planted area to selected crops in Matou and Shanshang. In both townships, the area planted to vegetable crops has expanded tremendously. Tomato has been an important contributor, Chinese cabbage has declined slightly, and mungbean has been fairly stable. Soybean has undergone a serious decline in Tainan district because of more favorable soybean growing conditions in Pingtung and Kaohsiung districts to the south.

Table 8. Trends in the area planted to selected crops in Matou and Shanshang, 1966-75; AVRDC, 1978.

	Planted Area			10 yr. statistics		
	1966	1971	1975	C.V.	Avg.	Trend
	ha					
Rice						
Matou	n.a.	n.a.	2082	0.06	2197	-36
Shanshang	n.a.	n.a.	164	0	0	0
Corn						
Matou	183	150	616	0.64	245	+22
Shanshang	90	54	87	0.45	63	+3
Sugarcane						
Matou	817	753	931	0.12	815	+1
Shanshang	333	376	367	0.10	364	+7
Cassava						
Matou	55	269	70	0.50	143	+0.2
Shanshang	232	105	58	0.37	157	-15
Sweet potato						
Matou	1962	2220	1246	0.23	2097	-115
Shanshang	374	336	32	0.26	293	-25
Soybean						
Matou	41	2	1	1.62	17	-6
Mungbean						
Matou	n.a.	n.a.	324	0.14	350	-19
Shanshang	n.a.	n.a.	16	0.15	14	+2
Tomato						
Matou	11	14	133	1.23	30	+8
Shanshang	n.a.	n.a.	172	1.13	77	+84
Chinese cabbage						
Matou	n.a.	n.a.	16	0.17	17	-1
Vegetables						
Matou	353	641	1174	0.46	681	+99
Shanshang	63	50	391	1.15	118	+33

Areas planted to rice and sugarcane have been stable. The areas planted to corn have increased despite wide fluctuations. By contrast sweet potato and cassava have declined significantly throughout Taiwan. The generally low-prestige root crops have been replaced by high-prestige vegetables.

Figure 4 shows the cropping patterns in use on the 18 record-keeping farms in descending order of importance. But, significant differences in relative importance may be observed between Matou and Shanshang. In Matou, with better irrigation, the most popular systems (II and IV) are rice-based with sweet potato, vegetables, and other crops filling in the slack periods. In Shanshang, on the other hand, the most popular systems feature year-round fruit crops, sometimes with short-term intercrops (I and V). Irrigation availability appears to determine the relative importance of these patterns.

There are various cropping patterns in which AVRDC target crops are currently grown :

1) Fresh tomato: II, III, and XII in Matou.

2) Processing tomato: III, VI, VII, and XI in both townships; II in Matou; and, V in Shanshang.

3) Sweet potato: II, IV, VII, VIII, and IX in both townships.

4) Mungbean: IV and VII in both townships; and, XI in Matou.

5) Chinese cabbage: II, III, VII, IX, XII, and XIII in Matou.

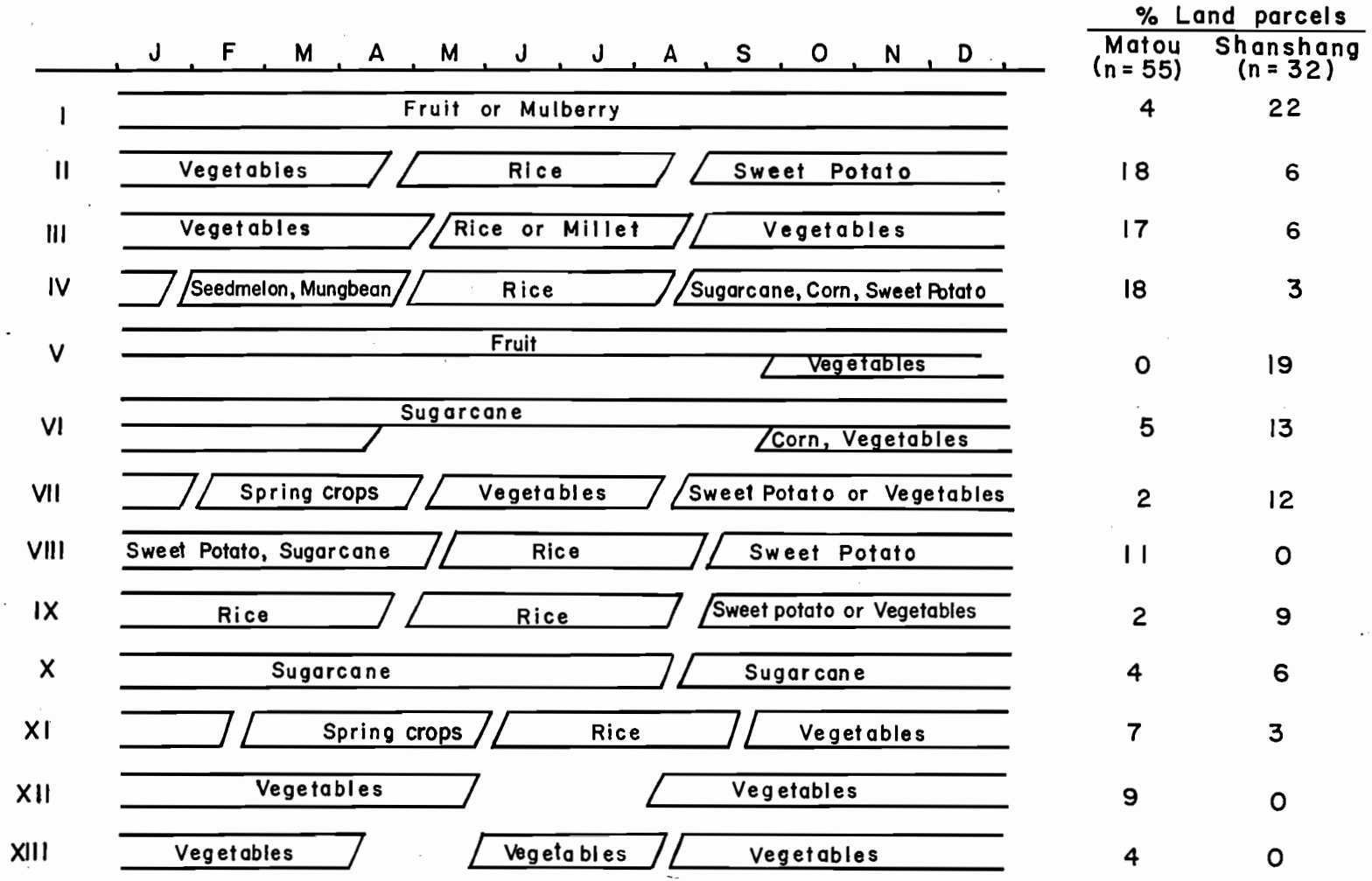
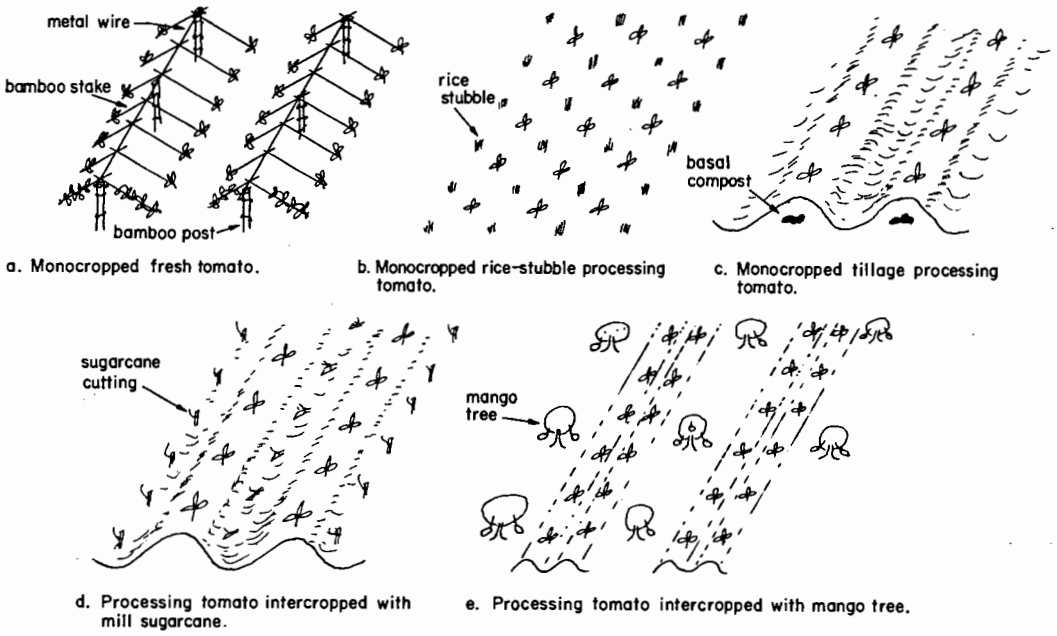


Fig. 4. Major cropping patterns on 18 record-keeping farms in Matou and Shanshang townships, 1976-77; AVRDC, 1978.

TOMATO

Of the 18 daily records keeping farmers, 11 planted tomato during fall on 18 land parcels (Tables 9 and 10). There was a wide variety of cropping methods (Fig. 5): (1) 4 plots to monocropped fresh tomato; (2) 3 plots to monocropped processing tomato planted in untilled rice stubble; (3) 1 plot to processing tomato monocropped after tilling the soil; (4) 4 plots to processing tomato intercropped with mill sugarcane; and, (5) 6 plots to processing tomato intercropped with mango or mulberry trees. Four plots in method 5, had to be abandoned because of poor stands. Therefore, we observed 14 parcels in all.

Some farmers planted pattern 1 because it is the most labor-intensive and, therefore, suitable to small-sized plots for which labor is sufficient. They have had more experience with monocropped fresh tomato than with processing tomato and have developed secure marketing outlets. All farmers in the area planted variety California #1 because it suits local market preferences for large, prodominantly green fruits and, thus, commands a higher price from marketing intermediaries. Because fresh market varieties have indeterminate growth habit, it is necessary to stake the tomato with either bamboo or reeds. This accounts for the high capital and labor inputs. Plant population is also denser and never intercropped. Plots planted in this way usually were near the road to facilitate carrying the crop. The crop is planted at the end of September and harvested every other day over a 95-day period from the middle of December until the end of March, intermediate in length among all the cropping patterns.



a. Monocropped fresh tomato.
b. Monocropped rice-stubble processing tomato.
c. Monocropped tillage processing tomato.
d. Processing tomato intercropped with mill sugarcane.
e. Processing tomato intercropped with mango tree.

Fig. 5. Five methods of planting tomatoes, Matou and Shanshang; AVRDC, 1978.

Table 9. Indicators of agroeconomic efficiency[a] in tomato, Matou, 1976-77; AVRDC, 1978.

	Unit	Fresh Market	Processing
No. of observations		4	3
Variety		California No.1	Roma & UC
Duration	days	176	204
Population	plants	26,325	19,383
Yield	kg	76,778	25,692
Yield/plant	kg	2.9	1.31
Fertilizer cost	US$/ha	286	58
Pesticide cost	"	102	53
Total material cost	"	792	244
Human labor	hrs	6,273	1,424
Human labor cost	US$/ha	2,832	762
Pre-harvest labor, material cost ratio		2.08	1.44
Average farm gate price	US$/t	47(42-50)	46(32-74)
Net return[b]	US$/ha	-415	-99
Net return/day	"	-2.36	-0.49
Farm income[c]	"	2,737	941
Farm income/day	"	15.55	4.61
Revenue/cost ratio[d]		0.90	0.93
Break even point, yield/plant	kg	3.3	1.45

[a]The use of production technology to achieve good agronomic yields and economic returns; [b]Net return = Total revenue - total (including non-cash) costs; [c]Farm income = Total revenue - cash costs; [d]Defined as $\frac{\text{Total Revenue}}{\text{Total (including fixed) Costs}}$

Farmers using pattern 2 plant processing tomato into the stubble of the preceding rice crop at the end of September, and harvest at irregular intervals over a 70 day period beginning in early February and lasting until the end of April. The plant density in rice stubble processing tomato is not as high as in fresh market tomato but higher than in tillage processing tomato. The plot size of rice stubble processing tomato is also intermediate. Farmers adopt this method primarily because wet soil during this season prevents tillage.

A second reason to adopt pattern 2 also applies to patterns 3-5. Tomato processing factories in southern Taiwan have complete programs of extension, provision of seedlings and pesticides, guaranteed prices, and marketing from the farmers' fields. Therefore, although the unit price of processing tomato is lower than that of fresh market tomato, both yield and economic return are much more secure for the latter. The area planted to tomato in the Tainan area has increased significantly over the past 10 years, largely because of the influence of the contractual system between farmers and factories for processing tomatoes. The

Table 10. Indicators of agroeconomic efficiency in processing tomato, Shanshang, 1976-77; AVRDC, 1978.

	Unit	Monocrop	Intercrop with Mango	Intercrop with Mill sugarcane
No. of observations		1	2	4
Variety		T.K.3	T.K.3 & 70	T.K.70
Duration	days	171	111	159
Population	plants	12,000	10,834	13,694
Yield	kg	62,916	11,100	43,284
Yield/plant	kg	5.2	1.04	3.28
Fertilizer cost	US$/ha	29	0	67
Pesticide cost	"	45	7	30
Total material cost	"	211	52	172
Human labor	hrs	2,070	706	1,300
Human labor cost	US$/ha	869	286	540
Pre-harvest labor, material cost ratio		2.16	2.62	1.31
Average farm gate price	US$/t	25	33	29
Net return	US$/ha	354	-46	405
Net return/day	"	2.07	-0.41	2.55
Farm income	"	1,372	248	896
Farm income/day	"	8.02	2.23	5.64
Revenue/cost ratio		1.30	0.89	1.51
Break even point, yield/plant	kg	3.40	1.32	2.08

Matou area has increased at the rate of 8.3 ha/year with a mean value of 30.3 ha. Tomato in Shanshang has only been planted on a wide scale since 1972; however, since then, the annual trend has been to increase the area by 84.0 ha/year.

Suitable soil and the desire to experiment with appropriate plant spacing to maximize yields are reasons farmers adopt pattern 3. Therefore, the tomato is not intercropped. Because soil tillage is necessary, tomatoes are planted in the middle of October and harvested at irregular intervals over 85 days between the beginning of January and the beginning of April.

Patterns 4 and 5 are adopted mainly to fully utilize land already planted to other crops. Thus, the planting density is the lowest, as is the yield per plant. Farmers are interested in increasing the total revenue from the plot, not optimizing tomato culture. In general, intercropping with mill sugarcane is better than intercropping with fruit trees. Four of the latter plots failed to produce any tomatoes. These four all included mulberry trees, among which it was impossible to spray pesticides for disease and insect control in the tomato crop. The tomato is planted from the middle of September to the beginning of October, and harvested 6 times in 95 days between the middle of January to the beginning of April.

Agronomic Relationships in Tomato Production

Although tomato adaptability to soil pH value is very wide, the optimum pH range is 5.5-7.0. The data indicate that tomato performs well in moderately alkaline conditions, producing better quality but thicker skinned fruit than in acid soil. The 2 most popular varieties for the 11 tomato farmers sampled were Kuo-Wang 601 (fresh tomato) and TK-70 (processing tomato), planted in slightly acid (pH 6.0-6.5) to medium alkaline (pH 8.0-8.5) soil. Both achieved good yielding (over 50 tons/ha) from moderate levels of management. At one target village, Low Wall, where soil pH is about 8, the Roma variety is superior to TK-70.

Tomato is also adaptable to various soil textures. We found tomato planted by survey farmers on 6 soil types (the major exception was silty clay loam). With good management tomato produces well on all soils. Two parcels of silty clay loam soil and one parcel of very fine silt loam soil had low harvests because of over-irrigation and poor drainage.

Available potassium in the survey parcels ranged from medium (106-240 kg/ha) to high (>240 kg/ha), while available phosphorus ranged from medium (59-115 kg/ha) to high (>115 kg/ha).

According to Table 11, nitrogen appears an important limiting component in tomato yields at Shanshang and Matou. Regression analysis shows a significant correlation between nitrogen fertilization and yield. Generally, Taiwan agricultural soils contain 0.1-0.2% total nitrogen; however, the content of our surveyed farmers' tomato fields ranges only from 0.05-0.13% N. Thus, additional nitrogen fertilizer is especially important to their tomato production.

Fruit worms and diseases such as late blight, powdery mildew, tomato bacterial wilt, leaf mold, and grey leaf spot perenially cause substantial losses in yield. The more successful farm managers control pests according to the calendar rather than waiting for signs of pest incidence.

Table 11. The relationship between added nutrients and yield on 12 plots of processing tomatoes, Shanshang and Matou, 1976-77; AVRDC, 1978.

Yield	Fertilizer Applied N	P_2O_5	K_2O
-ha-	--------kg/ha--------		
97.2	722	60	0
78.6	210	65	0
76.1	583	62	33
70.4	100	69	114
62.9	28	21	36
57.0	131	39	0
47.9	47	12	24
37.5	33	0	0
34.0	89	60	0
24.0	157	21	43
19.0	108	56	50
17.3	105	36	60
Correlation with yield (r)	0.66[a]	0.43	-0.12

[a]Significant at the 5% level.

Conclusions Regarding Fresh Market Tomato

1) The higher the yield, the higher the net return. This is a

concern of profit-oriented farmers in southern Taiwan. Because there were only four observations, regression analysis is difficult; however, simple plotting suggests this conclusion.

2) The higher the investment in total material costs, especially those for fertilizer, the higher the yield over the sample range. Again, simple plotting shows a trend of higher yield from increased investment. Farmers also stress the importance of fertilizer in total costs, between which the correlation is strong (r=0.94). Analysis of the data suggests that the use of micro-elements such as copper, molydenum, zinc, and iron is particularly important in elevating yield. The two farmers who used such micronutrients achieved an average yield of 3.2 kg/plant, versus 2.6 for those who did not.

3) Addition to total labor do not consistently lead to higher agronomic yield and net return. In contrast to the situation for capital inputs, simple plotting reveals no trend between labor and either yield or profit. Indeed, growers told us that they used extra labor to assure the careful handling and aesthetic appearance of their crop. It was the older farmers with small-sized farms who spent the most unnecessary time in the field. In terms of strict profit, we might advise such farmers to go home early, but we must also note the importance of the noneconomic considerations mentioned in Chapter One.

4) A good agronomic yield is not acceptable economically. Consultation with crop management specialists showed that a yield of 2.4 kg/plant is acceptable in terms of using the plant's productive potential. However, since the price of output in the spring of 1977 was US$47/t and production inputs and technology were relatively fixed, farmers had to achieve a yield of 3.3 kg/plant to break even. This is partly because the price of output has fallen from a level of US$58 in 1973. Indeed, one farmer who had a good agronomic yield of 3.0 kg/plant actually had negative net returns. The declining trend in output price also helps to explain why the area planted to fresh market tomato has not increased while that of processing tomato has climbed steadily. Furthermore, the benefit/cost ratio declines for the crop if it is planted more than one year in the same plot (from 1.1 in the first year to 0.7 in the third year.) One farmer believed that yield could be maintained by investing more in fertilizer. However, the necessary break even point in yield/plant would increase even further. Therefore, fresh market tomato production is a tightrope which farmers must walk with some skill.

5) Farmers who harvest early are able to increase their profits because of favorable price without necessarily increasing agronomic yield. Figure 6 shows the selling and revenue patterns of Farmer Lee, who was able to capitalize on high price in the early part of the season. Despite the fact that Farmer Lee had lower yields than a neighbor, he captured a higher average price (US$50 vs 47), and, therefore, narrowed the gap between the total revenue on the two farms. This principle is more influential in such crops as cauliflower and limabean, which have greater price fluctuations during the season. In processing tomato, those farmers who sell directly to the market are interested in early varieties to take advantage of high price.

