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Assessing Rainy Season Vegetable Production Alternatives:

A Case Study in "Upstream" Farming Systems Research

John S. Caldwell

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Assessing Rainy Season Vegetable Production Alternatives: A Case Study in "Upstream" Farming Systems Research

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INTRODUCTION

Farming Systems Research and Development and AVRDC Clientele

Farming Systems Research and Development (FSR&D) is a term that has come into wide use in recent years for applied multi-disciplinary research designed to strengthen the technology adaptation process. The term embraces two distinct types of research activities. The first type is called Farming Systems Research/Extension (FSR/E), or simply Farming Systems Research (FSR). This refers to applied, site-specific crop and/or animal research designed to adapt production technology to meet the goals of households, taking the economic, institutional and social constraints they face "outside the farm gate" as given. The second type of activity is called Farming Systems Infrastructure and Policy Support (FSIP). This refers to socio-economic research designed to provide recommendations for institutional and policy change, with the ultimate objective of expanding the range of alternative production technologies that can be tested "within the farm gate" (40, 49, 51, 55).

Both FSR/E and FSIP share a common objective, to expand the "menu" of production alternatives available to farm families. All FSR&D work begins from a common starting point: diagnosis. Diagnosis is the first of the four stages of FSR&D: diagnosis, design, testing and extension. These stages result in the generation and adoption of new technologies in homogeneously-defined groups of farm families. These groups are termed "recommendation domains" (36). Based on the diagnosis of current production practices, constraints, and goals of the farm families in each recommendation domain, decisions can be made early in the FSR&D process concerning the degree of emphasis to place on FSR/E versus FSIP. Ideally, then, FSR/E and FSIP activities should reinforce each other as the FSR&D process proceeds through diagnosis, design, testing and extension (19).

In reality, however, there have been few examples of FSR&D projects where FSR/E and FSIP have been integrated. The Caisan project in Panama is an exception (48). Most FSR&D projects have either stayed "within the farm gate" and focused on on-farm trials, as in Hildebrand's work in Guatemala (37), or emphasized surveys for policy recommendations, such as Purdue studies in West Africa (45).

Within FSR/E, a further distinction is made between "upstream" and "downstream" FSR/E. "Upstream" FSR/E refers to crop and/or animal research based on diagnosis of farm conditions, but done on-station. It is designed to generate prototype solutions that can be further adapted to each recommendation domain in the target region where the diagnostic work is done. "Downstream" FSR/E, on the other hand, refers to crop and/or animal research

done on-farm. In many cases, diagnosis can lead directly into "downstream" research, if available technology from previous station research matches farm family priorities and constraints. Where such station technology is not available, however, "upstream" research may be needed to provide technology alternatives for "downstream" on-farm testing (28).

Current FSR/E methodology is based largely on work with agronomic crops. Examples include the rice-based cropping systems work of the International Rice Research Institute (IRRI) in Asia (33, 60), the maize-based work of the International Maize and Wheat Improvement Center (CIMMYT) in Latin America and East Africa (16, 36, 48, 53), and the corn and bean-centered work of the Instituto de Ciencia y Technologia Agricolas (ICTA) in Guatemala (37).

For the past 10 years, the Asian Vegetable Research and Development Center (AVRDC) has worked to expand the range of technology alternatives for vegetable crops in Southeast Asia. In a very broad sense, all of AVRDC's work could be called a type of "upstream" research for Southeast Asia as a whole. This has also been moved to a country-, and even within-country region-specific, basis, through the Outreach Programs and cooperating national and regional experiment station research in the different Southeast Asian countries.

AVRDC research is aimed at two different types of clientele. The first type is specialized vegetable producers, usually located either in highland areas or around large urban centers in Southeast Asia. These producers are highly commercialized and can readily utilize new, advanced technology. There is less need to take a systems approach to the introduction of new technology for these specialized producers.

The other type of clientele served by AVRDC are diversified, small-scale producers. These farm families grow vegetables as one component of a complex mix of activities, including staple crops, fruits, animals, fuelwood plots, and non-agricultural activities. Their objectives in growing vegetables include both sale and home consumption. For these clientele, a systems approach is essential, in order to target opportunities for technology development most likely to be compatible with all the diverse activities and goals that comprise their farming systems.

AVRDC recognized the need to understand the farming systems of the second type of clientele when it established the economics department. The work of Calkins, Huang, and others in the economics department did not restrict itself to economic evaluation of individual crops, but rapidly moved towards studies of whole farms and the goals of farm families in Taiwan in the mid-1970s (23, 24, 41).

The ultimate objective for AVRDC's diversified clientele is to select AVRDC technologies to meet farm family needs in appropriate recommendation domains and tailor the technologies to the local conditions of the domain. The primary responsibility for this task lies with the personnel of national research and extension institutions. AVRDC can help by developing methodology for technology tailoring. In recognition of this, the AVRDC Development Program was established in 1979.

The study reported here is one part of the AVRDC Development Program effort. It built on the earlier work by Calkins and colleagues in Taiwan, and sought to expand its scope, both in methodology and in target area. The study was conducted with the goal of developing a methodology for integrating surveys of vegetable production, consumption, and marketing with experiments based on AVRDC crop management research. The target area was two municipalities in Ilocos Norte, Philippines. The study was begun in 1978 with the stated objective of assessing the potential for increased rainy season vegetable production within the context of the "farmer's system" (17).

The case study is presented with three objectives. First, it documents one way in which AVRDC has sought to develop farming systems methodology for its diversified clientele. Second, it provides an example of the application of some of the tools of farming systems analysis to a vegetable-centered

problem. Third, it illustrates the importance of policy and infrastructure support (FSIP) considerations for vegetables.

Organization of the Case Study

In 1979, a survey of farm family consumption of seven vegetables and farmer experience with and attitudes towards their production was done for 175 farms in two municipalities, Laoag and Dingras, in Ilocos Norte. Prior to the survey, the 175 farms were first classified into three locational strata and four farm types based on secondary informaton, an informal survey of village heads and extension personnel, and a census of seven villages. This work corresponded to what is now termed the diagnostic stage of FSR&D. The farming systems conceptual model, methods, and major findings of the diagnostic work are reported in an AVRDC Technical Bulletin titled "Vegetable Consumption and Production in Two Municipalities in Ilocos Norte, Philippines" (20) (see Fig. 1).

The inclusion of consumption reflects the unique mandate of AVRDC. Alone among the major international centers, AVRDC's mandate includes nutritional improvements. This in turn reflects the important contributions that vegetable crops can make to mineral, vitamin, and protein nutrition (44, 54). At the same time, increasing recognition is also being given now to the need to include consumption in the design and evaluation of FSR&D technology development (27, 56).

The study also included a survey of cropping patterns, crop production practices, and overall farm household organization for a sub-sample of 32 farms. Data on vegetable prices were gathered from two local markets, and data on input prices were gathered from farm supply stores in both municipalities. These data represent what is now called "continuing characterization" in the design and testing stages of FSR&D.