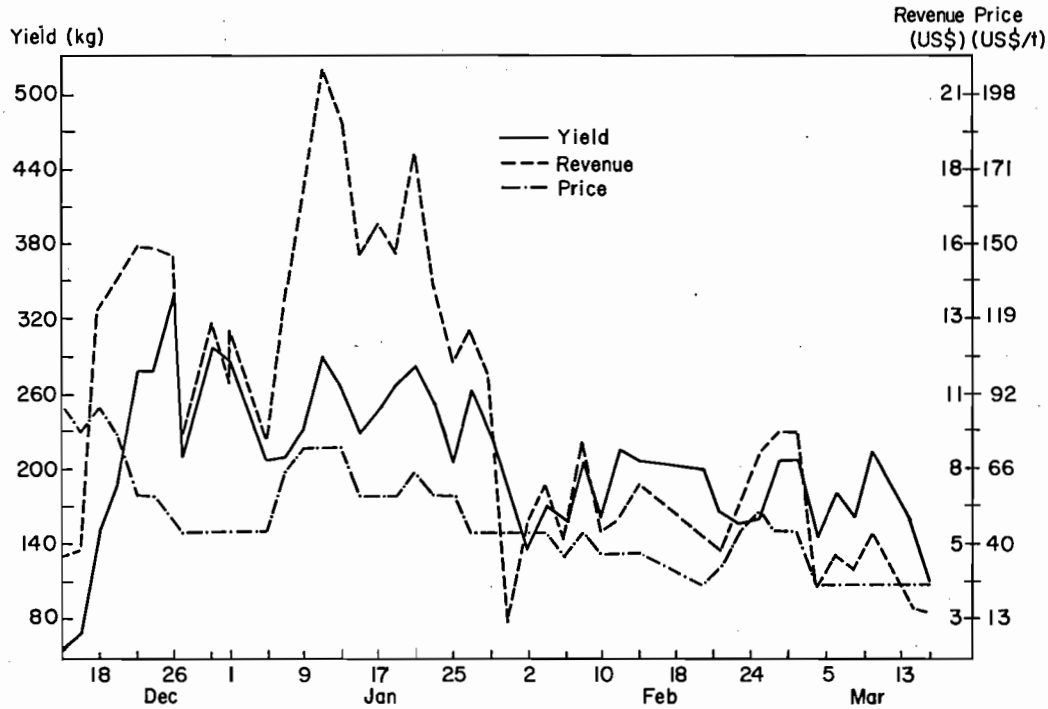


Fig. 6. The relation between selling data and revenue for Farmer Lee's fresh market tomatoes; AVRDC, 1978.

Conclusions Regarding Processing Tomato

1) In processing tomato, as with fresh market tomato, the higher the yield the higher the net return. Since there was only one pattern-3 farm, we added two neighboring farms to the sample, enabling us to make inferences about pattern 2-4. Regression analysis (Fig. 7) showed that, for the combined sample, r=0.67, significant at the 10% level. The slope indicates that for every one-ton increase in yield, processing tomato growers may expect to earn US$16.

2) The higher the investment in total material costs, the higher the yield. This relationship holds, however, only for pattern 2. Moreover, in contrast to fresh tomato, there is no evidence of the positive impact of fertilizer costs (except to N) on yield under any cropping pattern (Table 11).

3) The higher the inputs of labor, the higher the agronomic yield and net return. For processing tomato, unlike fresh tomato, these relationships are significant (Fig. 8). There are also strong correlations by individual method. The slopes suggest that for method 2, every 8 hours of additional labor input increases yield by 96 kg and net return by US$6.31 and, for pattern 3, 133 kg and US$4.61. For pattern 4, yield increases by 544 kg, but there is no significant change in net return.

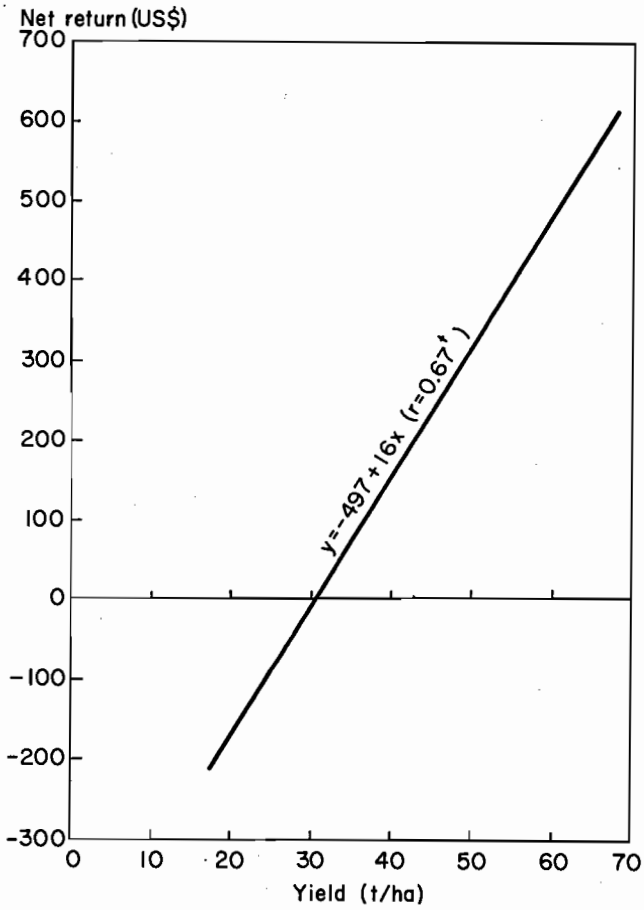


Fig. 7. The effect of processing tomato yield and net returns, winter, 1977; AVRDC, 1978.

4) A good agronomic yield is economically profitable. The break even point under current technology employed by the farmers is 2.05 kg/plant, well below an agronomically good yield (3.1 kg/plant). Farmers using pattern 2-4 achieve yields of 2.2, 2.5, and 3.3 kg/plant, respectively, one reason for the rapid increase in area planted to processing tomato in the region.

5) Monoculture tillage gives the best yields to processing tomato. Tables 9 and 10 show that pattern 3 has the highest yield per hectare, largely because of the benefits from land preparation and lack of competition with other intercropped species. However, pattern 4 gives higher net return because it requires fewer inputs, notably weeding, irrigation, and land preparation.

Pattern 5: A Special Problem

Two of the six Shanshang farmers participating in the first year of record-keeping raised tomato as an intercrop with mango, but

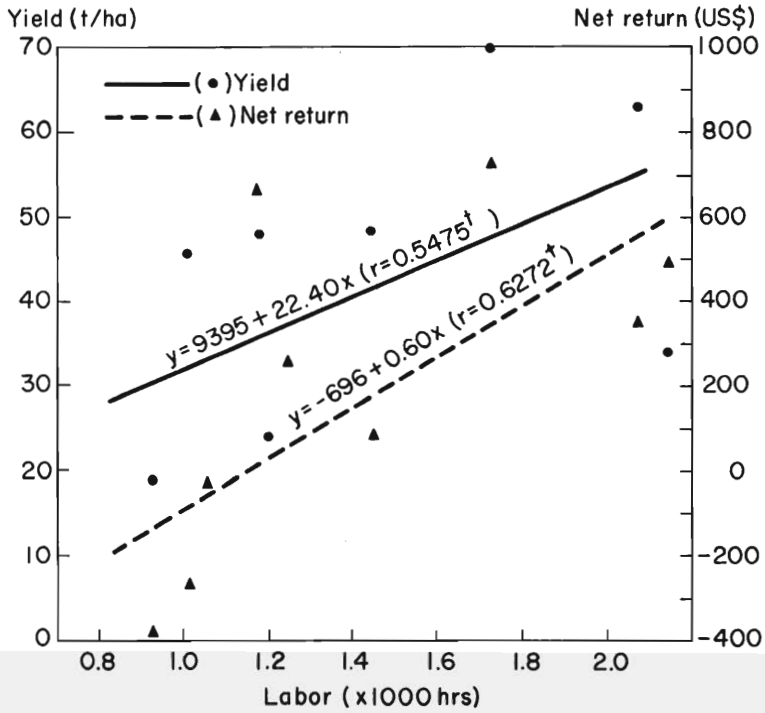


Fig. 8. The effects of labor hours on processing tomato yield and net return, winter, 1977; AVRDC, 1978.

yield, net return, and farm income were well below that of other cropping Patterns for processing tomato. This particular cropping pattern is widespread. Therefore, we conducted and in-depth study in 1977 of such farmers to understand better their decision-making processes and determine how, if at all, crop yield and profitability might be enhanced. Since there were only 2 farmers (out of 18) who adopted this method, we expanded the sample to 15 by including 13 farmers who grew processing tomato on contract to local factories. However, when the expanded sample was used to construct revised production budgets (Table 12), pattern 5 still had the lowest yields and returns.

Table 12. Production costs and revenue for processing tomato, 1976-77; AVRDC, 1978.

	Intercrop with mango (n=15)	Intercrop with sugar-cane (n=4)	Monocrop (n=1)
YIELD (t)	23.9	43.3	62.9
REVENUE (US$)	621	1,202	1,546
Expenses			
Materials:			
Seedlings	36	35	30
Fertilizer - organic	0	11	0
- chemical	40	56	29
Pesticides	69	32	45
Power source	38	33	95
Miscellaneous	31	5	12
Subtotal	214	172	211
Labor:			
Bed formation & land preparation	14	12	20
Transplanting	26	44	32
Fertilization	8	12	5
Intertillage & weeding	41	63	203
Pesticide spraying	121	69	91
Irrigation	15	26	106
Harvesting	179	313	413
Subtotal	404	539	870
Others:			
Interest on capital	8	19	30
Interest on land	51	42	51
Land tax	30	24	31
Subtotal	89	85	112
TOTAL	707	796	1,192
NON-CASH	452	491	1,019
NET RETURN	-86	405	354
FARM INCOME	366	896	1,372

We were interested in learning more about the farmers' motivations. Table 13 shows the characteristics of land and labor use on the 15 farms. The smaller the farm, the larger the number of full-time workers per hectare, hours worked per week, and the multiple cropping index.

Table 13. Farm management indices for the 15 sample farms, 1976-77; AVRDC, 1978.

Farm Size (ha) Range	Avg.	Workers/ha	Farmwork hr/wk/ha	Multiple Cropping Index[a]	Mango planted area Total % Farm area	With Tomato % Mango area
0.5 & below (n=4)	0.25	4.2	86	215	84	100
0.51-1.00 (n=4)	0.90	1.7	76	172	41	86
1.01-1.50 (n=2)	1.10	1.8	95	176	45	100
1.51-2.00 (n=1)	1.60	1.2	69	144	12	100
2.0 & above (n=4)	2.71	1.2	59	138	38	67

[a] No. of $\frac{\text{crops grown/year}}{\text{ha}}$ x 100.

This shows that small farms involved more management per unit area than large farms. Moreover, the area planted to mango trees depends positively on farm size but at a declining rate. This suggests that management of the orchard is more intensive than the average for total farm management. One reason for the high intensity of orchard management is that almost 100% of the mango is intercropped with processing tomato. Thus, farmers adopt pattern 5 to help increase the management intensity of their orchards.

Farmers also listed the following motivations for adopting pattern 5:

1) To even labor peaks. The harvest period of mango falls between July and September. Afterward, except for annual spraying and pruning, labor inputs slack off drastically. By intercropping processing tomato, which is harvested over a long period in the spring, farmers are able to utilize their family labor more fully.

2) To fully use land. Especially when the mango trees are small, intercropping tomato permits fuller use of the land. However, when the trees mature the shading effect is a contributor to the low tomato yields achieved.

3) To increase farm earnings. The more crops a farmer can manage - provided they are all profitable - the more money he can make and the less risk he encounters.

There are many alternative crops which could be grown in the same way as tomato intercropped in mango: sweet potato, peanut, corn, pumpkin, green pepper, and yard-long bean. Farmers report that they plant tomato because of the guaranteed price system offered by processing factories, the ideal height of tomato (in comparison with, say, corn), and the fact that their neighbors planted it with acceptable results.

Figure 9 shows the general schedule of cultivation practices in pattern 5. Despite the uniformity of this schedule among the farms,

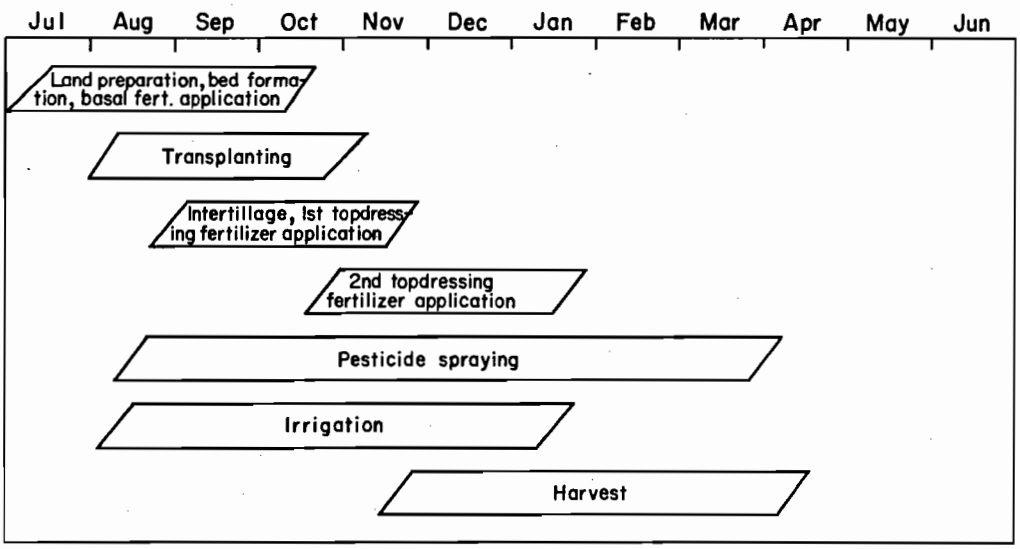


Fig. 9. Schedule of crop management operations on tomato intercropped with mango, Shanshang, 1976-77, AVRDC, 1978.

there was a wide range in the intensity of various operations and, therefore, in yield and return.

Through regression analysis of the individual cost components for 15 farms, we found that, although there was no significant effect of fertilizer cost level on yield, the use of chemical pesticides had a clear effect on output per hectare (Fig. 10). To determine the optimum pesticide management level, we divided spraying capital and labor into three management categories and discovered consistent relationships only with the box outlined in Table 14. Although highest yield is obtained at maximum levels of labor and pesticide input, consistent yield increases are achieved only up to the point where pesticide costs are US$54-105 and labor costs are US$80-158. The effect of pesticide management level on farm income shows a similar pattern.

When we evaluated the effect on yield of increasing total preharvest costs (Fig. 11), we found a significant impact, especially to additional labor when material inputs are fixed at $265-395.

From our analysis of processing tomato intercropped in mango orchards, we drew the following conclusions:

1) Farmers adopt this cropping pattern mainly to utilize more fully their land and family labor resources, and to add to their cash income.

2) Production practices in the intercrop with mango are similar to those in the monocrop and intercrop with sugarcane; but, because of an adverse physical environment, yield, net return, and farm income are much lower.

3) There is no close relationship between fertilizers applied and yield; therefore, lower levels of fertilizer application can reduce input costs without significant yield loss.

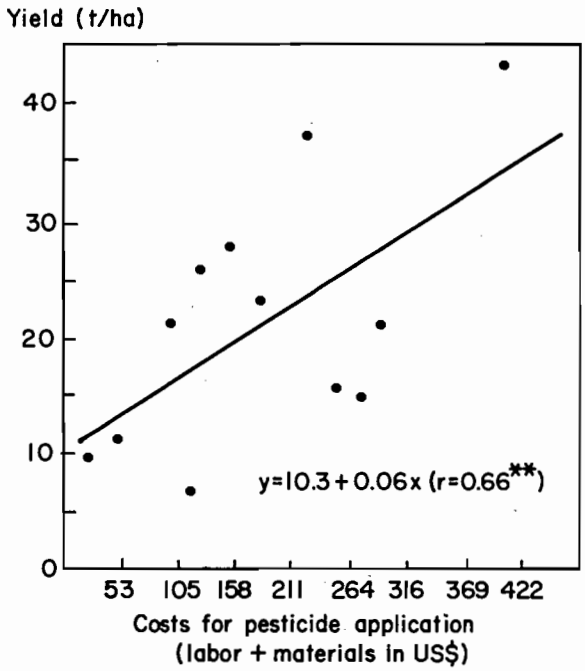


Fig. 10. The relationship between pest control cost and tomato yield, 1976-77; AVRDC, 1978.

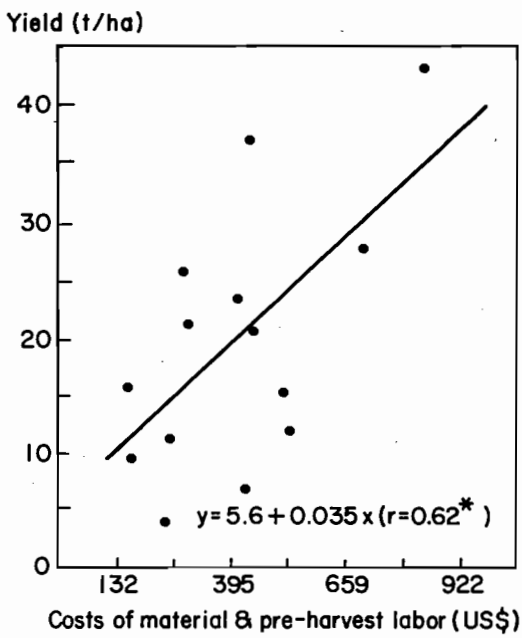


Fig. 11. The relationship between pre-harvest costs and tomato yield, 1976-77; AVRDC, 1978.

Table 14. The effect of pesticide management level on intercropped processing tomato yield, 1976-77; AVRDC, 1978.

		Value of pesticide (US$)			
		0-53	54-105	106-158	
Spraying labor (US$)	0-79	12.2 (N=6)	16.4 (N=2)		Yield (t/h)
	10-158		29.4 (N=3)		
	159-264	21.1 (N=1)	13.9 (N=2)	43.1 (N=1)	

4) The most economic level of pest control expenditures is $54-105 for chemicals and $80-158 for labor.

5) As production costs increase, net profit declines but farm income rises. Therefore, processing tomato intercropped with mango is profitable when farms have unemployed family labor.

SWEET POTATO

Sweet potato was grown on the 18 farms in 3 different ways (Table 15):

1) Rice-stubble method. After harvesting the rice, sweet potato stem-cuttings are planted near the stubble. As it requires no tillage, this is a minimum input technique. Crop duration is from late September to early April. The main motives for adopting this method are: the soil is too wet and sticky to be cultivated, farmers want to plant as early as possible, and they want to economize on labor use. Thus, farmers adopting this technique are interested in extra income at low cost, rather than maximum yields. Some farmers are even willing to harvest a partial crop in early March to allow time to plant a successive spring crop, showing their concern with economic gain. It is, however, necessary to inter-cultivate and make mounds, so the total labor is still significant.

2) Tillage method. The tillage method crop is planted about 2 weeks later than the rice stubble method, depending on the moisture level in the soil. The soil must be dry to be cultivated. As this is a higher input technique, farmers hope the extra effort will bring higher than proportional returns. Many are intent on high sweet potato yields for sale to starch factories. Their yields tend to be the highest of the 3 methods. Therefore, they plant the varieties designated by the factories as most suitable for processing. Some farmers, as with the rice-stubble method, harvest early so they can plant a subsequent mungbean or other spring crop. The method is the most common fall sweet potato cultivation technique practiced throughout Taiwan.

Table 15. Indicators of agroeconomic efficiency in sweet potato, Matou and Shanshang, 1976-77; AVRDC, 1978.

	Unit	Matou Culture Method			Shanshang[a]
		rice stubble	tillage	Intercrop	tillage only
No. of observations		5	9	1	3
Variety		New 31	Tainan 14 & New 31	New 31	New 31 & Tainan 15
Duration	days	192	176	211	191
Population	plants	38,032	38,242	33,333	33,509
Yield	t	16.9	29.5	20.0	19.2
Yield/plant	kg	0.44	0.77	0.60	0.61
Fertilizer cost	US$/ha	111	139	0	29
Pesticides cost	"	6	0.70	0	4
Total material cost	"	301	385	94	210
Human labor	hrs	637	876	733	766
Human labor cost	US$/ha	316	425	262	285
Pre-harvest labor/ material cost ratio		0.70	0.75	2.00	0.73
Average farm gate price	US$/t	35	35	38	39
Net return	US$/ha	-316	-67	13	128
Net return/day	"	-1.65	-0.38	0.06	0.67
Farm income	"	189	490	519	458
Farm income/day	"	0.98	2.79	2.46	2.40
Revenue/cost ratio		0.65	0.94	1.02	1.21
Break even point yield/plant	kg	0.82	0.80	0.58	0.54

[a]Farmers in Shanshang adopt the tillage method because they have less rice planted and because of irrigated sandy loam soils with good drainage.