Concurrently, field experiments were conducted on common cabbage, mungbean, tomato, and sweet potato at the Philippine Bureau of Plant Industry Experiment Station, Dingras, Ilocos Norte. These experiments represent what would now be called regional "upstream" FSR.

The results of the diagnostic surveys, the continuing characterization, and the "upstream" field experiments were then combined to assess the potential for expanding alternatives for rainy season vegetable production in Ilocos Norte. The study was thus a type of component technology development, taking into account the entire farming system (31).

The body of the report consists of three parts. The first part, "Assessing production capability", describes the rationale for the selection of the four crops tested, experimental materials and methods, and major findings from the "upstream" field experiments. The second part, "Assessing compatibility with the existing farming system", presents the methodology used to integrate the survey and experimental results, together with highlights of the integration of results. The third part, "Implications for future FSR&D work with vegetables," summarizes the conclusions of the case study and indicates ways in which the methodology presented here could be modified based on recent developments on the FSR&D literature. These suggestions also indicate how FSR/E and FSIP can be more effectively linked as future tailoring of AVRDC technology moves from "upstream" design to "downstream" testing and extension. Figure 1 depicts the organization of this report and its relationship to the previous bulletin (20).

The particular findings reported here reflect the state of farming systems in Ilocos Norte and AVRDC technology in 1979-80. Subsequently, there have been changes in the farming systems in Ilocos Norte. Likewise, farming systems will differ in other areas where AVRDC technology might meet farm family needs. AVRDC technology also has continued to progress. The results here are presented, therefore, not as specific production recommendations, but to provide concrete illustration of ways to integrate farm family surveys and "upstream" FSR/E experiments.

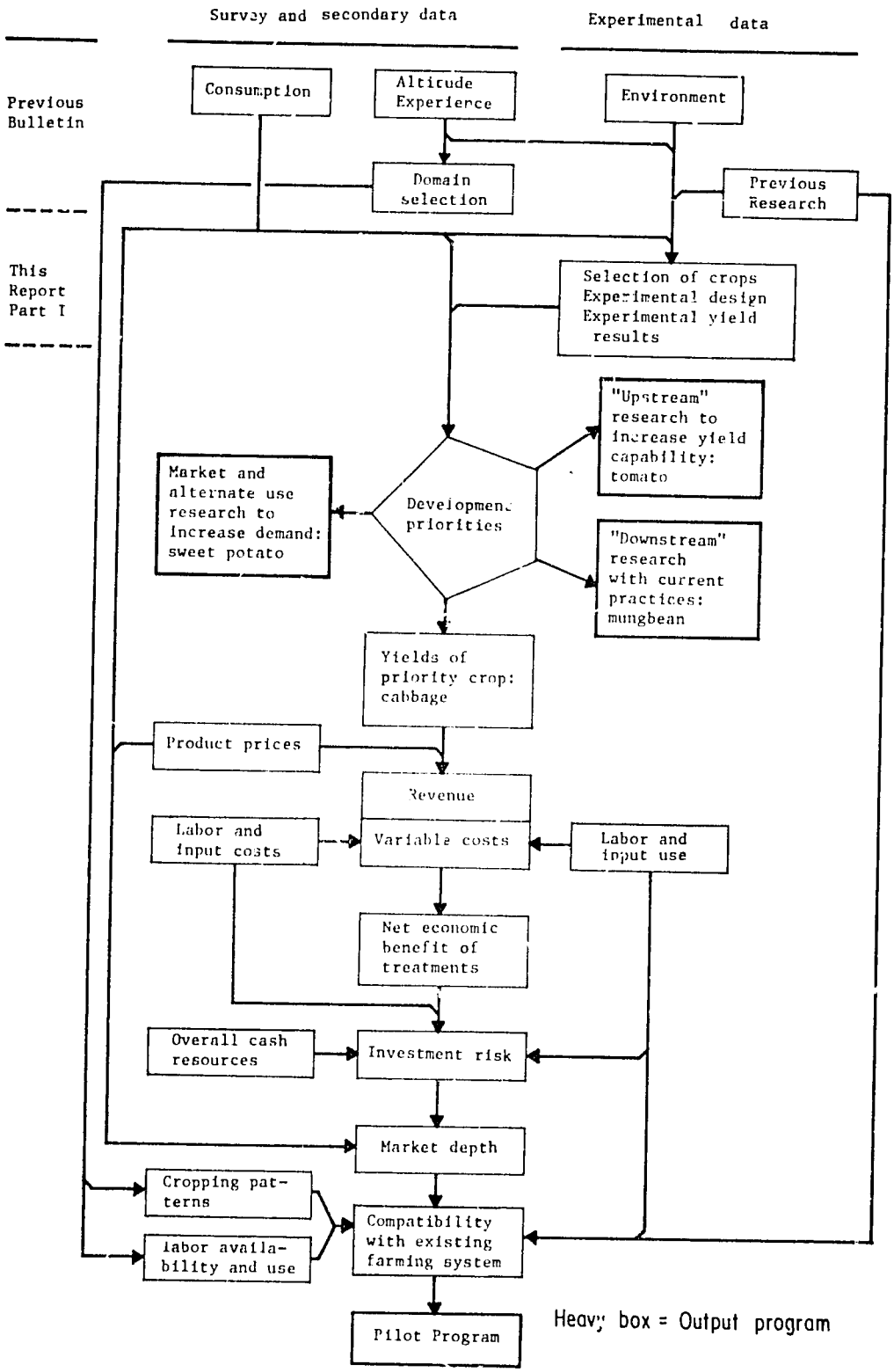

Fig. 1. Organization of this report and relationship to previous bulletin.

PART I: ASSESSING PRODUCTION CAPABILITY

Selection of Crops

The survey data served as the basis for the evaluation of field experiments conducted at AVRDC, Shanhua, Taiwan, from June to December 1978, and the Bureau of Plant Industry Experiment Station, Dingras, Ilocos Norte, Philippines, from June to October 1979. Four vegetable crops were investigated: tomato, common cabbage, mungbean, and sweet potato.

The Ilocos area is known in the Philippines for the importance of vegetables in the diet. Despite the preference for vegetables in the diet, however, consumption declines during the rainy season due to lack of local production and high prices of vegetables from highland areas (personal observation, 1968-70). This was the problem which led to this study.

There were several reasons for choosing the above four vegetables. Both tomato and mungbean are among the most popular vegetables in the diet. The survey on farmer vegetable production (20) indicated that some farmers planted tomatoes before the end of the rainy season, and that many planted mungbean during the rainy season. Sweet potato is predominantly a snack food, but new AVRDC varieties higher in Vitamin A could contribute to improved nutrition. Common cabbage is used more in the diet than Chinese cabbage, and improved varieties capable of heading under high temperatures are available in the Philippines.

In choosing the above vegetable crops for experimental study, this work used a definition of horticultural crops, and vegetable crops in particular, that is broader than the definition traditionally used in the United States. In the United States horticultural crops are distinguished from agronomic crops on the basis of perishability and intensity of cultivation. Agronomic crops are usually utilized in a dry, mature state, but horticultural crops are more often utilized in an immature state high in water content. Horticultural crops are also characterized by more intensive labor use and by greater inputs of technology and capital per unit area of land (46).

In the Asian setting, however, the above distinctions present problems. For example, mungbean is a grain legume utilized in the dry state, but AVRDC includes it among its priority vegetable crops, along with soybean, another legume used in both the immature and mature states. Rice may be planted in the United States by broadcasting the seed from airplanes, requiring very little labor input, but in much of Asia, rice is typically hand-transplanted one seedling at a time. Tremendous amounts of hand labor are similarly used at harvest to cut each rice stalk at the base. On the other hand, in the United States, planting and harvesting of many vegetable crops, even perishable fruits such as tomato, is becoming increasingly mechanized. Moreover, in the target region of this study, more farmers used purchased imputs for rice than for vegetable crops (Table 1). In farmer exposure to and adoption of new seed and technology, rice has also preceded vegetable crops.

Table 1. Sub-sample farmer use of fertilizer and agricultural chemicals (percentage of sub-sample farmers who planted in 1979).

Crop	Number planting in 1979	Fertilizer			Agricultural chemicals		
		Basal		Side-dressing (commercial)	Insecti-cide	Fungi-cide	Herbi-cide
		Commer-cial	Organic matter				
Rice	31	13	42	90	84	6	13
Watermelon	3	0	33	100	100	33	0
Bell pepper	3	0	0	67	67	0	0
Eggplant	17	6	18	47	59	6	0
Tomato	11	0	18	36	55	9	0
Mungbean	23	0	17	9	65	0	0
Sweet potato	9	0	44	0	0	0	0

In order to avoid these problems associated with traditional definitions of vegetable crops based on perishability or intensity of labor, capital, and technology use, this study used a definition based on dietary utilization. In both Northeast and Southeast Asia, rice is the staple food of the overwhelming majority of the population. Although, for example, the Malay languages Ilocano and Tagalog in the Philippines have no linguistic relationship to either Chinese or Japanese, it is significant that all of these languages classify foods in the same way. In Japanese, the word commonly used for "meal" (gohan) literally means "cooked rice"; in Ilocano, the word "to eat" (mangan) is a modified form of the word kanen, "to eat rice."

Contrasted with the staple food are supplementary foods that are eaten together with rice. This concept is identical in Chinese (fushi), Japanese (collogually, o-kazu; the Chinese-derived word, fukushoku, is also used in writing), Ilocano (sida), and Tagalog (ulam). In all cases, these words include both vegetables and other foods eaten with rice such as fish, meat, and eggs, although they do not include desserts or other "foods of pleasure" (shikohin, in Japanese) such as fruits, beverages, or sweets. This study, therefore, defines vegetable crops as "supplementary foods of herbaceous plant orgin that are eaten together with a staple food." This definition is sufficiently broad to include all of the crops treated as vegetables at AVRDC and is entirely consistent with the emic (1, 50) food concepts of people in both Northeast and Southeast Asia.*

Experimental Materials and Methods

Previous research and observation of farmer practices in Taiwan suggested several methods of crop management which might be investigated in combination as a means of improving the conditions for growth and yield of the above four crops during the rainy season. The rainy season in Ilocos Norte is from June through September. Rainfall during these months averages over 300 mm monthly (36). Figures 2 and 3 show that rainfall and temperatures in Ilocos Norte and southern Taiwan, where AVRDC is located, are similar during the rainy season months (9, 30).

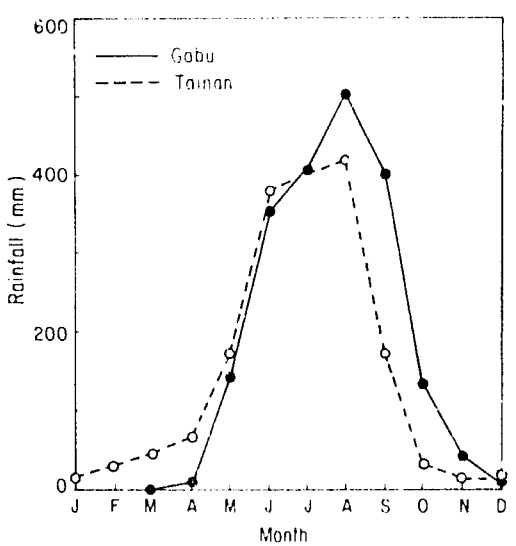

Fig. 2.

Mean monthly rainfall at Gabu, Ilocos Norte, 1965-79, and Tainan, Taiwan, 1897-1970.

* This definition was originally proposed to (then) AVRDC Associate Director Dr. James J. Riley in 1978 when reviewing a paper which he was co-authoring, and first appeared in the final version of that paper which Dr. Riley presented at the Conference on Tropical Foods: Chemistry and Nutrition, held 28-30 March 1979, at Honolulu, Hawaii (54).

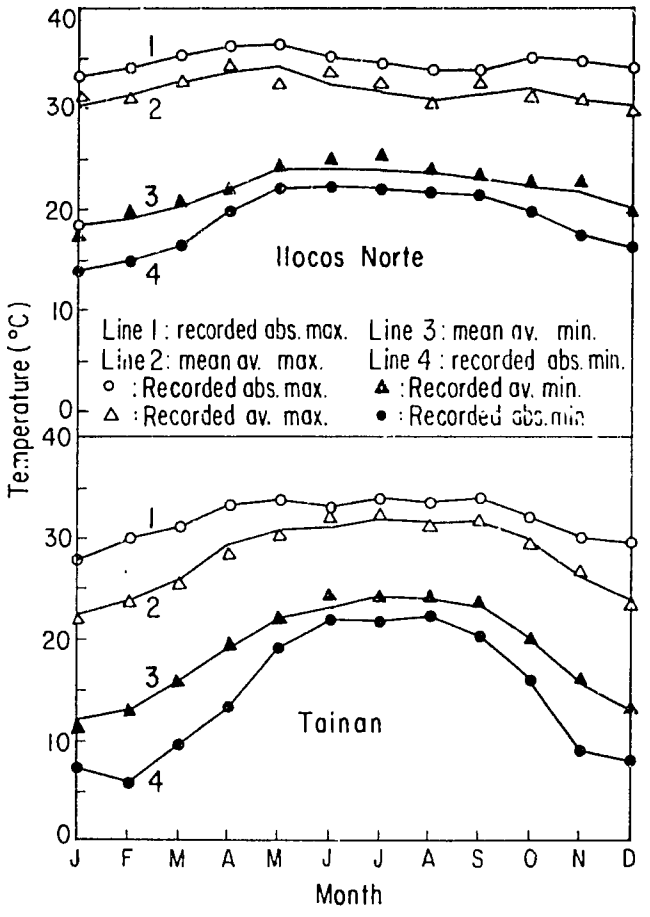

Fig. 3.