3) Intercrop with corn and edible sugarcane. The farmer's main crop in this pattern is sugarcane, but since factories do not buy mill sugarcane which has been intercropped with sweet potato, farmers plant edible rather than processing varieties. Although complex as a whole, the amount of inputs required for sweet potato is the least of the three methods. However, labor is intermediate among the three methods to make sure that sweet potato does not adversely influence the other crops. Because of the generally low input, yields are also intermediate, but profit is highest.

Table 8 shows that in both Matou and Shanshang, there has been a steady and declining trend in the area planted to sweet potato over the past ten years. The average rate of decline in Matou is 5.5% from a much higher base, while the rate of decline in Shanshang is 8.5%. These percentages agree with the general decline in sweet potato area throughout Taiwan since 1971.

Agronomic Relationships in Sweet Potato Production.

Sweet potato tolerates low pH and the optimum pH range is from 5.5-7.0. There were, however, 5 parcels of sweet potato in our sample in which the soil pH values were over 8, one of which produced about 35 t/ha.

Among the 3 soil types found on the 18 sweet potato parcels, fine sandy loam and high silt loam soil achieved higher yield than silt clay loam. Sandy loam and silt loam soil produced well-shaped tubers while silty clay loam soil produced many which were misshapen.

In both Matou and Shanshang, available phosphorus is very high (>115 kg/ha) while available potassium ranged from medium (106-240 kg/ha) to high (>240 kg/ha). From yield data (Table 16), we found that increasing the application of potassium and phosphorus fertilizer had no significant effect on yield (r=0.02 and 0.05, respectively).

Total soil nitrogen ranged from 6-18% and applications of 100 kg/ha seemed to bring about a yield response. However, many farmers used excessive levels of N (4 applied more than 200 kg/ha), so that there was no significant correlation between this factor and yield for the whole sample.[a]

Table 16. The relationship between added fertilizer and yield in sweet potato, Shanshang and Matou, 1976-77; AVRDC, 1978.

Yield	Fertilizer Applied			
	N	P_2O_5	K_2O	Compost
-t/ha	---------kg/ha--------			-t/ha-
46.8	107	53	80	30.0
36.8	217	41	81	0
34.8	67	58	192	24.0
29.3	115	66	0	45.5
28.9	155	22	43	0
27.5	105	262	227	0
25.2	128	64	96	0
23.6	28	21	36	0
23.3	239	60	100	0
23.1	0	0	0	0
21.8	0	0	0	0
20.3	115	83	165	12.9
19.4	73	63	130	0
17.0	20	100	0	0
11.4	211	18	36	0
10.8	56	72	80	0
7.5	266	51	184	0
Correlation with yield(r)	-0.08	0.05	0.02	

Most of the survey farmers irrigated once at the root formation or enlargement stage. However, only 3 parcels received pest control treatments (1-2 treatments total).

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[a]This finding confirms the conclusion (AVRDC Tech. Bull. #4) that farmers in Taiwan use too much fertilizer on sweet potatoes.

Conclusions

From agronomic relationships, production budgets, and simple regression analysis, we drew the following conclusions:

1) The higher the yield, the higher the net return. Figure 12 shows that, for both the combined sample and the rice-stubble farmers in Matou, this relationship holds. For every one ton increase in sweet potato yield, the combined sample may expect US$17 and the Matou rice-stubble farmers US$55 in increased profits. The much lower levels of correlation between yield and net return in the Shanshang and Matou tillage samples (r=0.62 and 0.44, respectively) suggest that added costs in these subsamples do not result in higher yields with sufficient regularity to guarantee increased net return..

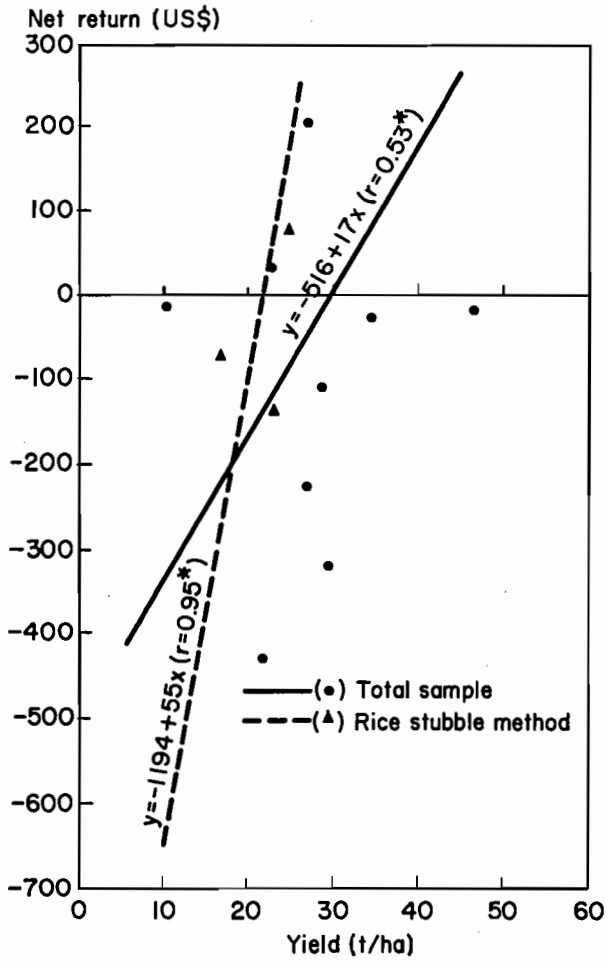

Fig. 12. The effect of sweet potato yield on net return, rice stubble method and total sample, 1976-77;AVRDC, 1978.

2) There is no significant relationship between capital inputs (notably fertilizer) and yield. Therefore, in contrast to the contribution of fertilizer and material costs to yield and net return in

tomato, farmers may be applying excessive capital inputs to sweet potato. Table 15 suggests that increases in capital up to the average of the Matou tillage method farms (US$385) lead to increases in yields. The tillage group with the highest yields also has insignificant pesticide costs, suggesting that rice-stubble and intercrop farmers could use no pesticide in the interest of reducing input costs.

3) The higher the investment in human labor, the higher the yield. Figure 13 shows a significant relationship between these two factors for the combined sample. For every extra 8-hour day of labor input, yield increased approximately 130 kg/ha. Unfortunately, because of high wages and low sweet potato prices in Taiwan, the increase in yield results in negligible profit; and there is no significant relationship between labor input level and net returns.

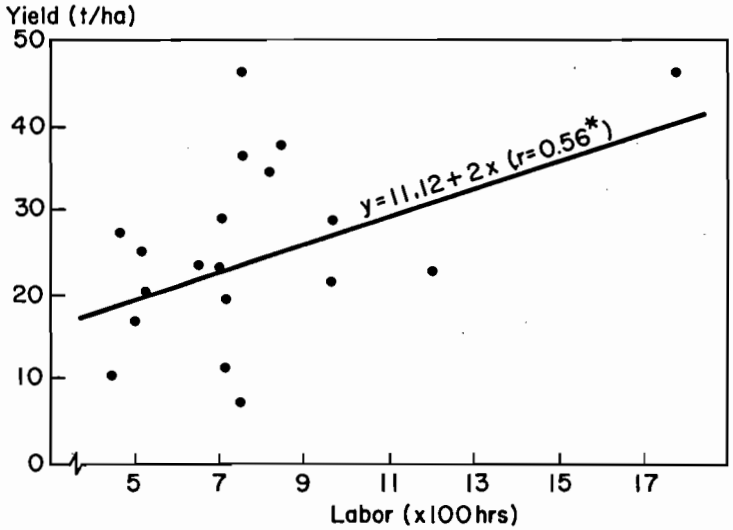

Fig. 13. The effect of labor hours in sweet potato production on yield, 1976-77; AVRDC, 1978.

4) The most labor-intensive operations are planting and harvesting, regardless of cultivation method. For the rice stubble tillage and intercrop methods in both Shanshang and Matou, the most intensive use of labor is made at planting (21-25% of total labor) and harvesting (31-49%).

5) Regardless of cultivation method, sweet potato is less labor and capital intensive than alternative vegetable crops which may be grown in the fall. These alternatives are tomato (Table 9 and 10) and cauliflower intercropped with limabean (Table 21).

6) The highest net and farm return are associated not with high yield but with low cost. Table 15 shows that although the intercrop

method gives only intermediate yields, it has the lowest cost, particularly in capital investments. Therefore, it provides the highest farm return, net return, and revenue cost ratio, and the lowest yield per plant necessary to break even.

7) There is a strong impact of agro-economic environment on sweet potato yield and profitability. The Matou farms yield much higher with the tillage method (Table 15); but Shanshang farms have more favorable net return, revenue/cost ratio, and break even point because of high price and low human labor costs.

MUNGBEAN

Farmers used two cultivation methods for mungbean (Table 17): four monocrop plots and one plot intercropped with sugarcane (pattern VI, Fig. 4). The intercrop is relatively less intensively cultivated than the monocrop, but all five plots have generally low input levels. All the farmers had more than 10 years experience with mungbean, but its importance in their cropping systems is slight.

Table 17. Indicators of agroeconomic efficiency in mungbean, Matou and Shanshang, 1976-77; AVRDC, 1978.

	Unit	Matou monocrop	Shanshang mono- & intercrop
No. of observations		3	2
Variety		2007, 2184, 1381,& local	2007, 2184, & local
Duration	days	69	87
Population	kg seeds	28.26	33.05
Yield	kg/ha	592	532
Yield/kg seeds	kg/kg seeds	20.95	16.10
Fertilizer cost	US$/ha	42	0
Pesticide cost	"	15	11
Total material cost	"	136	45
Human labor	hrs	664	616
Human labor cost	US$/ha	288	326
Pre-harvest labor, material cost ratio		1.52	4.58
Average farm gate price	US$/t	597	818
Net return	US$/ha	-174	17
Net return/day	"	-2.52	0.20
Farm income	"	146	362
Farm income/day	"	2.12	4.16
Revenue, cost ratio		0.67	1.04
Break even point, yield/kg seeds	kg	31.23	15.48

Monocrop mungbean is planted at the beginning of March and harvested at the end of May. Because the standing sugarcane does not have to be harvested first, mungbean can be planted earlier in the intercrop pattern to allow more time for full growth. However, during 1977 mungbean planting on the three Matou monocrop plots was delayed when the sugarcane was machine-harvested by the mill later than usual. As a result, many of the monocrop plots suffered flooding on June 7, a date by which they normally would have been harvested. Thus, limited field time often determines the fate of the mungbean crop, and any technique which secures sufficient time for the harvest is important.

Early-maturing varieties offer one such technique. This year, all four monocrop farmers planted AVRDC early-maturing test varieties (55-60 days) to compare with local varieties (70+ days). The AVRDC varieties and one local variety planted in Matou were all harvested before the flood. Although AVRDC varieties had slightly lower yields than the local varieties on plots where they both could be harvested, farmers preferred AVRDC varieties because of the security that at least some of the crop would be harvested.

One Shanshang farmer intercropped with sugarcane to more fully utilize his land and gain additional income. The other farmers used a monocropping system for income and soil enrichment. Alternative crops included millet, maize, and rice, but farmers were afraid that such crops might deplete the soil of vital nutrients and adversely affect the following summer rice. Mungbean is a legume and will not deplete the land of existing soil nitrogen.

After the harvest, farmers reported that AVRDC variety 2184 was the best early-maturing variety, especially since it could produce on poorly drained soil. They recommended breeding mungbean varieties for light green rather than black seed coat color, larger seeds, and harvest uniformity.

Matou farmers sprayed an average of three times to control caterpillar, cabbage worm, powdery mildew, aphid, and leaf spot. But in Shanshang, farmers did not spray, largely because of the lower levels of pest incidence. In Shanshang, no fertilizer was used; but in Matou, farmers applied a basal fertilization of N, P, and K. Cultivation practices included land preparation, pesticide spraying, fertilization, banking, and harvest.

Table 8 shows that planted area in Shanshang is increasing steadily by 10% per year from a base of 12.5 ha in 1972. This partially reflects the relatively flood-free conditions prevailing in the upland area. However, the planted area in Matou is decreasing by 6% per year on a base of about 350 ha in 1972, showing that Matou farmers are decreasing the area planted to mungbean because of better alternatives.

From our data, we drew the following conclusions:

1) The main factor determining yield and profitability is natural conditions. Table 17 shows that farmers in Shanshang did not intend to strive for the highest yields. Their investments in all types of capital

and labor hours devoted to the crop were less than in Matou. Yet unfavorable weather reduced yield and crop quality in Matou. Therefore, the Matou farmers' net return, farm income, and revenue/cost ratio were less than those of the Shanshang farmers.

2) AVRDC varieties have both higher yield and profit than local varieties in Matou but not Shanshang (Table 18). The extremely adverse weather conditions in Matou prevented harvest of the late-maturing local varieties.

Table 18. A comparison of AVRDC and local mungbean varieties, 1976-77; AVRDC, 1978.

	Matou		Shanshang	
	Local (N=3)	AVRDC (N=3)	Local (N=1)	AVRDC (N=1)
Duration (days)	69	69	76	76
Yield (kg/ha)	434	655	911	615
Total revenue (US$/ha)	286	426	800	540
Net return (US$/ha)	-241	-100	157	-103
Farm income (US$/ha)	78	347	697	437

3) Mungbean is very labor-intensive, especially at harvest time. The ratio of pre-harvest labor to pre-harvest capital costs in Matou and Shanshang is 1.52 and 4.58, respectively; while that of total labor to total capital costs is 2.12 and 7.20. Because of poor yield in Matou, the relative labor intensity of harvest is much higher in Shanshang. Farmers in both townships invest almost equal levels of pre-harvest labor cost; but farmers in Matou are more concerned about applying adequate levels of capital (fertilizer and pesticide).

4) The higher the yield the higher the net return. The correlation between these two variables is significant (r=0.89).[a] The slope in Figure 14 suggests that for every one kilogram increase in yield, net return increases by US$0.62.

5) Neither higher material costs nor added fertilizer leads to significantly higher yield. Furthermore, there is no significant correlation between material costs and net return (r=-0.54). This suggests the necessity of using low capital inputs on this low-yielding crop.

6) Higher labor inputs do not increase yield significantly (r=0.58). Nor is there any significant relationship between labor inputs and net return.

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[a]Since most local varieties failed because of late maturity, the regression analysis includes only the AVRDC varieties in the combined Matou and Shanshang sample.

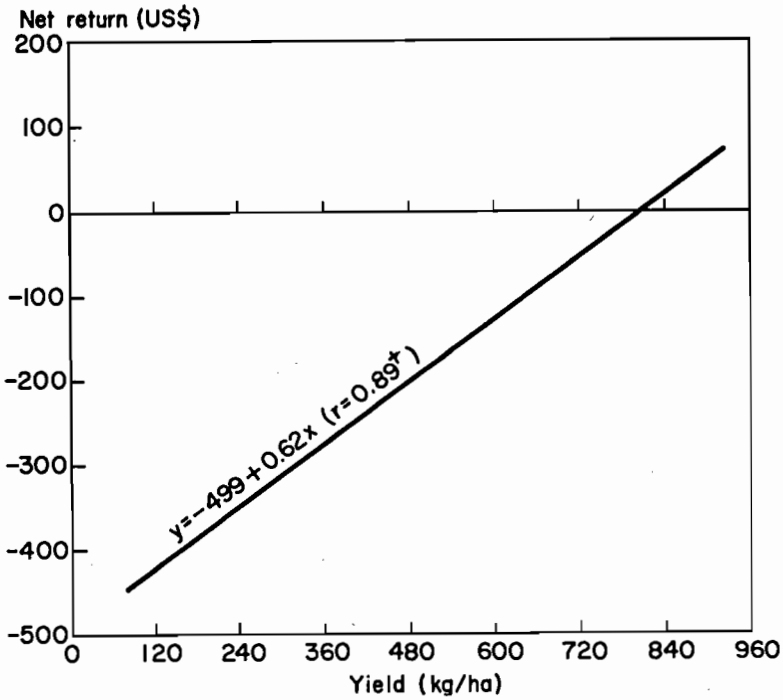

Fig. 14. The effect of mungbean yield on net returns, 1977; AVRDC, 1978.

CHINESE CABBAGE

Two Matou farmers planted Chinese cabbage on a total of three plots (Table 19). One farmer planted during the summer or typhoon season (pattern XIII, Fig. 4)); but, because of wind and rain damage, the crop failed. We classified the cultivation practices on the two plots planted at the beginning of October (the fall crop) into two categories: moderately managed intercrop with sugarcane and intensive monocrop. The farmer who intercropped used low input levels, did not use a rice-straw mulch, and sold the standing crop in the field. The other farmer used rice-straw mulch, much higher levels of fertilizer and weeding (both of which are critical to the sensitive *Brassica*), and harvested the crop himself, which gave him a much higher price to recoup the higher input costs.

Cash income, stable soil, and extensive successful experience with the crop in the past motivated the farmer who monocropped. Not only did the crop add extra income, but also the labor patterns complemented those of the predominant limabean-cauliflower intercrop favored in this season. Furthermore, family labor was available for harvests every other day over a three-week period.

A desire to supplement farm income from sugarcane, a larger cultivated area with less family labor, and the wish to experiment with a wide range of crops motivated the farmer who intercropped. A general consideration in planting Chinese cabbage on both farms was that farm income might be generated from either low or high levels of labor input.

Table 19. Indicators of agroeconomic efficiency in Chinese cabbage, Matou, Winter, 1976-77; AVRDC, 1978.

	Unit	Monocrop	Sugarcane
Parcel size	ha	0.12	0.39
Variety		n.a.	Pinglu
Duration	days	71	77
Population (seeds)	gm	783	385
Yield	kg/ha	27,717	17,949
Yield/gm seeds	kg	35.4	46.6
Fertilizer cost	US$/ha	329	175
Pesticide cost	"	178	136
Total material cost	"	655	433
Human labor	hrs	1,975	811
Human labor cost	US$/ha	1,069	407
Pre-harvest labor, material cost ratio		0.97	0.89
Average farm gate price	US$/t	145	42
Net return	US$/ha	2,206[a]	-253
Net return/day	"	31.07	-3.56
Farm income	"	3,374[b]	238
Farm income/day	"	47.52	3.35
Revenue, cost ratio		2.24	0.75
Break even point, yield/gm seeds[c]	kg	24.23	39.68

[a]-174 @$42/t; [b]562 @$42/t; [c]Matou area average farm gate price $93.54/t.

The statistics of planted area in Matou and Shanshang for the 10 year period 1966-1975 show no significant planted area in Shanshang. Records of planting in Matou begin only in 1973 and show a steady decline of 7% per year (Table 8).

From our data, we concluded:

1) Fluctuations in price and, hence, the inability to predict returns on a fairly high input crop are responsible for the low declining area planted to Chinese cabbage. The coefficient of variation of Chinese cabbage prices is high compared with that of selected vegetable crops which may be grown during the same season.

2) The higher the capital inputs, particularly fertilizer, the higher the yield. Table 19 shows that total material costs are 50% higher and yields are 54% higher on the monocrop than on the intercrop (and fertilizer costs are 100% higher).

3) The higher the labor inputs, particularly for weeding, the higher the yield. The monocrop farmer devotes 43% of his total pre-harvest labor to laying down rice-straw mulch and weeding. By contrast, the farmer who intercrops devotes 35% of his much lower total pre-harvest labor for weeding. The monocrop farmer invests 57% more pre-harvest labor than the intercrop farmer.

4) The differences in farm and net income between the two farms result from pre-harvest practices rather than price differences. If we standardize the statistics from the two farms by removing harvest labor from the monocrop farm and assigning an equal price of US$42/t to both farms, the monocrop farm income becomes US$562 and the net return US$174, both figures are still more favorable than those from intercropping.

WHICH AVRDC TARGET CROP SEEMS MOST SUITED TO SHANSHANG AND MATOU?

By comparing the farm income to be derived from planting tomato, sweet potato, mungbean, and Chinese cabbage in Matou and Shanshang (Tables 9, 10, 15, and 19), we conclude that processing tomato is the most profitable alternative for farms in Shanshang. Thus, if AVRDC were to actively promote the cultivation of one of its target crops in the area, it should be fall processing tomato.

The picture in Matou is not so clear-cut, for, while Chinese cabbage has slightly higher farm income, the average conceals the great variability in yields and prices. By comparison, fresh market tomato has more stable yields. Therefore, the most profitable alternative among AVRDC target crops in Matou seems to be fall fresh-market tomato.

Table 8 shows that farmers are well aware of these facts and apparently manage their farms on the basis of such decision criteria. Despite its high profitability, the area to Chinese cabbage in Matou is declining while that to tomato is expanding. Similarly, the area planted to tomato in Shanshang is also increasing.

LIMABEAN INTERCROPPED WITH CAULIFLOWER: A MAJOR ALTERNATIVE IN MATOU

Among the vegetables grown during the winter in Matou, limabean intercropped with cauliflower is the most common (Table 20). We found that 9 of the 12 Matou farmers devoted 2.95 ha (30.9% of their total 9.54 ha) to this particular cropping pattern. Thus, AVRDC target vegetables may not necessarily provide the greatest benefits in every agroeconomic environment in the tropics.

Table 20. Distribution of winter-season planted area to major crops on nine representative farms in Matou, 1976-77; AVRDC, 1978.

	Limabean/ cauli-flower	Sweet potato	Tomato	Sugar-cane	Corn	Sugar-cane/ corn	Cauli-flower	Other	Total
Area Planted (ha)	2.95	2.13	1.21	1.43	0.5	0.38	0.27	0.69	9.54
Number of parcels	16	10	7	6	4	2	2	7	54
% of area planted	30.9	22.3	12.7	14.9	5.2	4.0	2.8	7.2	100

In assessing the comparative success of this pattern over AVRDC target crops, we studied:

1) the motivation for intercropping limabean with cauliflower and the choice of planting method;

2) the production costs and crop management practices for three planting methods; and,

3) the agronomic productivity and economic profitability of the three methods.

Survey Procedure

We selected those farmers with complete records for parcels planted to limabean intercropped with cauliflower from Low Wall and High Hill in Matou township. There are three planting methods for this particular intercropping pattern: Method A by High Hill farmers on three parcels and methods B and C by Low Wall farmers on four parcels for each.

Agronomic Aspects of Limabean and Cauliflower Cultivation

Limabean and cauliflower require similar management and environment. They both thrive in temperate weather and are susceptible to extremes of heat and cold. In southern Taiwan, a planting season lasting from the end of August to the beginning of October is practical. Both suit fields with slightly acid soil, good fertility, and an adequate irrigation and drainage system. Limabean, as a long term crop, is relatively less labor intensive than most short term crops. Farmers intercrop cauliflower, with its short growth duration, to increase income during limabean's early growth period when little management care is needed. In addition, shade from the limabean plants protects cauliflower from sunburn, especially in the flowering stage when cauliflower also needs to be covered with clinging leaves.

Motivation for Cropping

The farmers reported five incentives for intercropping limabean with cauliflower:

1) Limabean and cauliflower are two high-value crops. During the 1976-1977 crop year, the maximum farm price of limabean was US$0.79/kg (US$0.32 average); while cauliflower enjoyed a maximum price of US$0.53/kg (US$0.13 average) (Fig. 15). The farmers in our sample estimated that revenue from limabean plus cauliflower is four times that of sweet potato and one and a half times that of tomato.

2) The cropping pattern of limabean with cauliflower fits the local rotation system. Land is under full utilization year-round with this rotation system: second season rice (4 mo)- intercropped limabean with cauliflower (6-8 mo)- second season rice.

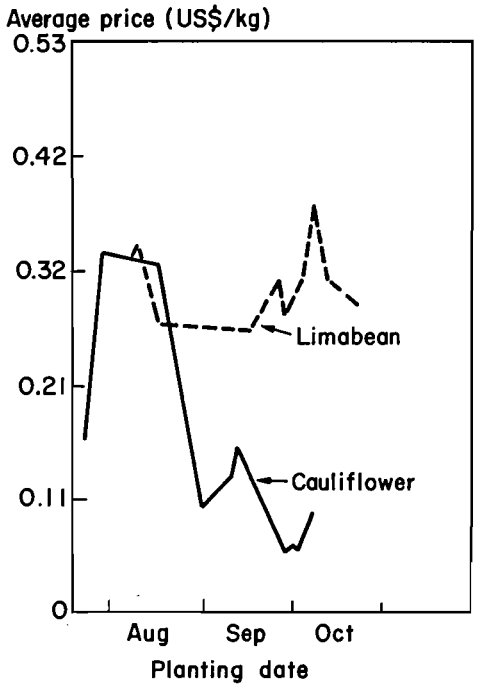

Fig. 15. The relationship between planting date and prices received for 9 representative farmers, Matou, 1976-77; AVRDC, 1978.

3) There is rational use of family labor. Limabean and cauliflower are multi-harvest crops. The labor required to pick limabean and cauliflower is within the scope of the average farm family's available labor. Hence,costs for outside labor are spared.

4) Matou provides both a concentrated production area and an adequate marketing system. Vegetable shippers have assembly lots in both Low Wall and High Hill. In the special case of cauliflower, a prized commodity in foreign countries, shippers assemble the product at the Matou market for export to Singapore, Hong Kong, and Malaysia.

5) Many farmers have as much as 20 years experience with this cropping pattern. They are both confident and technically experienced.

Disincentives for Cropping

Table 20 shows that, besides limabean intercropped with cauliflower, farmers also planted sweet potato, tomato, and other crops as major alternatives in the winter season. In view of the five obvious advantages stated above, why did they not plant limabean intercropped with cauliflower on their entire planted area? The farmers listed three reasons:

1) Besides staking and vine-tying, limabean requires much harvest labor. Thus, the availability of farm labor limits the area planted to limabean intercropped with cauliflower, and farmers plant labor-extensive crops such as sweet potato to better utilize their family labor and excess land.

2) The standard rotation system for every 3-year period is: second rice - limabean intercropped with cauliflower - second rice - sugarcane. The Irrigation Association grants water for rice cultivation only during the first two years of every three-year period. While the farmers could grow limabean and cauliflower for the initial months of the "sugarcane" period they would have to leave their fields fallow for the remainder. Therefore, they plant sugarcane instead.

3) Land suitable for limabean and cauliflower is limited to slightly acid soil with good fertility and water management.

Three Planting Methods for Limabean Intercropped with Cauliflower

The major field practices for this intercropping pattern are similar in all three methods:

the cultivation of cauliflower seedlings
land preparation
bed formation
basal fertilization
cauliflower transplanting
watering
limabean sowing
cauliflower mulching
limabean staking
cauliflower harvest
limabean pruning
staking and vine-tying
limabean harvest

Disease and insect control, top dressing, irrigation, and weeding are applied when needed.

Within the context of these general practices, there are distinct differences in bed size, planting method for cauliflower, and the seedling population and staking pattern for limabean (Fig. 16). As a result of relatively abundant labor, season,and custom, farmers with small land holdings usually adopt method A. Method B suits those who plant their crops late in the season, and method C is better adapted to early season planting.

In Method A, a row of limabean in the center is blanked by a row of cauliflower on each side. The crop density is 21,000-30,000 seedlings/ha for cauliflower, and 25-30 kg/ha seed for limabean. Two rows of stakes are set near the cauliflower and tied up over the bed at the crossing of every four stakes to support the limabeans. The cost for staking material is US$105-171/ha.

Under method B, farmers plant one line of limabean and one line of cauliflower on the bed. The crop density is 15,000-16,500 seedlings/ha for cauliflower, and 60-90 kg/ha seed for limabean. Farmers set stakes near the limabean and tie them up over the furrow at the crossing of every four stakes to support the limabeans. The cost for staking material is US$87-111/ha.

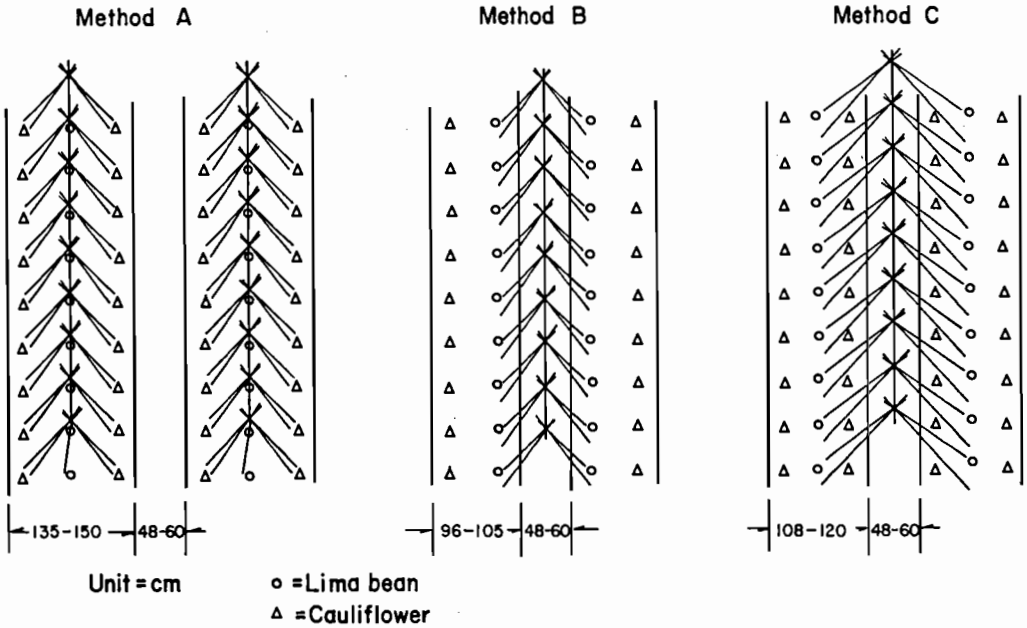

Fig. 16. Three planting methods for cauliflower intercropped with limabean, Matou; AVRDC, 1978.

Under method C, cauliflower and limabeans are planted as in method A, but the staking method is the same as that of method B. The crop density is 20,000-29,000 seedlings/ha for cauliflower and 50-70 kg/ha seed for limabean. The cost for staking material amounts to US$82-100/ha.

The management characteristics and related revenue for the three planting methods are as follows:

Method A. The 1976 planting season for cauliflower under method A was from August 5 to September 23, and for limabean from August 15 to September 30, intermediate among the three methods. As a result, the prices of US$0.15 for cauliflower and US$0.29 for limabean were also intermediate. The expense for labor and material inputs was, however, the highest per unit area among the three methods (Table 21). The farmers in High Hill, in view of their small farms and sufficient family labor, all adopted method A. The soil is relatively infertile and required much organic fertilizer. The staking material cost is greatest because method A involves one staking pattern on each bed while the other methods use one staking pattern for two beds.

A comparison of yields between the two crops and the three cropping methods is shown in Figure 17. Method A had high yields, frequent harvests, an adequate supply of family labor, intensive management, a high frequency of intertillage and weeding, and much labor for staking. Thus, the labor input was the costliest among the three methods. The total production costs of method A were higher than that of method B by US$1,186, and method C by US$953. However, method A had both the highest revenue, and the highest farm income, in part because of self-supplied organic fertilizer and family labor (Table 22, item f).

Table 21. Comparative yield and profitability of three intercropping methods, Matou, 1976-77; AVRDC, 1978.

Item	Method A		Method B		Method C	
YIELD (kg/ha) - Cauliflower	10,910		9,620		9,485	
- Limabean	12,395		12,545		8,228	
REVENUE (US$) - Cauliflower	1,599		376		1,726	
- Limabean	3,508		3,958		2,443	
TOTAL	5,107		4,334		4,169	
	-US$-	-%-	-US$-	-%-	-US$-	-%-
Expenses						
materials:						
Cauliflower seedlings	80	2.0	54	2.0	87	2.9
Limabean seeds	70	1.8	192	7.1	137	4.6
Fertilizer - inorganic	338	8.7	249	9.1	244	8.2
- organic	307	7.8	82	3.0	55	1.9
Pesticide	106	2.7	134	4.9	204	6.9
Expenses for stakes	142	3.6	107	3.9	95	3.2
Miscellaneous	104	2.7	106	3.9	84	2.9
Subtotal	1,146	29.3	925	33.9	907	30.6
Labor:						
Bed formation & land preparation	15	0.4	36	1.3	29	1.0
Planting	146	3.7	63	2.3	137	4.6
Fertilization	139	3.5	77	2.8	104	3.5
Pesticide spraying	108	2.8	151	5.5	135	4.6
Intertillage & weeding	303	7.8	137	5.0	186	6.3
Irrigation	120	3.1	83	3.1	142	4.8
Harvesting	925	23.6	558	20.5	684	23.1
Additional practices	541	13.8	290	10.6	286	9.6
Subtotal	2,297	58.7	1,395	51.1	1,702	57.5
Others:						
Irrigation water fee	91	2.3	84	3.1	46	1.6
Interest on: capital	66	1.7	54	2.0	58	2.0
land	216	5.5	187	6.9	178	6.0
Land tax	76	1.9	62	2.2	57	1.9
Depreciation	22	0.6	20	0.7	13	0.4
Subtotal	471	12.0	407	14.9	353	11.9
TOTAL COSTS (US$)	3,914		2,728		2,961	
NET RETURN (US$)	1,193		1,606		1,208	
FARM INCOME (US$)	4,171		3,539		3,369	

Method B. Farmers who planted their second rice crop in the late season generally adopt method B. The planting period for cauliflower is from October 3-16, and for limabean October 6-21 (Table 21). Farmers predict from experience that the price of cauliflower will drop during the peak harvest period of vegetables while the price of limabean will rise in response to the reduced supply of vegetables. Thus, they plant more limabeans as the main crop to maximize income. Cauliflower yield under method B is next to that of method A and higher than that of method C (Table 21). This favorable agronomic situation is, however, offset by relative prices. Method B farmers favor limabean because of their awareness of such price relationships. Indeed, method B enjoys

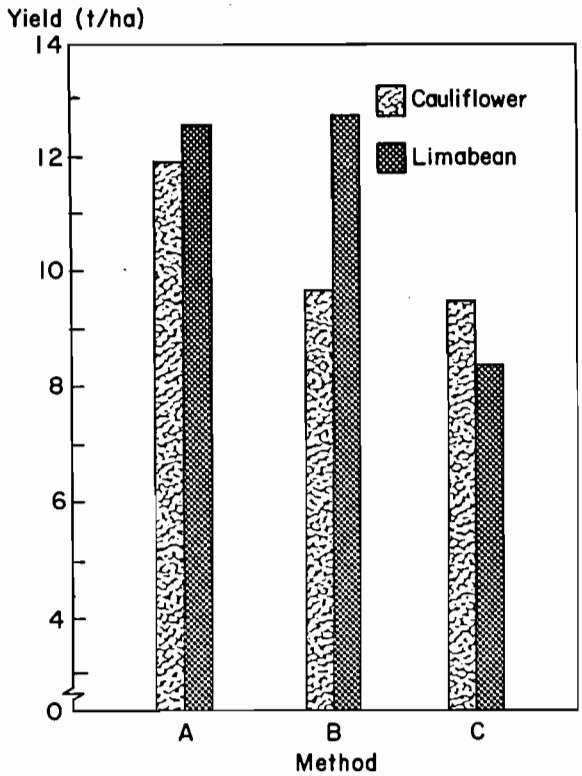

Fig. 17. Comparative yield performance of 3 intercropping methods, Matou, 1976-1977; AVRDC, 1978.

Table 22. Indicators of agroeconomic efficiency under three intercropping methods, Matou, 1976-77; AVRDC, 1978.

Item	Method A	Method B	Method C
a. Planting date			
Cauliflower	Aug 5 - Sep 23	Oct 13 - 16	Jul 30 - Sep 9
Limabean	Aug 15 - Sep 30	Oct 6 - 21	Aug 15 - Sep 9
b. Average price (US$/kg)			
Cauliflower	0.15	0.05	0.21
Limabean	0.29	0.32	0.30
c. Duration (days)			
Cauliflower	70	79	66
Limabean	230	207	217
Total	237	210	243
d. Yield/day (kg/ha)			
Cauliflower	155.9	121.8	143.7
Limabean	53.9	60.6	37.9
e. Farm income/day (US$/ha)	18	17	14
f. Total production costs (US$)	3914	2728	2961
Cash	936	795	800
Hired labor	54	64	14
Other	882	731	784
Non-cash	2978	1933	2161
Self-labor	2243	1331	1486
Other	735	602	675

both the highest yield and the highest price for limabean, so that the total revenue for limabean plus cauliflower ranks ahead of that under method C. Moreover, low production costs give method B the highest net return (Fig. 18). This makes it appealing to farmers with relatively scarce owned assets per hectare.

Method C. Farmers who plant early adopt this intercropping method. The planting period for cauliflower under method C is from Jul 30 - Sep 9, and for limabean from Aug 15 - Sep 9. The price of early planted cauliflower is very high, with a maximum of US$0.63/kg (average US$0.21); therefore, the procedures focus much of their attention on this crop. They plant two lines of cauliflower on each bed to increase yield. Despite the lowest yield, this method provides the highest revenue because of high price. At the same time, however, limabean has the lowest yield and revenue of the three methods, so that the total revenue of cauliflower plus limabean is also the lowest of the three methods. Moreover,

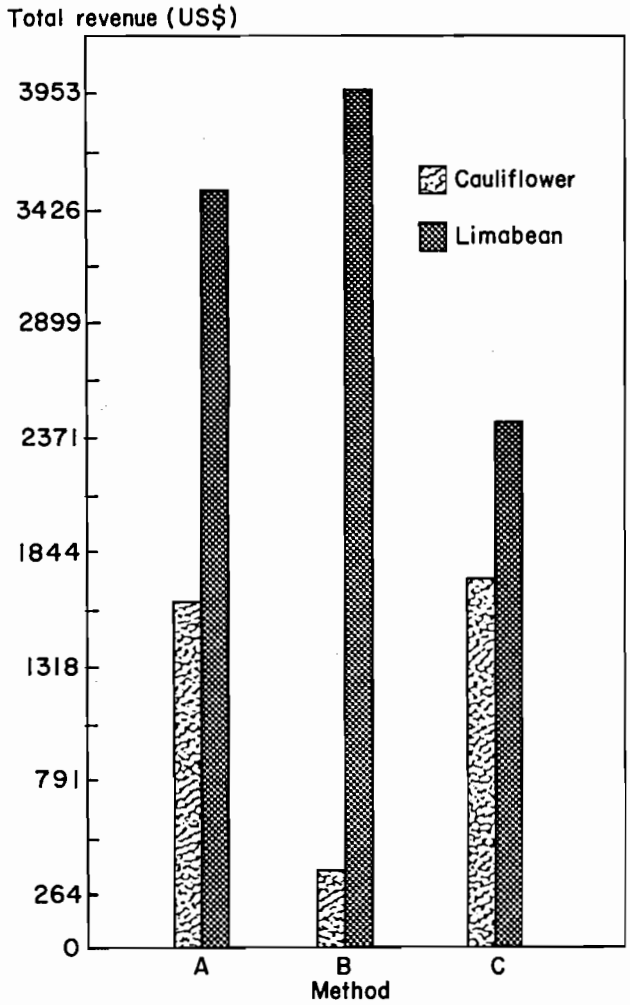

Fig. 18. Contribution to total revenue of cauliflower and limabean under 3 intercropping systems, Matou, 1976-77; AVRDC, 1978.

the net return is also lowest. Unless their total cropping pattern forces them to plant early, farmers seem ill-advised to adopt method C. At the same time, however, farm and net income under method C are higher than those from competing crops.

Conclusions.

1) Each intercropping method can bring a relatively high revenue, at least US$1,186/ha.

2) If farmers have adequate family labor, they should adopt method A to pursue the highest farm income; otherwise, method B should be introduced to get the highest net profit. Method C should be adopted only if they are forced to plant early.

3) Planting date greatly affects the farm price of both commodities, but total growth duration has no significant effect on either yield or income.

4) Up to a given limit, the more seeds or seedlings the farmers use, the more they harvest. But excessive crop density cannot increase yield proportionally. Method A achieves high limabean yield from limited seeds while method C results in low cauliflower yield from a great number of seedlings.

5) Disease and insects were controlled by the farmers adopting method A with minimal cost. Farmers adopting methods B and C could reduce their production costs by spraying less.