Mean absolute and average monthly maximum and minimum temperatures at Gabu, Ilocos Norte, 1965-79, and AVRDC, Tainan, Taiwan, 1975-79, and maximum and minimum temperatures recorded at Dingras, Ilocos Norte, 1979, and AVRDC, Tainan, Taiwan, 1978.

First, experiments conducted at AVRDC in 1977 and 1978 suggested that organic matter (rice straw compost) compensated in part for low fertility due to leaching in the rainy season (42, 43). Interpretation of other data (2, 11, 12, 13, 14, 15, 57, 58) suggested that N contained in organic matter is most available 30 to 45 days after application in the soil. Thus, it was hypothesized that N in organic matter applied just prior to a rainy season planting would be held until the time that the plant would be entering a period of rapid vegetative growth.

Second, specialized high beds 60 cm in height which are maintained for up to five years are used for year-round vegetable production by farmers in the Yung Ching area of West Central Taiwan (25, 59). Little research has been done, however, to modify this system for shorter-term use by farmers in other developing countries.

Third, previous research at AVRDC has shown that rice straw mulching was superior to other forms of mulching for determinate tomato and Chinese cabbage (3, 4, 5, 6, 7, 8).

Accordingly, experiments were designed to identify the economically-optimum combination of the following management practices for rainy season production of the four crops:

a) Organic matter (rice straw compost and/or pig manure) used as a partial (0, 25 and 50%) source of crop N, with the objective of reducing N loss due to leaching.
b) Fertilization at 75, 100, 125, and 150% of recommended rates.

c) Bed height (10-40 cm range) and width (1.0-2.0 m range), with the objective of obtaining improved drainage and aeration with less labor expenditure and for use over a shorter period of time than the specialized beds described above.
d) Rice straw mulching, as a means of reducing erosion and root exposure, controlling weeds, preventing excessive surface drying of raised beds during intermittent dry periods in the rainy season, and avoiding soil dispersion that occurs when raindrops directly strike the bed surface.

All experiments were conducted using three or four replications. In 1978, factors (a) and (b) were studied in one experiment each for tomato and common cabbage. Factors (c) and (d) were studied in a separate set of experiments, one for each of the four crops (Table 2). In 1979, all factors were combined in one experiment each for tomato, common cabbage and mungbean (Table 3).

Results of soil, compost, and pig manure analyses; calculation procedures used in deriving fertilization rates; and specifics of fertilization rates for the experiments are presented in detail elsewhere (18). In 1978, high bed subplots were prepared by physical transfer of soil from corresponding low bed subplots in each main plot. In 1979, a more realistic procedure involving repeated plowing and shoveling of soil up from furrows was devised for the 2.0 m-wide, high bed plots (Figures 4-5).

Crop protection followed AVRDC and/or Philippine Council for Agriculture and Resources Research recommendations, depending on the availability of chemicals. AVRDC cultural practices were followed in other regards except

Table 2. Summary of experimental designs for experiments conducted at AVRDC, 1978.

Experiment	Crop	Design[z]	Main plots	Sub-plots	Sub-subplots
I, II	Tomato, cabbage	3x3 LS	0, 25, or 50% om[y]	75, 100, or 125% of recommendation[x]	
III	Tomato	RCB, 3 reps.	Wide (1.5 m) vs. narrow (0.1 m)	High (32 or 26 cm) vs. low (20 or 17 cm)[w]	0, 5.625, or 11.25 t/ha mulch
IV	Cabbage	RCB, 4 reps.	Early (Aug.) vs. late (Sept.) planting[v]	High (33 cm) vs. low (23 cm)	0, 1.875 or 3.75 t/ha mulch
V	Mungbean	RCB, 4 reps.	Wide (1.5 m) vs. narrow (1.0 m)	High (41 or 33 cm) vs. low (26 or 21 cm)[w]	0, 2.5, or 5.0 t/ha mulch
VI	Sweet potato	RCB, 4 reps.	Wide (1.5 m) vs. narrow (1.0 m)	High (33 or 28) cm) vs. low (24 or 20 cm)[w]	0, 2.5, or 5.0 t/ha mulch

[z] LS = Latin Square; RCB = Randomized Complete Block.
[y] 0, 25, 50% om = 0, 25, or 50% of N recommendation supplied by organic matter (0, 11, or 22 t/ha rice straw compost and 0, 3.7, or 7.3 t/ha pig manure for tomato; 0, 20, or 40 t/ha rice straw compost and 0, 6.1, or 12.2 t/ha pig manure for cabbage).
[x] Inorganic N, P, and K added to bring totals up to appropriate sub-plot percentage, where 100% level was 180, 60 and 180 kg/ha N, P_2O_5 and 160 K_2O respectively for tomato (AVRDC recommendation) or 300, 80 and 160 kg/ha N, P_2O_5 and K_2O respectively for cabbage (Taiwan Experiment Station recommendation).
[w] First height value refers to wide beds; second to narrow beds.
[v] Planting dates arranged as strips across high and low plots. All beds 1.5 m wide.

Table 3. Summary of experimental design for experiments conducted at Dingras, Ilocos Norte, Philippines, 1979.

Experiment	Crop	Design[z]	Main plots	Sub-plots[y]	Sub-subplots
I	Tomato	RCB, 4 reps.	High wide (40 cm x 2.0 m) vs. low narrow (20 cm x 1.0 m)	Local w/o om, 100% w/o om, 100% w/ 25% om, 125% w/o om, 125% w/ 25% om	0, 7.5 t/ha mulch
II	Cabbage	RCB, 3 reps.	Semi-high wide (25 cm x 2.0 m) vs. low narrow (10-15 cm x 1.5 m)	Local w/o om, 100% w/o om, 100% w/ 25% om, 125% w/o om, 125% w/ 25% om	0, 5.0 t/ha mulch
III	Mungbean	RCB, 4 reps.	High wide (35-40 cm x 2.0 m) vs. low narrow (15-20 cm x 1.0 m)	Local w/o om, 100% w/o om, 100% w/ 50% om, 150% w/o om, 150% w/ 50% om	0, 2.5 t/ha mulch

[z] RCB = Randomized Complete Block.
[y] Local = Local Philippine Bureau of Soil Laboratory recommendation:
90, 120 and 0 kg/ha N, P_2O_5 and K_2O respectively for tomato;
150, 60 and 0 kg/ha N, P_2O_5 for cabbage; and
20, 40 and 0 kg/ha N, P_2O_5 for mungbean

100, 125, 150% = Corresponding percentages of AVRDC recommendations after modification to reflect differences in soil P and K status between AVRDC and Dingras fields. In treatments with organic matter, inorganic N, P and K added to bring totals up to appropriate sub-plot percentage, where modified 100% level was:
180, 120 and 120 kg/ha N, P_2O_5 and K_2O respectively for tomato;
200, 80 and 80 kg/ha N, P_2O_5 and K_2O respectively for cabbage; and
30, 60 and 100 kg/ha N, P_2O_5 and K_2O respectively for mungbean.

W/o om, w/ 25% om, w/ 50% om = 0 and 25% (tomato and cabbage) or 0 and 50% (mungbean) of N requirement supplied by organic mattter (30 t/ha pig manure for tomato, 34 t/ha for cabbage and 20 t/ha for mungbean).

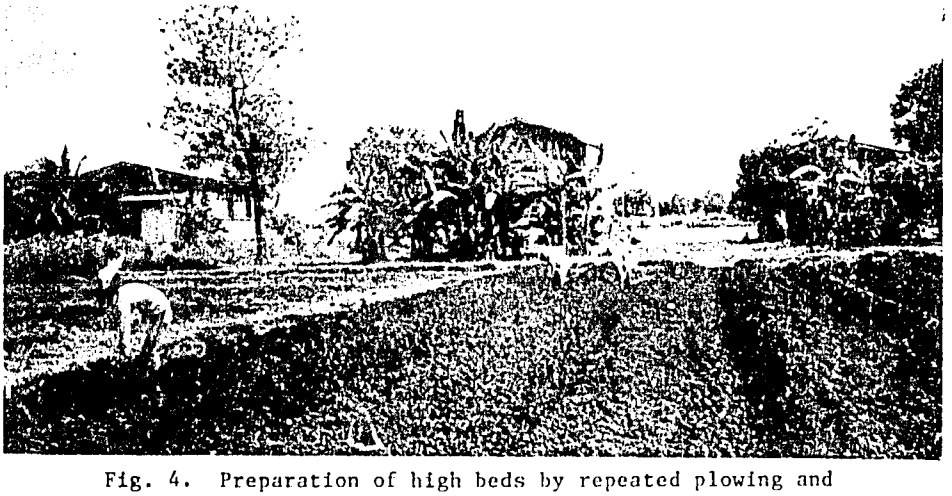

Fig. 4. Preparation of high beds by repeated plowing and shoveling of soil up from furrows on to bed tops.

Fig. 5. Completed 40 cm-high beds.

where deviations were required by the nature of the treatments or differences in soil fertility.

Common Cabbage Results

Early yield of cabbage (cultivar 'KK') planted in August 1978 was significantly ($P<0.05$) greater on high beds than on low beds (Table 4). Thin mulch tended to increase early yield, and absence of mulch resulted in highly significant ($P<0.01$) delayed yield, but bed-mulch interactions were nonsignificant in 1978.

Table 4. Effect of bed height on marketable cabbage yield, August 1978[z].

Bed system	Yield (t/ha)/harvest[y]					
	1-3	4	5	6	7-9	Total
High	8.1	8.7	10.7	8.2	3.1	37.7
Low	4.3	3.9	11.5	11.2	4.7	34.3
Significance[x]	*	*	NS	*	NS	NS

[z] Planted August 17.
[y] Means of three replications. Totals may not add across because of effects of missing values estimated by least squares. Harvests 1-3: Oct. 16-30; 4: Nov. 7; 5: Nov. 13; 6: Nov. 21; 7-9: Nov. 29-Dec. 15.
[x] NS, *: Nonsignificant or significant at the 5% level based on general linear models analysis of variance tests.

Environmental pressure was more severe in 1979 than in 1978. In 1979, precipitation from planting to initial harvest was 844 mm. Of that total, 82% (644 mm) occurred in the peak growth and head formation period 15-42 days after planting. Weekly precipitation during that four-week period exceeded 140 mm/week. In contrast, total precipitation in 1978 was only 454 mm. Over half occurred in the first two weeks after planting, while only 25% (115 mm) occurred during the period 15-42 days after planting. As a result, overall mean yields in 1979 were lower, but bed-mulch interactions were significant. Yield of cabbage planted in July 1979 was significantly ($P<0.05$) greater on mulched semi-high beds than on unmulched semi-high, mulched low, or unmulched low beds in 1979 (Table 5).

Table 5. Effect of interaction of bed system and mulch on marketable cabbage yield, 1979[z].

Bed system	Yield (t/ha)[y]	Significance[x]
Mulched semi-high	31.7	a
Unmulched semi-high	22.8	b
Mulched low	17.3	c
Unmulched low	14.0	c

[z] Planted July 5-7.
[y] Means of three replications, harvested Sept. 12-Oct. 12.
[x] Mulch-bed interaction significant at 5% level based on analysis of variance test. Means separation by Tukey's Honestly Significant Difference (w procedure), 5% level.

The use of organic matter and lower fertilization rates had highly significant ($P<0.01$) and significant ($P<0.05$), respectively, negative effects on marketable cabbage yield in 1978. Actual mean inorganic N rates were identical in both sets of comparisons, suggesting that yield responded primarily to the three sidedressings of inorganic N (80% of total inorganic N) applied near the shallow cabbage roots. In 1979, when the fertilization treatments covered a smaller range of inorganic N applications than in 1978 (150-250 kg/ha in 1979 vs. 75-375 kg/ha in 1978), there were no significant differences among fertilization treatments.

Tomato Results

Overall, yields of the AVRDC determinate line (C 11-d-0-2-2-3) used in the 1978 experiments were low (3.6 - 6.9 t/ha). Wide raised beds tended to increase early yield (1.1 t/ha vs. 0.5-0.6 t/ha) of tomato planted at the start of the rainy season in 1978, but late yield was significantly ($P<0.01$) greater on low beds than on high beds (5.8 vs. 3.8 t/ha). Similar but nonsignificant trends were seen in the fertilization experiment: yield in the earliest harvests was greater in the treatments where organic matter was used as a partial source of N, but late yield was greater in the treatment in which all N was supplied by inorganic fertilizer.

The 1979 experiment was terminated October 10, after six harvests, due to late blight. As a result, fruiting did not continue into the cool season. Paralleling the early harvests of 1978 summer planting, yields were higher on high beds, but overall yield levels were poor. Similar but nonsignificant effects were obtained with organic matter.

In 1978, mulch had significant ($P<0.05$) positive effect on early yield and highly significant ($P<0.01$) positive effects on late yields. Early yield differences between mulch rates were nonsignificant, but thicker mulch tended to increase late yield more than thin mulch. Mulch also increased yields in 1979.

Contrary to hypothesis, there were no significant differences between high and low beds in 1979 in the effects on yield of organic matter versus inorganic fertilizer use or of mulching. Absence of bed-mulch interaction may have been due to the sprawling, not fully determinate growth habit of the AVRDC line used. Observation of plant growth on high beds in 1978 and 1979 suggested that considerable fruit were lost from the high beds because vines tended to grow down from the mulched surface of high beds along the unmulched sides and into the furrows, exposing fruit to bare soil. Although comparison of rice straw mulching with several staking and trellising systems resulted in comparable yields in four out of five experiments at AVRDC in 1976 (6), these observations suggest that trellising may have greater benefits in conjunction with high, wide beds.