6) Total revenue is strongly affected by the revenue from limabean; therefore, if management time is limited, it pays to concentrate on limabean.

The question naturally arises: would even higher profits result from planting a monocrop of limabean in mid-October, as under method B? Very few farmers in Matou monocrop limabean because of risk aversion. Even if the price relationships in the 1976-77 crop year favored limabean, there is no guarantee that the same relative prices will hold in 1977-78. Moreover, although both crops require the same type of climatic conditions, they respond differently when conditions become suboptimal. Planting two crops, therefore, enhances both economic and agronomic security. The very fact that few farmers monocrop limabean is a good indication that profit per hectare is not maximized by monocropping in an average year. Thus, intercropping of cauliflower and limabean not only reduces variability but quite probably elevates expected returns.

CHAPTER THREE: THE CURRENT AND POTENTIAL ROLES OF VEGETABLES IN FARM MANAGEMENT DECISION-MAKING

Farmers have many competing demands on their productive resources and do not merely strive for maximum profit. This chapter will put vegetable production and the farmer's use of resources into the perspective of over-all decision-making processes on the farm. Our major objective is to understand why successful farmers include vegetables in their cropping patterns. We intentionally chose 6 progressive farmers from the 18 studied in Chapter Two. We shall attempt to determine what these farmers are doing right, and what goals they strive to achieve given the size and degree of irrigation on their farms. A second objective will determine on each farm what changes in resource allocation, if any, could help farmers make fuller use of vegetable crops to achieve their goals. This approach may allow researchers in other regions to perform similar analyses.

THE CHOICE OF ANALYTICAL TOOLS

Many record-keeping projects require high speed electronic computers to perform linear programming analysis in an effort to compute the optimal allocation of farm resources so that income may be maximized. The linear program seeks to maximize:

$$f(x) = cx$$

subject to: $A_x \leq b$

and: $x \geq 0$

where:

c= a row vector of enterprise returns net of variable costs;

x= a column vector of activity levels in terms of hectares devoted to individual crops or production units;

A= a matrix of technical coefficients of enterprise requirements for specific constraints; and,

b= a column vector of resource and enterprise constraints, such as land, labor, and capital.

The optimal solution to this problem indicates a specific number of hectares of land which should be devoted to each crop, the total income, and the marginal productivity of all constraints.

Although at first very appealing, linear programming suffers from the following problems:

1) high cost in both capital and trained manpower;

2) often based on the price information of a given year with no account of variance in expected returns and, hence, risk;

3) easily prescribes large areas to only one or a small number of crops, which may lead to susceptibility to pests and market overspecialization;

4) accounts for only one objective of the farmer -- maximization of income; and,

5) leaves out the evolutionary history of the farmers' cropping pattern, and the rationale for it.

A modification on linear programming which tries to take into account the variability in returns given a set income level is quadratic programming.[a] This helps solve problems 2, 3, and, to a certain extent, 4 above; but the data, capital, and manpower requirements of this technique are very great.

The development of analytical techniques that could be replicated at low cost in Asia was one aim of the AVRDC Farming Practices Project. We decided to use a linear and quadratic programming format; however, all computations were made on a hand calculator. We proceeded in the order of farmer priorities to avoid the simultaneous solutions required of linear and quadratic algorithms. Although the answers thus derived might not be "optimal" in terms of the single highest income or least variability in returns, in many ways they suggest improvements upon the current cropping situation which will be more acceptable to the farmer.

According to interviews, we ranked the progressive farmers' priorities in a stepwise way (Table 23), and set income/ha as our primary objective function.[b] Farmers in the large sample also listed income as the most important consideration in their farming goals (Table 3).

Table 23. Linear-quadratic type format for assessing improvements in crop technology; AVRDC, 1978.

Objective: Increased income/ha.

Subject to:
1) increase in income variance $\leq$ _____%
2) total labor use per month $\leq$ _____ mandays
3) increase in labor use variance $\leq$ _____%
4) average value product of labor $\geq$ _____US$/day
5) return to investment $\geq$ 40%
6) expand to suitable parcels to replace known crops

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[a]For further details, see references 5, 8, 12, and 14. [b]Operators of small-scale farms may seek instead to maximize income/hr.

Unless a given change yields income/ha greater than the average for the farm, there is no reason for the farmer to adopt it.

The objective function is subject to many constraints:

1) Stability of income from one year to the next. This we embodied as a risk constraint. We collected prices for the seven year period 1971-77 in the Matou Fruit and Vegetable Market, corrected them for inflation, calculated their variance and covariances, asked the farmers for the yield histories of their crops, and computed the variances and covariances of each crop's revenue (price times yield/ha). Any recommended change must not increase variance in income more than a level acceptable the the farmer.

2) Labor. Since labor is migrating from Taiwan's agricultural sector rapidly, 10% of the farmers wanted to reduce labor requirements, if possible. Labor constraints are of three kinds: first, total labor use should never exceed a given number of days per month as specified by the farmer; second, month-to-month variability of labor use on the farm should not be increased by more than a given percentage as indicated by the farmer; and, third, average farm income per hour worked should not decline (because of the opportunity cost of farm labor in a rapidly industrializing economy).

3) Capital. We posit that total cash expenditures should not increase by more than $x\%$[a] over the year. Also, studies show that return to investment should be at least 40% to provide a sufficient return to management and to cover interest rates.[b]

4) Land. The crop to be replaced and its position in the cropping pattern should be clearly identified.[c] Then, crop expansion should be limited to parcels with acceptable agronomic characteristics.

Unless these constraints are recognized and met, it is unlikely that a farmer will accept a suggested change in cropping technology.

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[a]The figure is supplied by each farmer. [b]See reference 20. [c]The three-year rotation commonly used by farmers in southern Taiwan is one of the main reasons why they achieve such satisfactory agronomic and economic results. When we suggested initial changes to the progressive farmers, they all said that they could not adopt them the following year. Even on the one farm where we are able to make significant improvements based on the 1976-77 data, they could not be adopted until the crop year 1979-80! However, in many countries, especially those where there is a fallow period during part of the year, the crop rotation is only one year in length. In such cases, the analytical techniques could be used immediately to make improvements in the farm plan.

THE SELECTION OF SIX PROGRESSIVE RECORD-KEEPING FARMERS

Of the 130 farms interviewed in Matou and Shanshang municipalities during the benchmark survey (Fig. 2), 71 were smaller than 1.0 ha, 42 ranged between 1.01-2.0 ha, and 17 were larger than 2.0 ha. We labeled the farms small, medium, and large, respectively.

Almost 50% of the farmers surveyed planted no vegetables at all, while the remainder operated highly-developed intercropping systems. We divided these farms into vegetable and non-vegetable categories for each size group, and studied their basic land, labor, capital, and management indices, and the intensity of both overall and vegetable cropping (Table 24).

The percentages of irrigated land on vegetable farms is higher than on non-vegetable farms. However, irrigated farms allow profitable vegetable cropping except when their size becomes so great that labor is a constraint.

The ratio between available full-time and total workers per hectare of arable land declines as farm size increases. The multiple cropping index declines as well. Therefore, as the man/land ratio increases, the number of crops grown per hectare per year increases. The relative importance of vegetables in the cropping mix also climbs. Not only do vegetable farms of all sizes have a higher multiple cropping index, but both the vegetable cropping and relative vegetable intensity indices tend to decrease with farm size and overall land use intensity.

Of the 18 first-year farms, we selected 6 (shown in Table 24) to participate in a second year of record-keeping which emphasized crop production, livestock raising, household activities, and off-farm employment patterns. We selected five of the six farms in the vegetable category: one small, two medium, and two large. Farmer Chen, the only non-vegetable farmer in the group, was chosen because his farm is medium in size, and his farm characteristics were close to typical. He grows AVRDC target crops mungbean and sweet potato. We desired more information on these even though they are not technically considered vegetables in the vegetable intensity indices.

The other five are progressive vegetable farmers. Farmer Tseng has a slightly smaller farm than the average small vegetable farm, but has almost the same absolute irrigated area (Table 24). This allows him to achieve a higher overall and a higher vegetable cropping intensity than the average for small vegetable farms. Because of the small size of his farm, he and his wife engage in off-farm employment; there are technically no full-time workers. But because of his substantial family size, the number of total workers per hectare is very high and this helps him maintain his vegatable cropping intensity.

Farmer Liang's vegetable farm is almost identical to the average in terms of farm size, percentage of area cultivated, capital assets, and number of full-time and total workers per hectare. However, his vegetable cropping intensity indices are twice the average.

Farmer Shih is also a medium scale vegetable farmer. However, his

Table 24. A comparison of bench survey farm averages with those of six record-keeping farmers, 1976-77; AVRDC, 1978.

	FARM CATEGORY											
	Small			Medium					Large			
	Non-veg.	Veg.		Non-veg.		Veg.			Non-veg.	Veg.		
	avg.	avg.	Tseng	avg.	Chen	avg.	Liang	Shih	avg.	avg.	Lee	Chiu
Cultivated land												
Area/farm (ha)	0.58	0.56	0.47	1.38	1.18	1.20	1.27	1.51	3.58	2.50	2.32	2.43
% irrigated	87	92	100	89	100	98	100	100	95	56	87	100
Labor/arable ha												
Full-time workers	2.6	3.0	0	1.4	1.7	1.7	1.6	1.5	0.5	1.0	0.9	2.1
Total workers	3.8	4.7	14.9	2.4	2.5	2.1	1.6	2.7	0.8	1.0	2.2	2.9
Capital												
No. pumping sets	0.6	0.9	1.0	1.0	1.0	1.2	2.0	3.0	1.6	0.9	4.0	2.0
No. power tillers	0	0	0	0	0	0.2	0	2.0	0.6	0.1	1.0	0
No. draft animals	0.1	0.2	0	0.5	0	0.4	0	1.0	0.7	0.6	1.0	1.0
% land in fruit trees	6	18	0	12	42	2	0	0	12	25	7	0
% land in fish ponds	0	0	0	0	0	0	0	42	0	0	0	0
Head of livestock raised	2.6	2.6	5.0	3.4	9.0	12.5	11.0	145	8.0	6.1	12.0	4.0
Management												
Education of household head (yrs)	3.7	4.9	6.0	5.5	9.0	5.2	6.0	6.0	5.4	5.1	9.0	9.0
Average in family	5.6	5.2	5.1	5.5	6.8	5.4	6.4	6.4	6.6	6.4	8.0	3.9
Input use												
Multiple-cropping index	232	239	279	196	199	241	313	307	150	181	196	264
Vegetable cropping index	0	71	106	0	0	67	123	164	0	30	18	110
Relative vegetable intensity index	0	0.23	0.40	0	0	0.24	0.58	0.46	0	0.11	0.09	0.65

farm size, and the number of full-time and total workers per hectare are slightly greater than Farmer Liang's. He represents the upper range of the medium sized vegetable farmer. Nevertheless his overall and vegetable cropping intensity are about equal to Farmer Liang's, and well above the average for medium vegetable farmers.

Farmers Lee and Chiu are large scale vegetable farmers. Farmer Lee's vegetable cropping intensity is almost identical to the group average for large vegetable farmers. Farmer Chiu with more irrigated land and workers per hectare, and a higher overall cropping intensity index, can achieve a higher relative vegetable cropping intensity than Farmer Lee. His is the highest relative vegetable cropping intensity of all six farms.

We chose our sample to show farmers with higher than average vegetable intensity. Appendices II and III show that, just as the 6 farmers chosen are progressive in comparison with the 130 Benchmark Survey Farmers, so the 130 Benchmark Farmers are better educated, have larger and better equipped farms, and achieve higher resource use intensity than average farmers for their size categories in Taiwan as a whole and southern Taiwan (Chia-nan area) in particular. Thus, the six farmers chosen are outstanding by general standards for Taiwan.

FARMER TSENG: SMALL-SCALE VEGETABLE FARMER

On the smallest farm, the man/land ratio is the highest of the three farm categories (Table 24). When the winter vegetable crops cauliflower, limabean, and fresh market tomato are listed in terms of their relative crop areas (Table 25) and compared with rice, they exhibit a consistent pattern of decreasing return per hour of labor invested. This is Farmer Tseng's major crop-choice criterion. He already works part-time off the farm, so that if farm income per hour fell too low, he could abandon farming altogether for off-farm employment.

Table 25. Farmer Tseng's crop choice indicators, 1976-77; AVRDC, 1978.

Crop name	Crop area	Labor used	Cash income	Cash expenditure	Farm income	Farm income
	-ha-	-hr/ha-	US$/ha			-US$/hr-
Limabean	0.21	2,410	2,693	582	2,112	0.87
Cauliflower	0.21	1,238	1,316	396	920	0.74
Fresh market tomato	0.08	7,393	5,178	1,020	4,158	0.55
Rice	0.30	1,283	1,058	665	393	0.32

Conceivably, the return to labor per hour is not the only constraint which the small vegetable farmer must satisfy. Equalizing his on-farm labor use from one month to the next would enable him to work regularly

off the farm and avoid hiring outside help. Table 26 shows first the comparative month-to-month variability in labor use of each of these crops, and then the cumulative variability when they are combined on the basis of decreasing farm income per hour. If a pattern of declining variability in labor use emerged, it would suggest that the farmer is satisfying the combined objective of high return to labor and relatively even labor use throughout the year. Table 26 shows this conclusion to be invalid on the small farm. Labor variability increases because the small farmer is not vitally interested in criteria other than his major goal: the hourly "wage" he can derive from his operation.

Table 26. Comparative and cumulative labor-use variability in three winter vegetables and rice, Tseng Farm, Matou, 1976-77: AVRDC, 1978.

Crop name	Comparative variability			Cumulative variability[a]		
	Mean	S.D.	C.V.[b]	Mean	S.D.	C.V.[b]
	-8-hr workdays/mo-		-%-	-8-hr workdays/mo-		-%-
Limabean	5.75	3.35	58	5.75	3.35	58
Cauliflower	8.11	5.39	67	8.70	6.44	74
Fresh market tomato	10.56	4.42	42	15.42	11.18	72
Rice	9.63	10.40	108	18.15	14.77	81
Whole farm				25.47	14.09	55

[a]Crops are added on the basis of decreasing farm income per hour. Thus, the cauliflower row represents the variability of limabean plus cauliflower; the tomato row represents the variability of limabean plus cauliflower plus tomato; etc.

[b]C.V. (coefficient of variability) = $\frac{\text{standard deviation (S.D.)}}{\text{mean}} \times 100$

Figures 19 and 20 show Farmer Tseng's on-farm labor use pattern for the crop year 1976-77. The highest labor peak is in September, with a subsidiary peak in March, reflecting planting and harvesting peaks for winter vegetable production. The curve for total vegetable use is the main contributor to total farm labor use. Even though Farmer Tseng operates a small farm, he feels that his outside work in September is important enough to warrant hiring outside labor.

Figure 20 shows that Farmer Tseng has managed to reduce the amount of hired labor to a manageable extent by limiting the area planted to cauliflower in September (also the period of rice harvest), and by planting fresh tomato and limabean, which complement these crops in labor use. He exhibits concern not so much with labor variability as with full utilization of land.

Farmer Tseng told us that in order for him to accept a change in his cropping pattern, he would require an improvement of at least 20% in his objective function -- higher income per hour of labor -- subject to the constraints of 20% higher returns to investment and 50% higher income per hectare. Therefore, any change we suggest will involve increasing the area planted to the highest value crops in his operation.

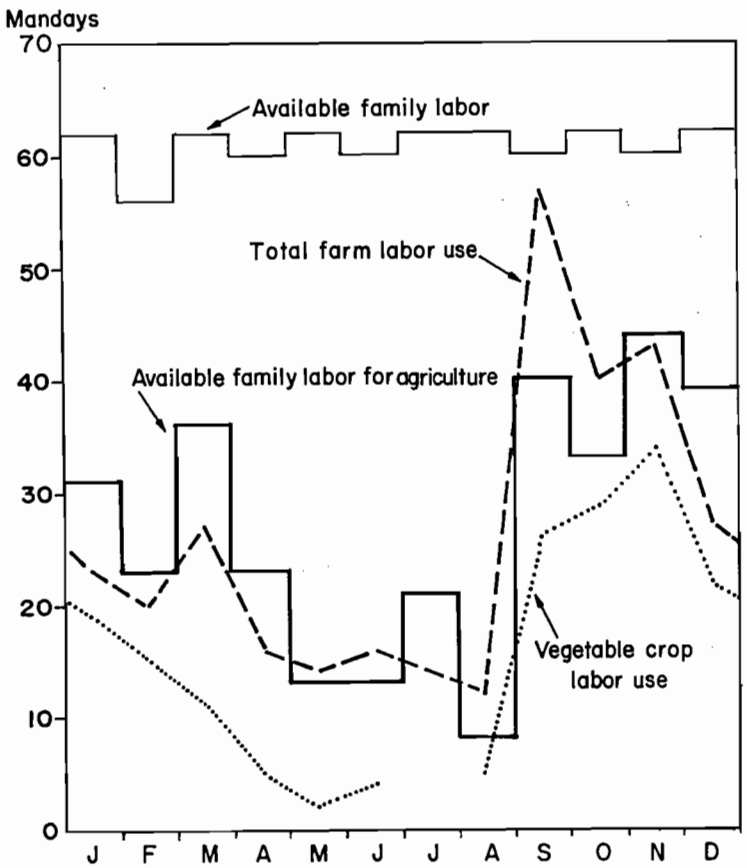

Fig. 19. Small-scale vegetable farm, Matou: total farm and vegetable labor use, 1976=77; AVRDC, 1978.

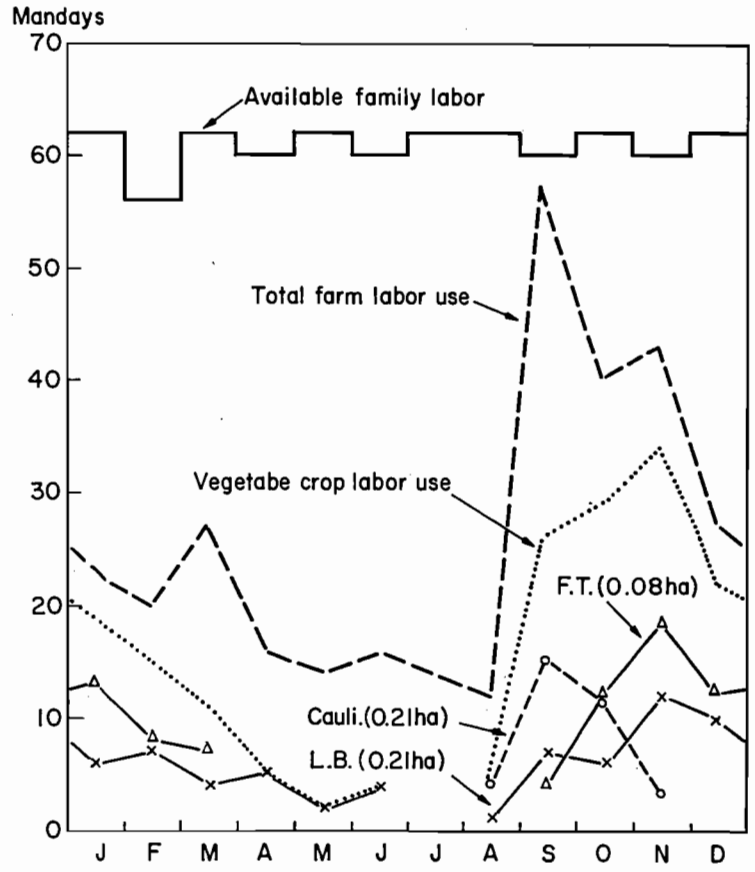

Fig. 20. Small scale vegetable farm, Matou: fresh market tomato (F.T.), cauliflower (cauli.), and limabean (L.B.) labor use, 1976-77; AVRDC, 1978.

In 1976-77, Farmer Tseng's total income was US$3143: $1454 from off-farm employment and $1689[a] in farm income from his own operation. Table 25 shows that limabean and cauliflower have the highest farm income per hour. Assuming constant returns to scale, if the area planted to these crops is increased from 0.21 to 0.37 ha, and the area planted to the low income corn crop is reduced by an equal amount, the efficiency of the farm operation will improve. However, Farmer Tseng would also have to give up some of his off-farm work to meet the demands of the increased labor-intensive crops. We assume that total labor hours worked per year remain unchanged.