The overall low yields in both years reflected inadequate heat tolerance of the line used. The same line planted at the end of the 1978 rainy season in the same field, on low beds, with inorganic fertilization only, and having the same management practices as in the rainy season planting, yielded 77 t/ha over seven weekly harvests.

Mungbean Results

Results of the field experiments suggested that adequate rainy season yields can be obtained with AVRDC line 'V 3476'. With a less severe rainy season in 1978, there were no significant differences between high and low beds, among mulching treatments, or due to bed-mulch interaction. Overall yields were approximately 1.2 t/ha. In 1979, wind damage occurred at six weeks after planting, when plants were approximately 70 cm in height. Wind damage was more severe on high than on low beds. As a result, low bed shelled yield (0.8 t/ha) was higher ($P<0.10$) than high bed shelled yields (0.4 t/ha) and mulch had a greater effect ($P<0.10$) on low bed yield (0.17 t/ha difference) than on high bed yield (0.06 t/ha) difference.

Observations in 1979 of an experiment at IRRI using high beds and a shorter cultivar (60 cm at maturity, in contrast to nearly 100 cm for AVRDC line 'V 3476') suggested that the tall AVRDC line was more susceptible to lodging when planted on 2.0 m-wide high beds in which rows were divided into two groups of four rows each. This row arrangment resulted in larger spaces between groups than the spaces between the four groups of two rows each on 1.0 m-wide low beds. The tall plants appeared to be better able to support one another without lodging in the low bed arrangement (Figure 6).

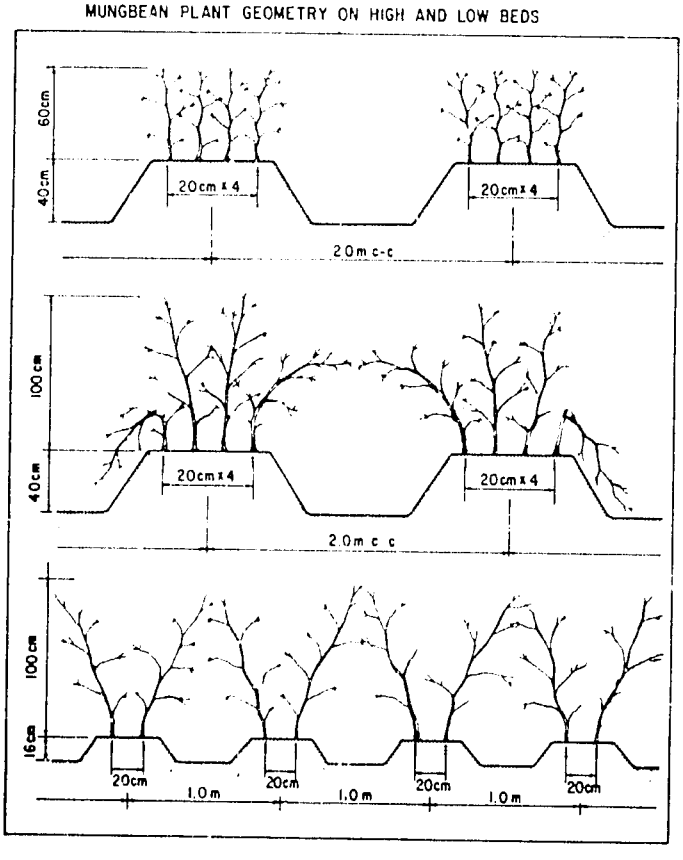

Fig. 6.

Mungbean plant geometry on high and low beds.

Sweet Potato Results

In 1978, high bed yield (11.5 t/ha) was highly significantly ($P<0.01$) greater than low bed yield (5.0 t/ha) for sweet potato (AVRDC line '35-2', orange flesh). Approximately half of the roots classified as nonmarketable by Taiwan market criteria were of less uniform shape or overly large. Such roots would have otherwise been acceptable for home consumption, sale in less-selective markets such as in the Philippines, or use as animal feed.

Due to difficulties in obtaining planting materials of the same AVRDC line, it was not possible to confirm the above results under 1979 Philippine conditions.

PART II: ASSESSING COMPATABILITY WITH THE EXISTING FARMING SYSTEM

Development Priorities for the Alternative Crops

Integration of the survey and field experiment data on tomato, common cabbage, mungbean, and sweet potato using the development priority grid of Calkins (23) indicated different current potentials and future research priorities for rainy season production of each of the four crops (Figure 7).

Demand for rainy season tomato was high (20), but production capability was poor due to inadequate heat tolerance. The conclusion was that priority in future rainy season tomato research should be placed on breeding, with the goal of incorporating a higher degree of heat tolerance and raising overall yield

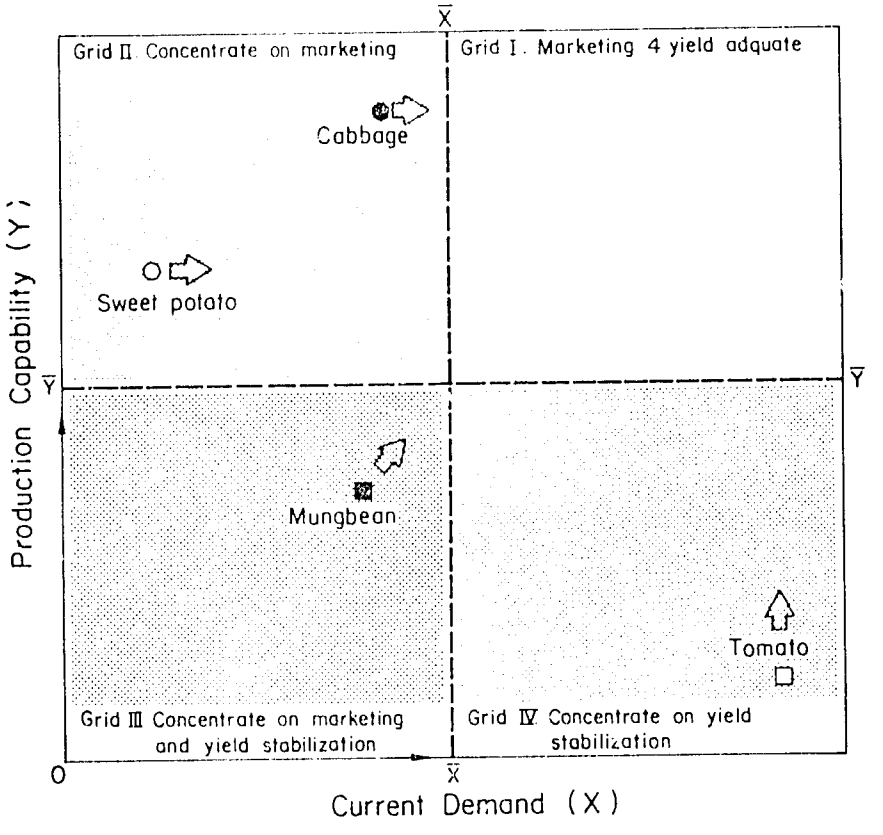

Fig. 7. Development priority grid for rainy season tomato, common cabbage, mungbean, and sweet potato production in Ilocos Norte, Philippines.

levels in the rainy season. At higher overall yield levels, it would then be possible to determine if the trends observed in the early harvests with higher beds and organic matter might result in meaningful benefits for rainy season production. Since this study was done, AVRDC tomato research has moved in these directions.