This new plan suggests the following:

1) Farm income per hour worked on the farm would increase from US$0.61 to $0.73, or just the minimum 20% required by Farmer Tseng's objective function. However, because Farmer Tseng can earn an average of $0.86/hr off the farm, return to labor overall declines by 1%. Thus, this new plan does not succeed in improving farmer Tseng's objective function.

2) There is an increase in returns to investment (defined as the ratio of farm income divided by total capital costs) of from 1.17 to 1.26. Although this is a significant increase, it also does not meet Farmer Tseng's 20% criterion, which reflects his preference for the security of off-farm earnings rather than attempting a possible increase by investing more on his own farm. The amount of capital needed also increases -- from US$1444/yr to $1513/yr -- which may make it more difficult for Farmer Tseng to obtain investment capital.

3) Income earned per hectare shows an increase of 117%, well above the amount stipulated in Farmer Tseng's 50% criterion. In the old plan, farm return per hectare was only US$1256, while in the new plan it is $2721. Thus, if Farmer Tseng's options for off-farm work were in some way cut off so that income per hectare became his major criterion, the new plan would probably become his best option. In the present case, however, Farmer Tseng is mainly interested in increased income per hour.

4) Month-to-month variability in labor use on the farm would jump from a 0.55 coefficient of variation to 0.74 (Fig. 21). To make matters worse, the peak labor requirements would occur in September when it is extremely difficult to hire outside labor because of harvesting rice and planting fall crops. Moreover, the total earnings of the household would drop from $3143 to $3107.

Therefore, in the current economic situation of southern Taiwan where the operators of small farms have the option of working off-farm, they seem ill-advised to adopt changes in their farm plan which require more on-farm labor.

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[a]Computed from all crops grown, not just those shown in Table 25.

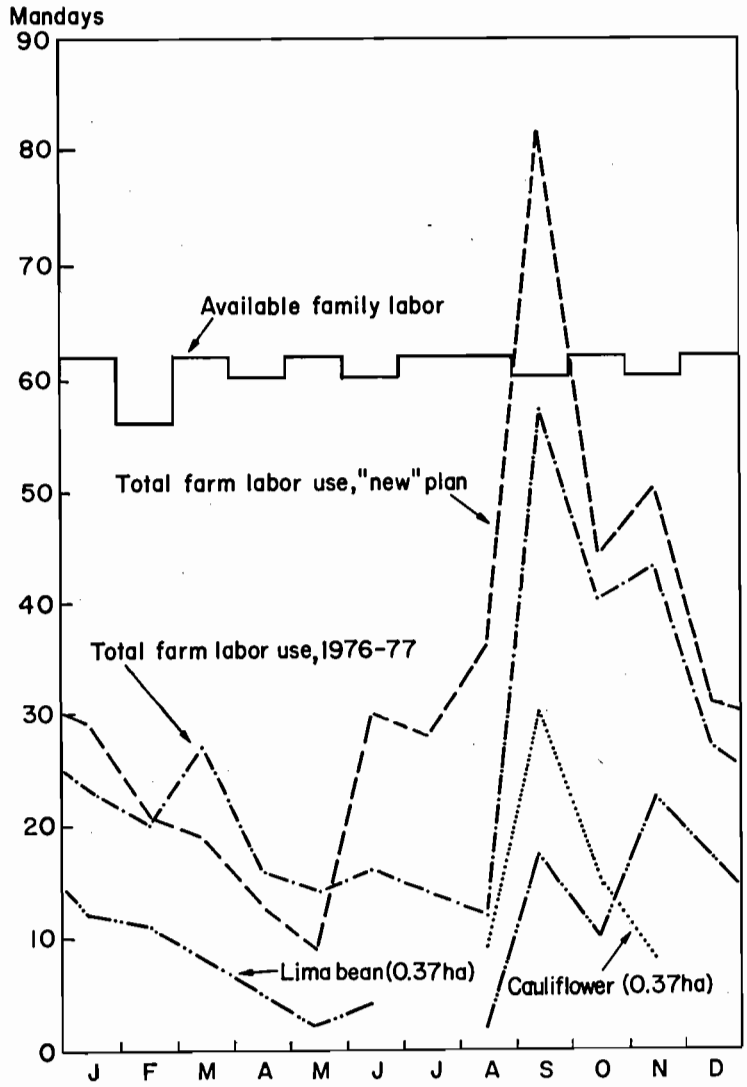

Fig. 21. Small-scale vegetable farm, Matou: comparative labor use patterns, 1976-77, and tentative "new plan"; AVRDC, 1978.

FARMER CHEN: MEDIUM-SCALE NON-VEGETABLE FARMER

Table 27 shows the relative profitability of the main winter crops and rice on the non-vegetable farm, listed in decreasing order of crop area. However, there is no index of input use or profitability which declines with crop area. Farmer Chen is interested in the preparation of fruit tree seedlings in a small area behind his house, and has made many wrong decisions in managing the rest of his farm. His major goal is farm income per hectare, but he has not been successful.

Table 28 shows the comparative and cumulative variability in labor use for Farmer Chen's crops. As commodities are added on the basis of decreasing farm income per hectare, there is a steady pattern of declining variability in labor use from month to month. Thus, Farmer

Table 27. Farmer Chen's crop choice indicators, 1976-77; AVRDC, 1978.

Crop name	Crop area	Labor used	Cash income	Cash expenditure	Farm income	Farm income
	-ha-	-hr/ha-	----------US$/ha----------			-US$/hr-
Corn	0.49	690	0	239	-239	-0.35
Sweet potato	0.19	1,384	863	419	444	0.32
Mungbean	0.10	1,000	519	62	457	0.46
Rice	1.62	775	558	488	70	0.09

Table 28. Comparative and cumulative labor-use varability in three winter field crops and rice, Chen Farm, Shanshang, 1976-77; AVRDC, 1978.

Crop name	Comparative variability			Cumulative variability[a]		
	mean	S.D.	C.V.	mean	S.D.	C.V.
	-8-hr workdays/mo-		-%-	-8-hr workdays/mo-		-%-
Mungbean	4.19	1.84	44	4.19	1.84	44
Sweet potato	3.71	5.27	142	5.11	6.97	136
Corn	7.05	4.72	67	9.80	7.70	79
Rice	19.61	12.52	64	20.43	15.19	74
Papaya and mango	9.88	6.21	63	30.31	18.34	61
Whole farm				81.60	21.25	26

[a]On the basis of decreasing farm income/ha.

Chen is interested not only in evenness of labor use on his farm but also in farm income, two goals which conflict. The only exception is mungbean, which has both the highest income and the lowest labor variability. Mungbean was introduced to this farmer by AVRDC and shows the potential of AVRDC's selected target crops for improving the farm operation of at least medium-scale non-vegetable farmers.

Figure 22 shows how poorly Farmer Chen manages his labor overall. In seven months out of the year he hires additional outside labor, a huge expenditure. He seems to have planned his farm on the basis of the peak labor available in February and late summer when his children are home from school. He persists in taking care of his seedling operation so that in every month of the year he must hire outside labor. Except for the harvests of sweet potato and corn, his winter crops do not show labor-saving complementary relationships of the kind Farmer Tseng exploits.

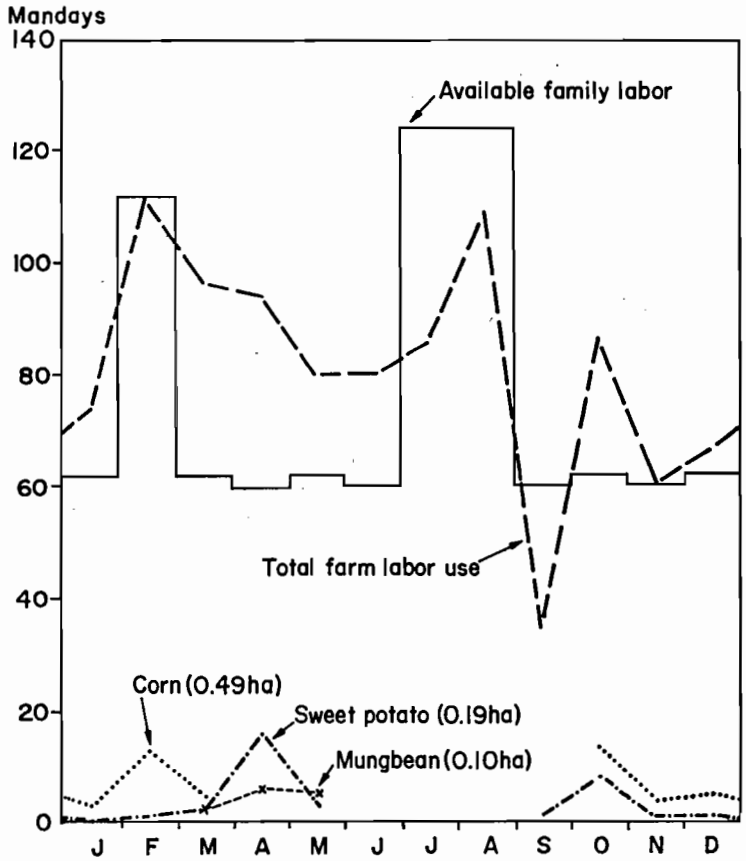

Fig. 22. Medium-scale non-vegetable farm, Shanshang: total farm, corn, sweet potato, and mungbean labor use, 1976-77; AVRDC, 1978.

Thus, Farmer Chen should: (1) reduce his overall use of labor, particularly that devoted to his unprofitable seedling business; and, (2) eliminate his corn crop and increase the area planted to sweet potato, mungbean, or processing tomato.

Farmer Chen's is the only farm of the six where a significant improvement in farm management may be made. However, because of the three-year rotation, he would be able to experiment with suggested techniques only in 1979-80. Farmer Chen informed us that, in addition to at least 7% higher income per hectare, any new plan must embody moderate labor use per month, higher returns to investment, and, if possible, less variability in labor use.

Inspection revealed that his operation was earning a negative US$138 for 1976-77. Moreover, despite a total investment of $455, his rice and corn (on certain plots), and his watermelon seedling production were netting zero returns. Therefore, we devised a new plan which would include an increase in planted area to sweet potato of 0.39 ha, and to corn followed by mungbean of 0.29 ha. This plan would bring about the following positive changes:

1) An increase in farm income to US$623, well over the 7% minimum required by Farmer Chen's objective function.

2) A reduction in the average use of labor per month from 82 to 70 days. It is true that the variability in labor use for the whole farm would increase from 26% to 47%. However, Figure 23 shows that this is mainly caused by increased labor demands during April, a period of slack labor use on other farms. Thus, unlike the case for Farmer Tseng, the new plan for Farmer Chen is not rendered infeasible by the need to hire much more labor than in the past during the peak season.

3) For the crops in question, the return to investment on the old plan was 0 from an investment of US$455, while that under the new plan is $306 from a lower investment of $181.

Thus, the new plan is able to satisfy Farmer Chen's criteria for improvement. The only exception is increased month-to-month labor variability, but even this is not likely to cause Farmer Chen problems because of the timing of labor peaks.

FARMER LIANG: MEDIUM-SCALE VEGETABLE FARMER

Table 29 shows Farmer Liang's crop choice indicators for winter vegetable crops and rice in descending order of planted area. No index

Table 29. Farmer Liang's crop choice indicators, 1976-77; AVRDC, 1978.

Crop name	Crop area	Labor used	Cash income	Cash expenditure	Farm income	Farm income
	-ha-	-hr/ha-	----------US$/ha--------			-US$/hr-
Limabean	0.86	2,064	3,440	616	2,824	1.37
Cauliflower	0.72	989	1,164	282	882	0.89
Pai-tsai	0.11	782	1,036	27	1,011	1.29
Spinach	0.06	1,010	1,983	183	1,805	1.79
Rice	1.04	866	1,282	431	851	0.98

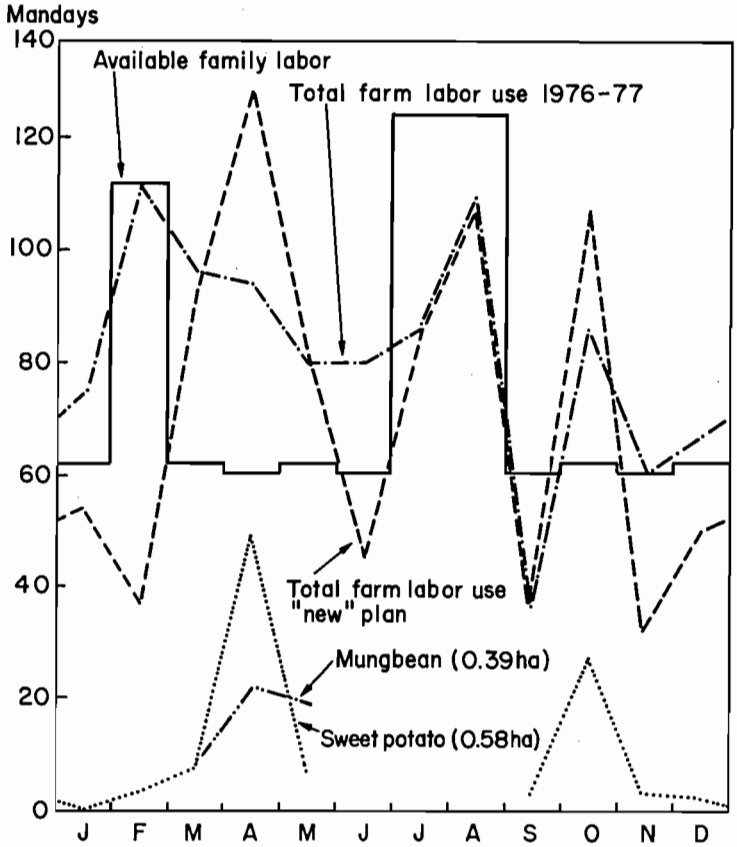

Fig. 23. Medium-scale non-vegetable farm, Shanshang: comparative labor use patterns, 1976-77, and tentative "new plan"; AVRDC, 1978.

shows a clear declining pattern with area planted because Farmer Liang is testing spinach and pai-tsai[a] plantings to replace cauliflower, which has a low profit. The correlation between labor use and cash income is great. Farmer Liang may have chosen these crops for intermediate cash income and in order to even out his on-farm labor use.

Table 30 shows the comparative and cumulative labor use variability in winter vegetables and rice. There is a declining trend, showing Farmer Liang's desire to decrease variability in labor use. The major exception is the relatively variable cauliflower. Thus, in both farm income per hectare and labor variability from month to month, this farm is in transition. While cauliflower seems unsuitable in terms of both, it has a better market because of the large numbers of farmers in the area who grow it on a large scale. In constrast, spinach lacks a market which could compete with the collection station for limabean and cauliflower. Cauliflower does better when intercropped with limabean. However, Farmer Liang is experimenting with intercropping spinach with limabean, and is the first farmer in his area to introduce spinach cultivation.

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[a]A type of non-heading Chinese cabbage.

Table 30. Comparative and cumulative labor-use variability in four winter vegetables and rice, Liang Farm, Matou, 1976-77; AVRDC, 1978.

Crop name	Comparative variability			Cumulative variability[a]		
	mean	S.D.	C.V.	mean	S.D.	C.V.
	-8-hr workdays/mo-		-%-	-8-hr workdays/mo-		-%-
Limabean	22.19	11.53	52	22.19	11.53	52
Spinach	3.79	1.80	48	22.95	10.97	48
Pai-tsai	10.75			21.84	11.04	51
Cauliflower	12.71	8.75	69	27.44	15.29	56
Rice	14.08	9.94	71	36.82	15.14	41
Whole farm				52.70	15.54	29

[a]On the basis of decreasing farm income/ha.

Figure 24 shows the importance of vegetables to Farmer Liang. The curves for vegetable labor use and total farm labor use are almost identical in shape if different in magnitude. As with Farmer Tseng, the major peak is in the fall, with a subsidiary harvesting peak in April and May. Limabean and cauliflower complement each other well in terms of labor use seasonality, and spinach tends to offset the huge variability in cauliflower. Farmer Liang also reduces his vegetable labor use in the summer time when rice is the major crop, which allows for relatively great consistency in overall farm labor use for the year. He plants limabean in August, September, and October, and cauliflower in July, August, September, and October to take advantage of the high price at the beginning of the season and large harvests at the end. This pattern also helps balance his labor use.

We conclude that, in the short run, Farmer Liang is already doing a good job, given the fact that his best yielding and most profitable crops do not yet have a market. However, other farmers have already begun to follow his example with spinach. And a market may soon develop. Thus, we could advise Farmer Liang to increase his area planted to spinach and pai-tsai, and reduce that to cauliflower.

FARMER SHIH: MEDIUM-SCALE VEGETABLE FARMER

The number of vegetable species grown tends to increase with farm size. Table 31 shows Farmer Shih's crop-choice indicators for various horticultural crops and rice. When ranked in terms of crop area planted, there is an inverse correlation with farm income and labor use per hectare. In constrast to Farmer Chen's case, labor is relatively scarce on Farmer Shih's farm (1.15 ha). Thus, even though onion is the most profitable crop, it is limited by high labor intensity. Farmer Shih's most important objective in his crop system component is farm income per hectare.

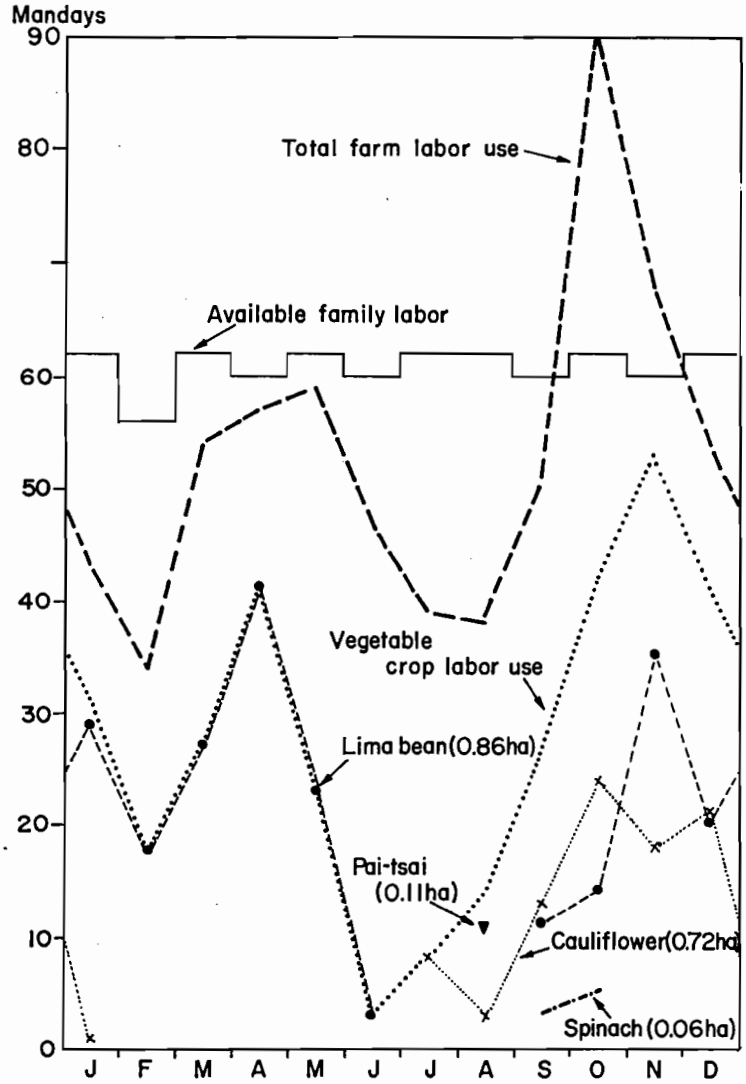

Fig. 24. Medium-scale vegetable farm (Liang), Matou: total farm, vegetable, limabean, cauliflower, pai-tsai, and spinach labor use, 1976-77; AVRDC, 1978.

Table 31. Farmer Shih's crop choice indicators, 1976-77; AVRDC, 1978.

Crop name	Crop area	Labor used	Cash income	Cash expenditure	Farm income	Farm income
	-ha-	-hr/ha-	----------US$/ha----------			-US$/hr-
Cauliflower	0.94	1,345	1,520	418	1,102	0.82
Sweet potato	0.62	615	989	127	862	1.42
Chinese cabbage	0.49	1,615	2,280	416	1,864	1.15
Limabean	0.43	2,848	3,333	395	2,939	1.03
Common cabbage	0.25	496	0	303	-303	-0.61
Spinach	0.15	758	3,534	179	3,355	4.43
Mungbean	0.14	518	0	91	-91	-0.17
Onion	0.07	4,557	5,517	541	4,976	1.09
Rice	1.26	543		202		

Farmer Shih's livestock component is large (150-200 head of hogs and a 1.10 ha fish pond). Therefore, in the same way that the off-farm component in Figure 1 is the most important for Farmer Tseng, the livestock component is most important for Farmer Shih. Farmer Shih is willing to take more risk in the latter (accounting for some of the anomalies in Table 31) because of his stable income from livestock.

Table 32 shows a declining pattern of labor variability as crops of decreasing farm income per hectare are added. However, sweet potato, mungbean, and common cabbage, which have the lowest farm incomes per hectare, do not follow the pattern. If they were removed and the area to the top five vegetable crops expanded, both farm income and labor-use stability would improve. But Table 32 also shows that the average monthly labor use of the top five crops (except spinach) is also high.

Table 32. Comparative and cumulative labor-use variability in six winter vegetables, two field crops, and rice, Shih Farm, Matou, 1976-77; AVRDC, 1978.

Crop name	Comparative variability			Cumulative variability[a]		
	mean	S.D.	C.V.	mean	S.D.	C.V.
	-8-hr workdays/mo-		-%-	-8-hr workdays/mo-		-%-
Onion	7.98	9.09	114	7.98	9.09	114
Spinach	4.74	7.01	148	9.02	8.30	92
Limabean	17.01	8.32	49	23.02	12.09	53
Chinese cabbage	9.89	10.96	111	27.83	15.81	57
Cauliflower	19.75	13.10	66	42.19	26.62	63
Sweet potato	6.82	6.64	97	46.53	29.24	63
Mungbean	1.82	0.74	41	43.41	30.69	71
Common cabbage	5.17	6.26	121	44.70	29.63	66
Rice	14.26	9.52	67	51.83	23.64	64
Whole farm				74.67	17.58	24

[a]On the basis of decreasing farm income/ha.

Figures 25 and 26 show the actual labor use patterns on this medium-scale vegetable farm. As on other vegetable farms, total-farm and total-vegetable labor use follow similar patterns. Cauliflower and limabean again show remarkable complementarity. Chinese cabbage or onion labor use further complements cauliflower and limabean taken together. Mungbean has stable labor use, but sweet potato is labor intensive at planting and harvest. Spinach has only three production points and does not contribute significantly to labor stability.

Farmer Shih could reduce the area planted to mungbean and expand his area to spinach, which has the second highest farm income and fifth highest labor use per hectare. However, he would not have enough labor to harvest spinach in the few days before it bolted. Moreover, the market for this crop is not developed. Therefore, in the short run Farmer Shih should not increase the area planted to spinach and, thus, we cannot significantly improve the management of his farm.

FARMER LEE: LARGE-SCALE VEGETABLE FARMER, SHANSHANG

Table 33 shows the crop-choice indicators for Farmer Lee in terms of declining area planted to winter crops and rice. Despite his large farm size, Farmer Lee grows only three main winter crops -- watermelon, processing tomato, and sweet potato -- because of his relative success in the past. Watermelon has the highest farm income per hectare; sweet potato has the highest farm income per hour and is labor saving; and processing tomato, contracted with the local factory, has the most stable expected returns. Thus, each crop has advantages for a large farm. However, the most important planting criterion for Farmer Lee is still farm income per hectare. This continues the trend which holds for all but the smallest farm.

Table 33. Farmer Lee's crop choice indicators, 1976-77; AVRDC, 1978.

Crop name	Crop area	Labor used	Cash income	Cash expenditure	Farm income	Farm income
	-ha-	-hr/ha-	----------US$/ha----------			-US$/hr-
Watermelon	0.45	1,180	1,347	137	1,210	1.03
Processing tomato	0.42	1,579	920	116	804	0.52
Sweet Potato	0.19	716	934	90	844	1.18
Rice	1.61	511	889	389	500	0.98

The importance of crop combinations with low variability in labor use is also evident (Table 34). As crops with decreasing returns per hectare are added, the consistency of overall labor use improves. Farmer Lee's labor management and profit levels seem the best of all six farms. He also achieves the highest returns to processing tomato, and returns in sweet potato comparable to those of Farmer Shih.

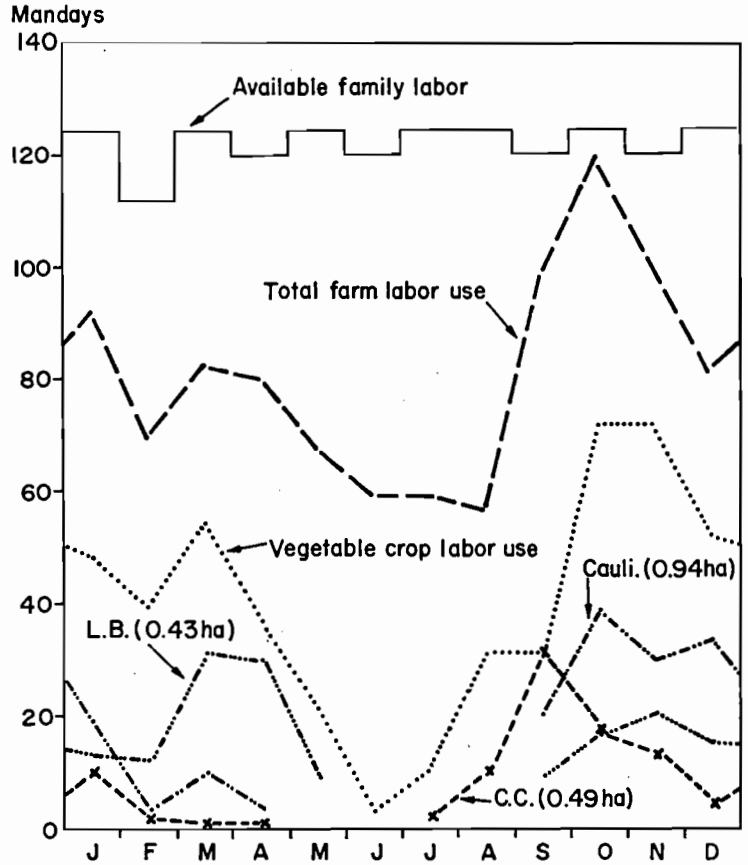

Fig. 25. Medium-scale vegetable farm (Shih), Matou: total farm, vegetable, cauliflower (cauli.), limabean (L.B.), and Chinese cabbage (C.C.) labor use, 1976-77; AVRDC, 1978.

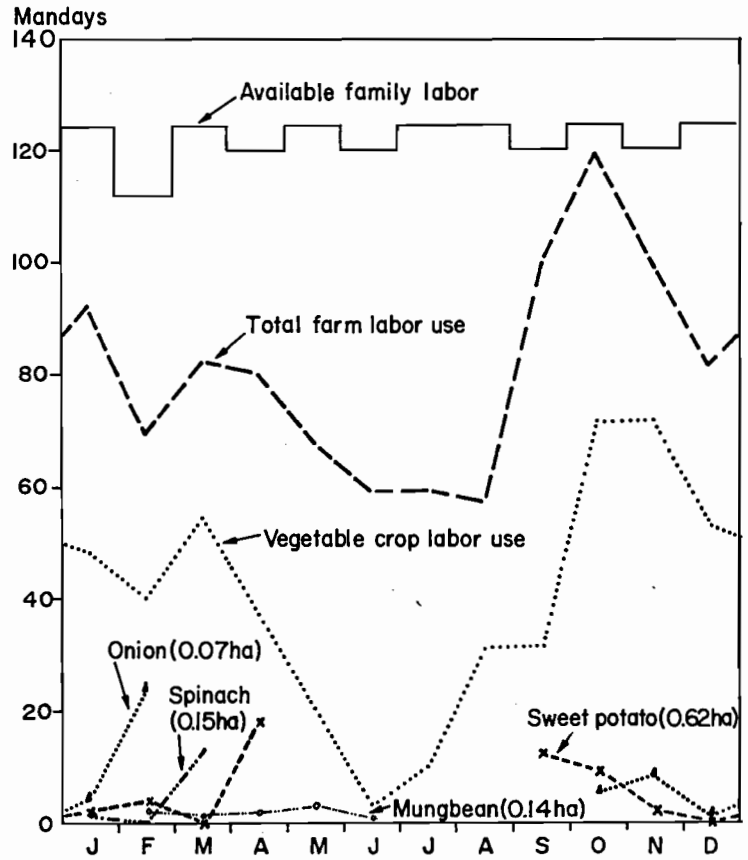

Fig. 26. Medium-scale vegetable farm (Shih), Matou: total farm, onion, sweet potato, spinach, and mungbean labor use, 1976-77; AVRDC, 1978.

Table 34. Comparative and cumulative labor-use variability in three winter crops and rice, Lee Farm, Shanshang, 1976-77; AVRDC, 1978.

Crop name	Comparative variability			Cumulative variability[a]		
	mean	S.D.	C.V.	mean	S.D.	C.V.
	-8-hr workdays/mo-		-%-	-8-hr workdays/mo-		-%-
Watermelon	8.30	8.28	100	8.30	8.28	100
Sweet potato	2.13	1.70	80	9.27	7.84	85
Processing tomato	10.36	6.69	65	16.63	10.09	61
Rice	9.36	7.81	83	22.44	8.99	40
Whole farm				44.92	7.04	16

[a]On the basis of decreasing farm income/ha.

Figure 27 shows that the labor use for vegetables complements summer rice production almost perfectly. Watermelon and processing tomato have complementary peaks and troughs in both fall and spring, and sweet potato has extremely consistent labor use patterns during these seasons.

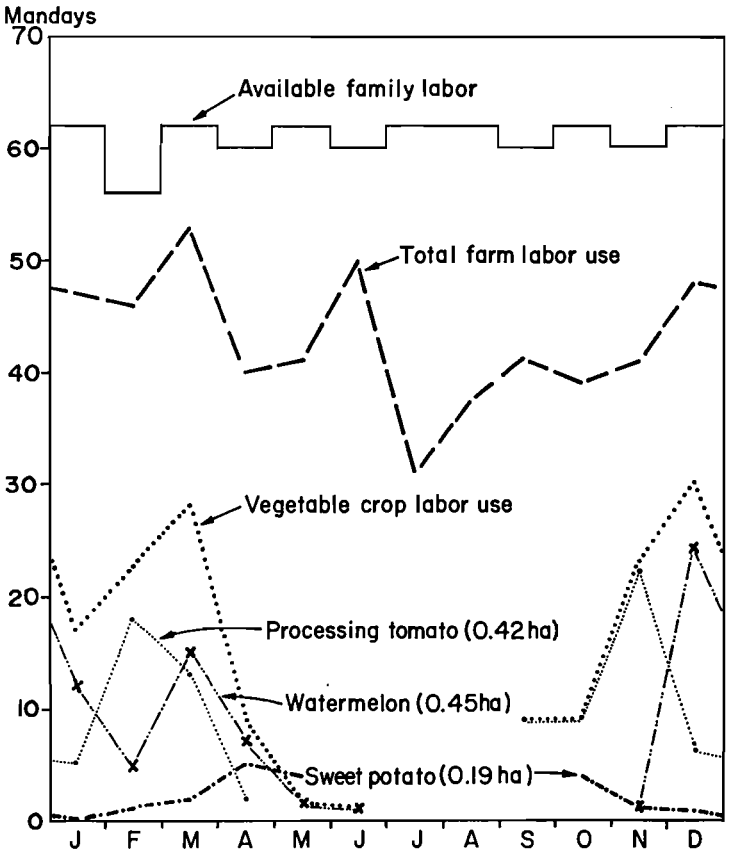

Fig. 27. Large-scale vegetable farm, Shanshang: total farm, vegetable, watermelon, processing tomato, and sweet potato labor use, 1976-77; AVRDC, 1978.

Farmer Lee makes unusually low investments in farming per hectare, showing his judicious use of limited capital and labor on crop combinations to satisfy his many farm management objectives.

FARMER CHIU: LARGE-SCALE VEGETABLE FARMER, MATOU

The most complicated farming patterns are found on the largest farm operation. Table 35 shows the crop-choice indicators on the Chiu farm in winter. The seven crops fall into three categories: (1) filler crops planted to large areas to make full use of land and labor (sweet potato and processing tomato); (2) high profit crops planted to intermediate hectarage with relatively high labor, cash inputs, and farm income per hectare and per hour (limabean to kohlrabi on the list), and, (3) a crop failure with high capital and labor inputs which even before planting the farmer felt to be risky (kidney bean).

Table 35. Farmer Chiu's crop choice indicators, 1976-77; AVRDC, 1978.

Crop name	Crop area	Labor used	Cash income	Cash expenditure	Farm income	Farm income
	-ha-	-hr/ha-	----------US$/ha----------			US$/hr
Sweet potato	0.85	626	397	285	112	0.18
Processing tomato	0.82	1,091	668	419	248	0.24
Limabean	0.59	2,971	3,307	1,260	2,048	0.69
Spinach	0.41	3,227	1,685	305	1,380	0.45
Cauliflower	0.41	1,011	2,796	669	2,126	2.06
Kohlrabi	0.27	1,156	1,863	234	1,629	1.05
Kidney bean	0.09	2,667	731	1,405	-674	-0.26

With farms as large as Farmer Chiu's, full land utilization through filler crops becomes an important secondary objective to farm income. Farmer Chiu plans to build a fish pond on about one hectare of inferior land that he previously planted to filler crops. Fish raising is not only labor-extensive, it also requires little capital if, like Farmer Chiu, the farmer has a hog raising enterprise to provide manure. Farmer Chiu derives his capital for expanding his hog enterprise from vegetable cultivation.

After all of these changes take place, Farmer Chiu's operation will be like Farmer Shih's in total cultivated area and large-scale fish and hog raising operations. In Matou there may be an evolutionary process of economic transformation on individual farms, whereby the profitable vegetable crops fuel investments to reduce overall crop area for more capital intensive enterprises. This process is analogous to what happens during national economic development: as the agricultural sector generates a surplus to fuel the industrial development of the economy, it is then able to support the demand for relatively high-priced agricultural products such as livestock and horticultural commodities.

Transformed farms in Matou feature fish and hog enterprises because of poor land quality.

The large size of Farmer Chiu's holding requires that he adopt cropping patterns which complement his labor use. Table 36 shows that the cumulative month-to-month variability on the farm has a declining pattern as crops with lower farm income per hectare are added. The only exception is in adding spinach. However, spinach is the last of the high-profit crops (category 2 above), and it is not surprising that, as Farmer Chiu moves from high profit to filler crops, his labor variability increases somewhat. With the filler crops and kidney bean, there is again a consistent pattern. Therefore, Farmer Chiu's overall objectives are much better met than those of Farmer Shih. We predict that, when Farmer Chiu adopts the general farm structure of Farmer Shih, he will manage it better.

Table 36. Comparative and cumulative labor-use variability in six winter vegetables, Chiu Farm, Matou, 1976-77; AVRDC, 1978.

Crop name	Comparative variability			Cumulative variability[a]		
	mean	S.D.	C.V.	mean	S.D.	C.V.
	-8-hr workdays/mo-		-%-	-8-hr workdays/mo-		-%-
Cauliflower	18.46	7.94	43	18.46	7.94	43
Limabean	27.88	14.69	53	34.30	10.41	30
Kohlrabi	6.63	4.19	63	37.52	12.61	34
Spinach	20.50	9.10	44	57.39	10.75	19
Processing tomato	14.13	8.06	57	71.09	18.18	26
Sweet potato	8.88	5.59	63	79.70	17.60	22
Kidney bean	5.80	4.76	82	83.21	17.76	21
Whole farm				105.17	22.27	21

[a]On the basis of decreasing farm income/ha.

Figures 28-32 show the skill with which Farmer Chiu balances labor use on his farm. As with Farmer Lee, there are three main labor peaks: spring vegetable, summer rice, and fall vegetable. Spinach and processing tomato balance each other in both fall and spring, in constrast to Shanshang where watermelon is the main complementary crop for processing tomato. Cauliflower and limabean also complement each other well. Finally, sweet potato and kohlrabi exhibit balancing labor patterns.

Thus, Farmer Chiu's skill is great. If he were not going to change his farm structure, we would recommend that he plant less processing tomato and sweet potato, However, that is precisely what he is planning to do by building the fish pond.

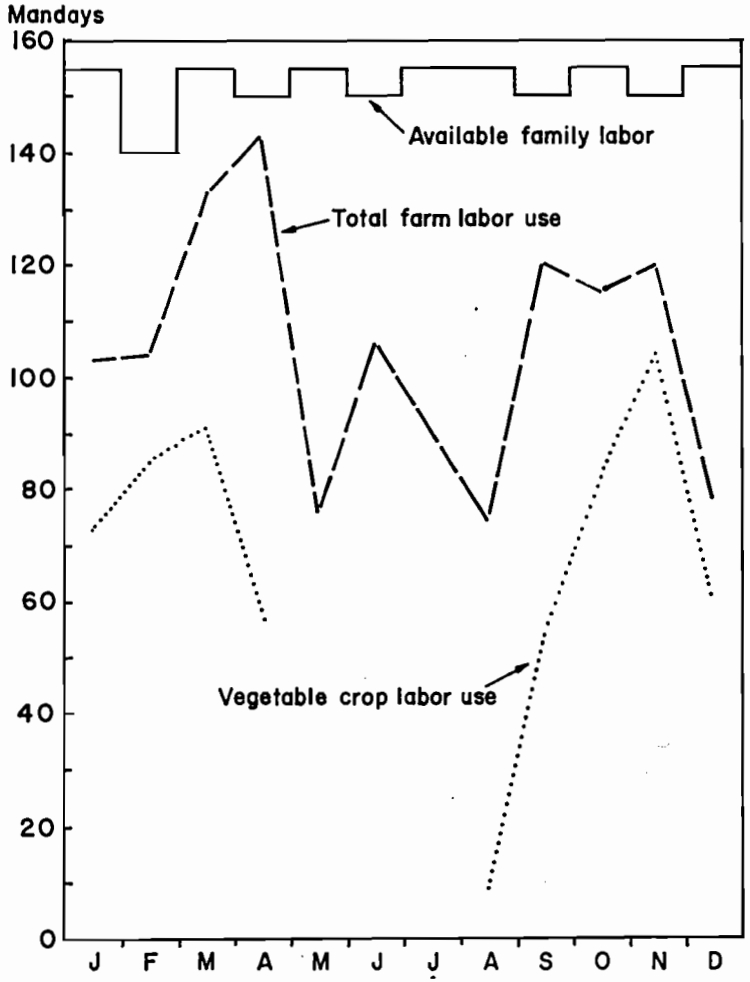

Fig. 28. Large-scale vegetable farm, Matou: total-farm and vegetable labor use, 1976-77; AVRDC, 1978.

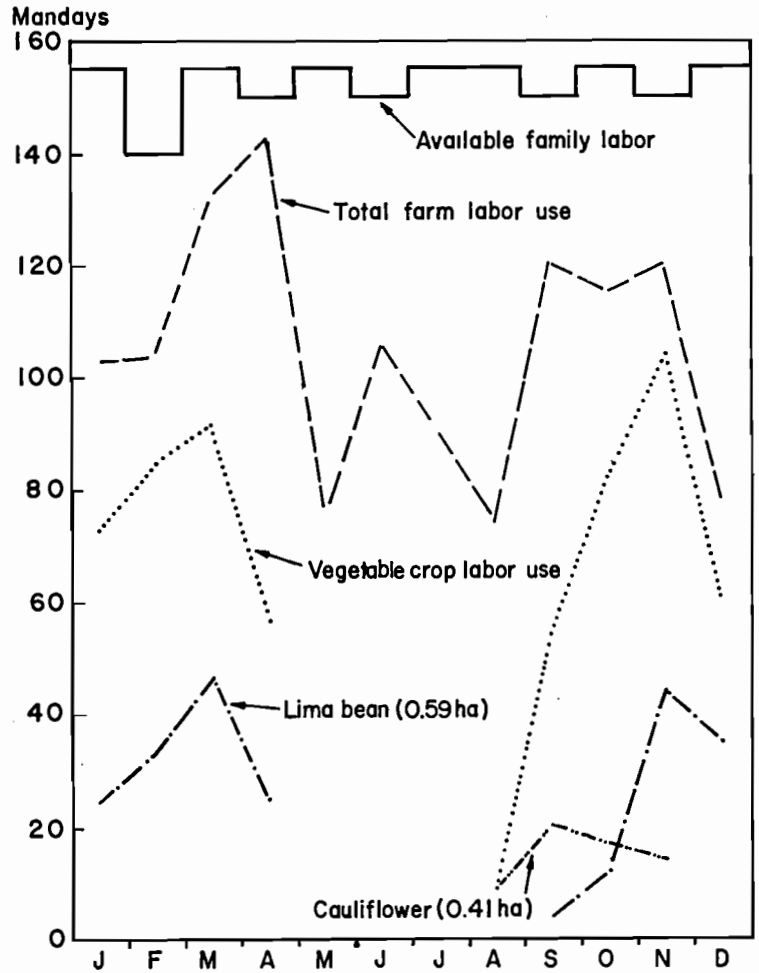

Fig. 29. Large-scale vegetable farm, Matou: limabean, and cauliflower labor use, 1976-77; AVRDC, 1978.