In contrast, mungbean rainy season production capability appeared to be adequate relative to current demand (20). Additional research on rainy season mungbean production thus would be given lesser priority relative to other vegetables. Primary research needs were for investigation of potential effects of the introduction of other crop production choices in the mungbean subsistence production-consumption cycle, the net economic benefit of low beds versus the farmer practice of no-till broadcasting, and economically-optimum pest control under rainy season conditions. In correspondence with observations in other parts of the Philippines by Litsinger et al. (47), the farmers surveyed in this study also identified large, conspicuous insect pests as their major mungbean pest problems but were unaware of beanflies as a pest of mungbean (20).

Sweet potato production capability appeared to be promising, but demand for sweet potato roots in the rainy season was low. However, in addition to use of sweet potato roots as a family snack food (20), sweet potato roots and vines were also widely used as swine feed. Data from the sub-sample farmers studied in the farm operations survey indicated that the majority of both large tenant farmers and owner-tillers (88%) and small tenant farmers (73%) raised hogs for sale (2.3 heads per large tenant farmer and owner-tiller household, and 1.1 heads per small tenant farmer household). Each hog resulted in US$68.93 (US $1.00 = P7.50) (small tenant farmers) to US $85.53 (large tenant farmers and owner-tillers) cash revenue to the farm household after 8-15 months of raising the hog.

These findings suggested that future rainy season sweet potato research should focus on ways of creating greater demand for sweet potato roots. One approach would be to develop culturally-acceptable ways for families to utilize more orange fleshed sweet potato roots. Another approach would be to develop alternative uses for sweet potato. One way might be to link sweet potato production on marginal sloping land to swine production in a system utilizing sweet potato tips and roots as food for human consumption, vine material as a protein supplement to swine feed, swine excreta in biogas generation, and biogas digester residue as an organic fertilizer. The biogas would serve to reduce dependence on firewood and petroleum products for cooking. Its sale to non-farm households through a village distribution system could also generate income for farm households. The digester residue could be characterized for nutrient content and used in production of other vegetables. Biogas digestion might also serve to increase the uniformity of organic matter nutrient composition. This could aid in standardizing recommendations for using organic matter as a partial source of crop nutrients. Subsequent AVRDC research and related studies have investigated some of these ideas for alternative sweet potato production systems (26).

Of the four crops investigated in the experiments, rainy season common cabbage production capability was highest (Figure 8). Additional analysis was, therefore, done to estimate the potential net economic benefit and investment cost of rainy season cabbage production, assess the depth of the market, examine examples of high input vegetable production in farmer cropping patterns, and assess labor availability and use patterns.

Common Cabbage Market Potential: Revenue, Net Economic Benefit, Investment Cost, and Market Depth

Revenue from the wholesaling by one farmer in the Dingras inland market of 0.02 ha of cabbage grown on semi-high mulched beds at the time of the 1979 experiment would have been US $316.40 (US $1.00 = P7.50). This is based on prices that range from US $0.40 to $0.80/kg over the peak four weeks of

Fig. 8. September harvest of cabbage planted on semi-high, wide beds in early July 1979.

harvest. This would be more than double the revenue of US $147.73 which would have been obtained in the same market from 0.02 ha of cabbage grown on low beds. The additional expense required in order to build the wider and higher raised beds, place mulch, and thereby obtain higher yield and revenue would have been only US $2.27 for 0.02 ha. Thus, a net benefit (defined as the difference between the increase in revenue from an alternative set of production practices and the increase in variable costs associated with the alternative set of production practices) of over US $160 would have resulted if only one farmer planted 0.02 ha.

Similar revenue, and consequently similar net benefit, would have resulted from wholesaling 0.02 ha of cabbage grown on semi-high mulched beds in the Laoag urban market in 1979. Moreover, revenue from production beginning one or two weeks earlier or one week later than that of the experiment (and assuming for purpose of discussion that the same yields would be obtained) would have varied considerably less in the urban than in the inland market. In the inland market, revenue from the latest four-week production period would have been less than half the revenue from production in the earliest period and only two thirds of the revenue in the period of actual experimental production. On the other hand, in the urban market with more stable prices, revenue would have been essentially constant regardless of whether planting and production had been two weeks earlier or one week later (Table 6). In addition, examination of price changes over a five-year period confirmed that the absence of sharp drops in price in the urban market was a regular characteristic (Figure 9).

In the context of rural income levels in Ilocos Norte, a net benefit of US $160 would be a very substantial addition to income. Rural income levels in the Laoag A recommendation domain consisting of coastal, more diversified villages which had greater experience with cabbage production can be estimated at US $44-104/month, based on monthly family expenses (including the inputed value

Table 6. Cabbage revenue over a four-week period in an inland and a coastal market.

Market	Revenue (US $/0.02 ha)[z]			
	2 weeks earlier	1 week earlier	Actual	1 week later
Inland	427.73	403.87	316.40	204.27
Coastal	337.73	336.00	325.07	311.07