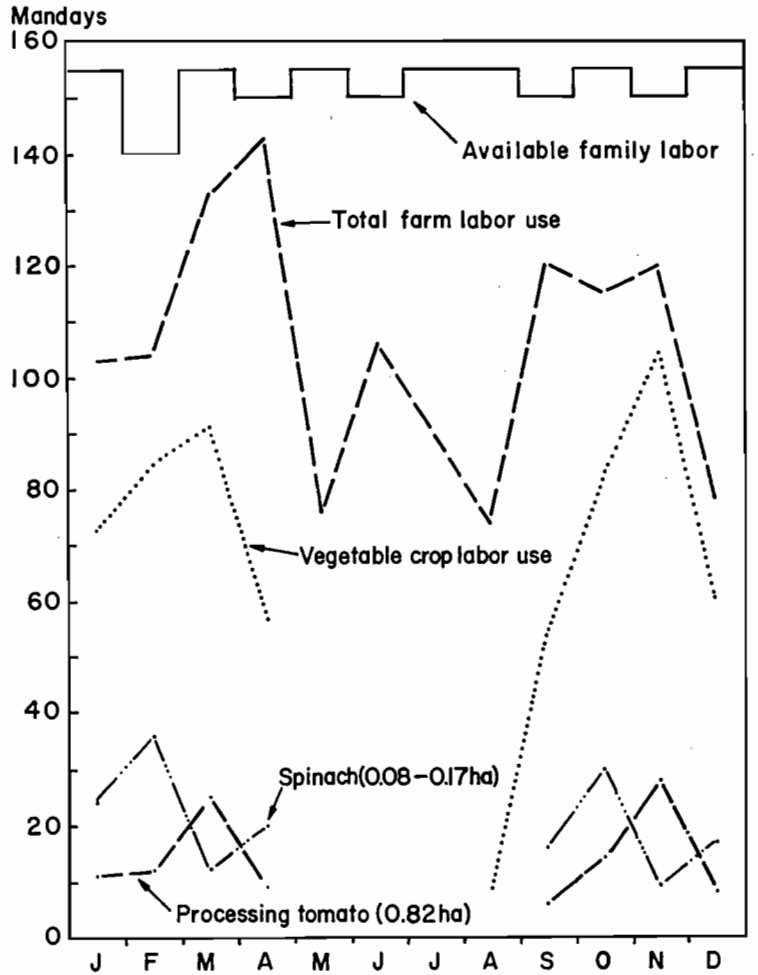

Fig. 30. Large-scale vegetable farm, Matou: processing tomato and spinach labor use, 1976-77; AVRDC, 1978.

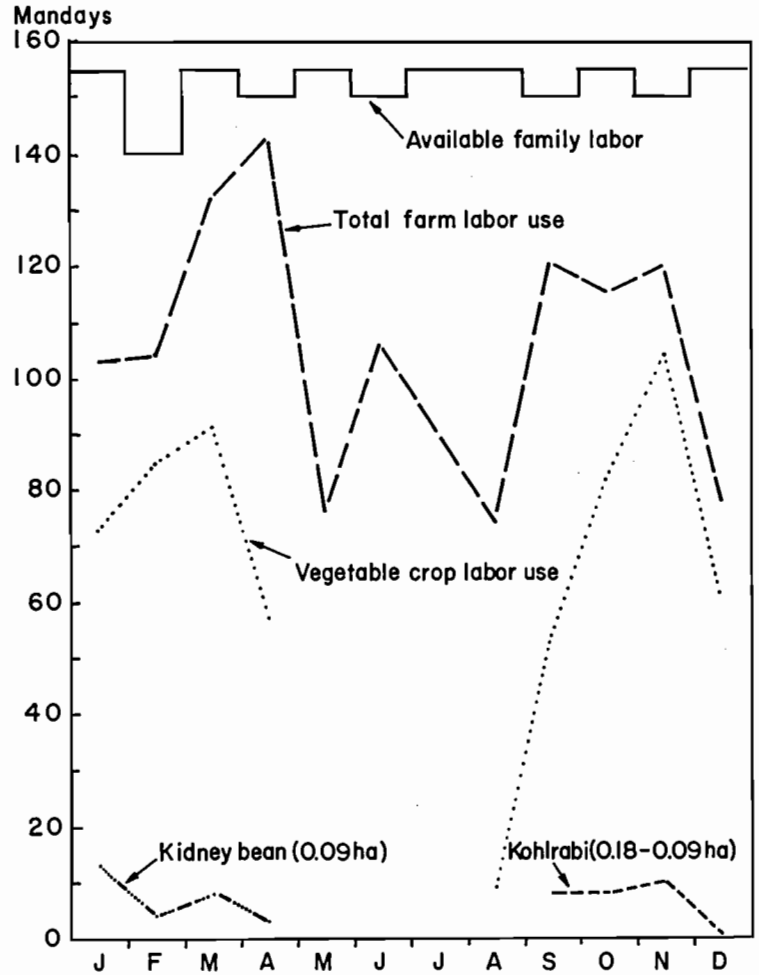

Fig. 31. Large-scale vegetable farm, Matou: Kohlrabi and kidney bean labor use, 1976-77; AVRDC, 1978.

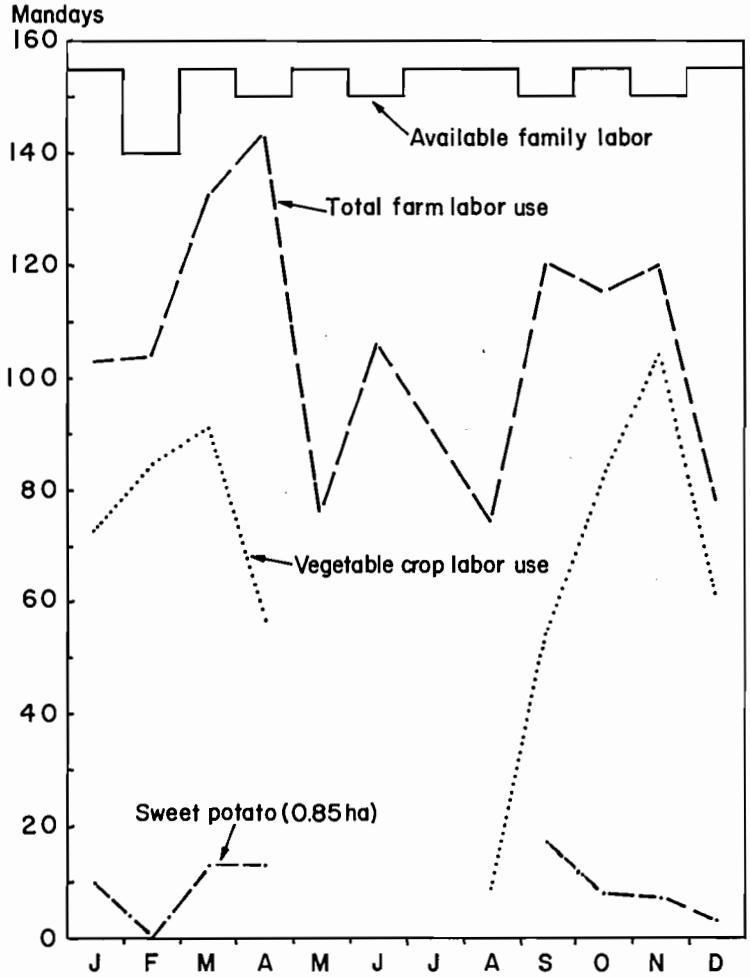

Fig. 32. Large-scale vegetable farm, Matou: vegetable and sweet potato labor use, 1976-77; AVRDC, 1978.

CHAPTER FOUR: SUMMARY AND CONCLUSIONS

AVRDC began a study of farm decision-making in 1975 with two objectives: (1) to determine the most suitable time during the crop year to introduce AVRDC's target vegetables into representative farming systems in southern Taiwan; and, (2) to determine which criteria must be satisfied before a farmer will devote more land, labor, and/or capital to vegetables, or to other crops. The unit of analysis was the entire farm, composed of the off-farm, household, crop, and livestock components, in order to account for all possible decision-making factors. We chose progressive farms to show why farmers in Taiwan have been so successful. we used a four-stage procedure to select these farms:

1) a pre-survey of 63 farm families in 7 townships adjacent to AVRDC;

2) a Benchmark Survey of 130 farm families in an upland area (Shanshang) and a lowland area (Matou);

3) the first year of daily record-keeping on 18 farms, with particular attention to AVRDC target commodities; and,

4) a second year of record-keeping and intensive study of farm decision-making on 6 of the 18 farms.

Significant differences appeared between lowland and upland farms in regard to resource endowment, water availability, and the ranking of agricultural problems. Water limitation is the major reason the farmer selects a particular cropping system in upland areas, while economic considerations are more important in the lowland. Drainage is the single most serious problem in the lowland, while serious diseases and inadequate roads impose hardship in the upland.

Increased profits is the primary goal of all farmers surveyed. Stable income, increased production per hectare, and reduced labor requirements are also important. The major problems in achieving these goals were economic (labor shortage and high wages) and agronomic (pests, diseases, and water).

A study of cropping intensity by farm size and location on the 130 benchmark farms showed that both these criteria are important in determining the role of rice, vegetable crops, field crops, fruit trees, and other crops in the total farm operation. Therefore, we chose the 18 farmers to represent both location and farm size.

Trends in areas planted to these crop groups showed that the generally low-price root crops have given way to high-price vegetables. We studied the agronomic and economic performance of various cultivation methods for tomato, sweet potato, Chinese cabbage, and mungbean on the 95 parcels operated by the 18 farmers. Among AVRDC target commodities, fall processing tomato is the most suitable for extension in upland areas (Shanshang) while fall fresh market tomato is best suited to lowland

areas (Matou). An alternative method intercropped cauliflower with limabean, crops which are mutually beneficial agronomically, have balancing price trends, and contribute to the stability of labor use.

From interviews, we determined that the major motivation for the progressive farmers (except on the smallest farm) was to increase income per hectare subject to the following constraints: (1) low income variance; (2) a limit on total labor use per month; (3) labor use variance; (4) high returns to labor; (5) a minimum return to investment; and, (6) the agronomic suitability of the land. Since these are rational, quantifiable criteria, we used a format modified from linear and quadratic programming to determine whether the farmers were meeting their objectives or not. We found that they were.

We selected five small, medium, and large sized vegetable farms, and one medium sized non-vegetable farm. On small farms, the major objective was to maximize income per hour worked. The farmer already worked part-time off the farm and could increase off-farm work if on-farm earning failed to yield the average wage. He was much less concerned than other farmers about the variability in labor use over the year.

On medium and large-sized farms, farmers sought to maximize income per hectare. In general, their cropping systems achieved this objective, as well as allowing for even labor use over the year and risk aversion through the cropping of a diversity of species. On the very largest farm, labor also became binding.

The non-vegetable farmer had the least appropriate cropping pattern, with low income, high and uneven use of labor, and crops that failed. Even on the basis of one year of data, we identified modifications in his farm plan which improve his present management practices.

EXTENDING THE RESULTS TO TAIWAN AND OTHER AREAS OF ASIA

Farmers chosen at each stage of the project were exceptional by Taiwan standards. Their farms represent models which could be emulated through research and extension on the average Taiwan farm. Taiwan Farmers as a whole are literate, have access to government publications and extension services, are members of farmers' cooperatives (or, specialized production areas with group marketing facilities), and have enough capital to invest in intensive agriculture. Thus, the vegetable farming systems discussed in Chapter Three are feasible in Taiwan, and the conclusions about individual management practices (Chapter Two) should help in choosing the most efficient and profitable production methods for specific crops.

The process of increasing yields and income on Taiwan farms in general may be expedited with improvements in irrigation and drainage. Mechanization to a level achieved on the Matou farms may also increase productivity of land and labor.

Taiwan has developed systems of sequential cropping and intercropping which have given it one of the highest outputs per hectare in Asia. These systems embody sophisticated farm management principles

which could be designed into intensive cropping systems for use in Asian countries where full resource use is still undeveloped. While every effort has been made to select irrigated and non-irrigated areas representative of Asian conditions, and to include information on the agronomic constraints to the adoption of different cropping patterns, the development and testing of intensive cropping patterns in other countries must ultimately lie with scientists in research and extension programs at the national level.

The methodology which we have used has intentionally been low-cost, both in terms of manpower and capital. No computer was used, although linear and quadratic programming lent a conceptual and procedural framework to the analysis. Similar projects in other countries may pinpoint weaknesses in current farm management systems, and evaluate the improvements which systematic changes could make.

The results of this study should, therefore, be of use not only in Taiwan where labor shortage has already forced complex cropping systems in some areas to give way to monoculture, but as a key to general principles of farm decision-making for other nations where cropping intensity is increasing.

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Appendices

APPENDIX I

The Production Environment in the Two Samples

Sample	Matou	Shanshang
Elevation above mean sea level (m)	12	12
Total annual rainfall (mm)	1793	2033
Annual mean max. daily temperature	31.09°C	31.4°C
Annual mean min. daily temperature	12.2°C	12.4°C
Major soil type	clay loam	loamy
pH	7.4	6.1
No. of months irrigated	12.0	12[a]
Limiting soil property	pH, aeration	Organic matter

[a]Only with pumpset, which gives less volume at greater cost than the irrigated sample.

APPENDIX II

A comparison of benchmark survey farm averages with those of Taiwan as a whole.[a]

	FARM CATEGORY							
	Small		Medium		Large		Total	
	Tainan benchmark	Taiwan	Tainan benchmark	Taiwan	Tainan benchmark	Taiwan	Tainan benchmark	Taiwan
Cultivated land								
Area/farm (ha)	0.57	0.47	1.29	1.39	3.07	3.03	1.13	0.84
% irrigated	89	79	93	70	80	55	87	69
Workers/arable ha								
Full-time	2.8	1.8	1.6	0.8	0.7	0.4	1.6	1.1
Total	4.2	3.9	2.2	1.9	0.9	0.9	2.3	2.5
Capital								
No. pumping sets	0.7	0.1	1.1	0.3	1.2	0.4	0.9	0.2
No. power tillers	0	0	0.1	0.1	0.4	0.3	0.1	0.1
No. draft animals	0.1	0.2	0.5	0.5	0.6	0.7	0.3	0.3
% land in fruit trees	12	7	7	10	17	16	12	10
% land in fish ponds	0	1	0	1	0	1	0	1
Head of livestock raised	12.5	2	8.0	4	7.1	6	4.9	3
Management								
Education of the head	4.2	4.3	5.4	4.6	5.3	4.7	4.7	4.4
Average in family	5.4	4.4	5.5	4.7	6.5	5.0	5.6	4.4
Input use								
Multiple cropping index	235	196	217	178	162	151	202	177
Vegetable cropping index	32	17	31	10	11	6	24	12
Relative vegetable intensity index	0.10	n.a.	0.11	n.a.	0.04	n.a.	0.08	n.a.

[a]Agricultural Census Report of the Taiwan-Fukien District of the Republic of China, 1975.

APPENDIX III

A comparison of benchmark survey farm averages with those of Tainan prefecture and the Chianan area.[a]

	FARM LOCATION		
	Tainan benchmark avg.	Tainan Prefecture	Chianan area
Cultivated land			
Area/farm (ha)	1.13	0.84	0.82
% irrigated	87	67	78
Workers/arable ha			
Full-time	1.6	1.2	1.2
Total	2.3	2.7	2.7
Capital			
No. pumping sets	0.9	0.2	0.2
No. power tillers	0.08	0.03	0.05
No. draft animals	0.3	0.3	0.3
% land in fruit trees	12	12	12
% land in fish ponds	0	2	2
Head of livestock raised	4.9	4.4	3.2
Management			
Education of the head	4.7	4.4	4.2
Average in family	5.6	4.7	4.4
Input use			
Multiple cropping index	202	162	175
Vegetable cropping index	24	11	12
Relative vegetable intensity index	0.08	n.a.	n.a.

[a]Agricultural Census Report of the Taiwan-Fukien District of the Republic of China, 1975.

APPENDIX IV

A NOTE ON FOSTERING HORTICULTURAL DEVELOPMENT

The transition between a subsistence agriculture in which horticulture plays a small role and a modern agriculture in which specialized production of fruits, vegetables, and flowers plays a large role is not often addressed by economic studies. Economic analysis of subsistence agriculture tends, like anthropology, to be micro in level and to use individual farms to represent the main types of production units. Let us call these Type I studies. Since no markets exist, managerial ability is low, and the area planted to horticulture is small. Such studies tend to focus on problems of capital shortage, education, and the likely impact of roads. Horticulture crops, if grown at all, are brought into the limelight only as the embarrassing result of linear programming computations of optimal cropping patterns -- embarrassing because, though it would be profitable to grow these scarce, high-value commodities, there is no market mechanism and no way to estimate the drop in price that would result if all the farms represented by the "representative" farm were to start growing them.

On the other hand, economic analysis of horticulture in modern agriculture tends to be macro in level and use specific-commodity industries on the national and international scale as the unit of comparison. We may call these Type II studies. The main question they address is: now that specific commodity industries are established, how can their productivity and competitive position be enhanced, either through technological improvements or through favorable government policy?

Thus, we know very little about how the transition between the roles of horticulture in the two types of agriculture has occurred in the past, and how we may study historical cases to develop a model for encouraging horticultural specialization where it has not as yet occurred.

A strong case can be made for starting from Type I studies of small units and working up, as in the following diagram:

	Nations
Type II Studies	Regions
	Districts
	Villages
Type I Studies	Representative farm
	All farms

There are many reasons for starting specialization at the lowest level possible: (1) if the commodities suggested for specialization by the linear program for representative farms are wrong, then the farmer can get off with little damage to his livelihood and the government

can get off with little damage to its reputation; (2) if the commodities suggested are right, then transportation costs per unit of produce shipped (and more importantly the cost of road and other infrastructural investments) are minimized; (3) markets are nearby and visible to the non-commercialized farmer, giving him both better price information and confidence that he knows what is going on; (4) until sophisticated post-harvest handling and/or processing industries develop, horticultural products may arrive at the consumer household in much better aesthetic and/or nutritive condition; (5) a large government bureaucacy and/or throngs of middlemen are not necessary to promote local trade; (6) since extension personnel are limited, they may be sent to target areas with specialized knowledge of target crops to work first with representative farmers; and, (7) at the same time as certain agroclimatic pockets begin to specialize in horticultural production, others may be encouraged to produce a surplus of grain and other crops in which they have comparative advantage, to assure those specializing in horticulture that they will not be deprived of their basic requirements and to thus promote "integrated rural development".

If specialization and trade can "take-off" in this manner at the village and district level, they should generate managerial skill, investment opportunities, and increased demand for the horticultural products so produced . Thus, if inter-regional or even international trade of horticultural products is the ultimate way to foster improved well-being of all concerned, the village and district models can serve as logical stepping stones in the long run. Increased extension personnel, education, investment in roads and markets, and processing and export outlets will be necessary, but these will have been justified by early successes at the lower levels. It is at these final stages that Type II studies become important.

It is quite possible that horticultural development is not suited to a given region or even a given country. The natural or economic environment may dictate that other pursuits are either far more profitable or far less risky. Even if horticultural development of one form or another is the answer to significantly improved producer and consumer welfare, the natural and policy environment of each region and nation will differ. The above general thoughts must, therefore, be given special form according to local conditions.