[z] US $1.00 = ₱7.50

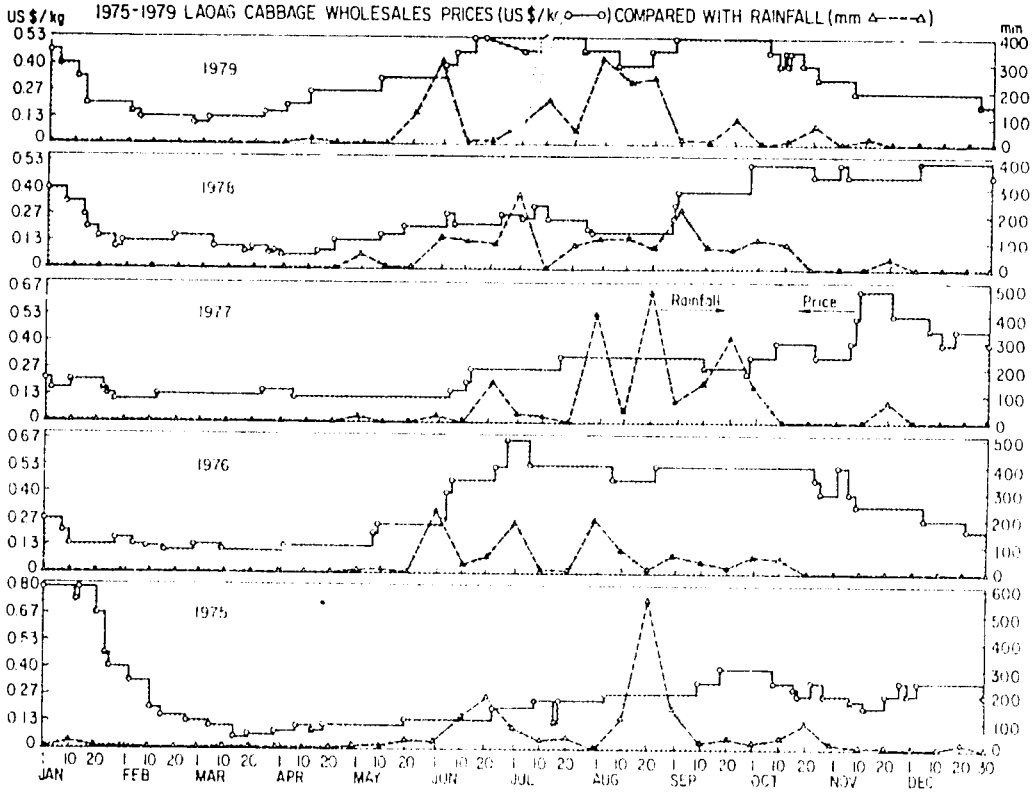

Fig. 9. 1975-79 Laoag common cabbage wholesale prices compared with rainfall.

of rice produced on farmers' fields and used for family consumption). These figures translate into mean yearly incomes ranging from US $66 to $279 per capita, depending on family size.

Two factors, however, would limit the real potential contribution of rainy season cabbage production to considerably less than the figures suggested by the above calculations of revenue and net benefit. First, successful rainy season cabbage production requires a high level of purchased inputs. Production of 0.02 ha of cabbage following the procedures used in the experiment would require an investment of US $11.87 for seed, fertilizer, and pesticides, and US $5.60 for labor for bed preparation, fertilizer application, planting, and mulching. If a comparison was made of semi-high, mulched beds not against low beds otherwise under intensive management, but against farmer practice of flat culture with low management, most of this US $17.47 would represent increased variable costs. (Of course, yields, revenue, and net economic benefit would also change in a comparison with farmer practice). Such an investment of US $17.47 would not be prohibitive, considering that a representative large tenant farmer in a coastal, more diversified village may spend US $37.33 for labor at rice planting time. It would, however, represent risking a considerable portion of monthly family income on a new venture.

Second, at the high price levels used in deriving the above estimates of revenue and net benefit, the size of the potential market is limited. A highly significant ($P<0.01$, $r = -0.94$) regression of percentage of farm households consuming cabbage on 1979 Laoag wholesale prices in the different months of the year indicated that 30% of farm households would frequently consume cabbage at a price of US $0.53/kg, the peak Laoag price in 1979 (Figure 10).

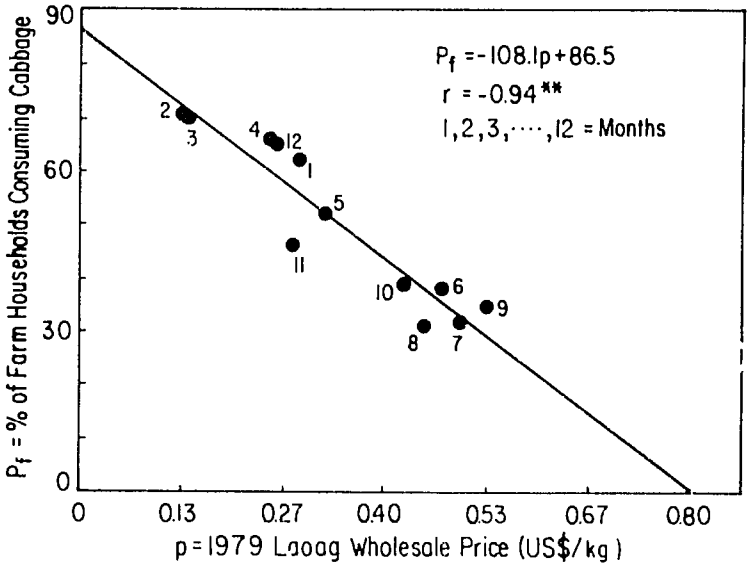

Fig. 10. Percentage of farm households consuming cabbage at different price levels.

This is within the range used in the earlier calculation of net economic benefit. Applying this estimated percentage to the total population of approximately 12,000 households in Laoag, and using an estimate that each household would consume two heads of 0.5-1.0 kg weight each over a four-week period, then total Laoag demand at US $0.53/kg would be 3.6-7.2 t. Each farm family which produced 0.02 ha of cabbage using semi-high mulched beds could supply 0.6 t over the four-week period. Thus, only 6-12 farm families would saturate the market at the peak price.

At US $0.27/kg, 59% of farm households would frequently consume cabbage. Assuming that each household consumed one head/week, or four heads over the same four-week period, then applying these estimates to the population would indicate a demand of 13.9-27.7 t. Even with the greater demand at this lower price, only 23-46 farm families producing 0.02 ha would satisfy the market. Of course, revenue and net economic benefit would be correspondingly less for the greater number of farm families.

Finally, at a price of zero, an estimated 87% of farm households would consume cabbage. Survey responses indicated 2.9 heads to be the mean maximum number of heads that a farm household would consume in one week. Applying these estimates to the population indicates a maximum demand of 60-120 t. Only 100-200 farm families planting 0.02 ha of cabbage on semi-high mulched beds in early July would thus completely saturate the Laoag market from mid-September to mid-October. In other words, the bottom would drop out of the market, families would lose their investment, and the following year would see very few if any families trying rainy season cabbage production again. The above analysis thus suggested that the introduction of rainy season common cabbage production should be carefully targeted so as to avoid inducing oversupply.

Potential for Integration of Rainy Season Common Cabbage Production into the Existing Farming System: Cropping Patterns and Labor Use

The results of the information access and attitudinal surveys indicated that owner-tillers and large tenant farm families (≥1.0 ha mean farm area) in the coastal, more diversified villages (Laoag A) could be expected to have the greatest potential receptivity towards increased vegetable production (20). The

Laoag A villages could be thus considered as a potential recommendation domain for the introduction of rainy season cabbage production. Examination of changes in cropping patterns during the four-year period, 1976-80, and family labor use for all farming systems activities in 1979 on Laoag A sub-sample farms suggested routes by which rainy season common cabbage production might be integrated into the existing farming system. This discussion of sample farms can also be compared with a similar study of sub-sample farms drawn from a larger sample in Taiwan (41).

Farmer Eusebio Lorenzo* is one of the four sub-sample large tenant farmers in the Laoag A villages. The Lorenzo family farms 1.90 ha of land, none of which it owns. This land consists of nine non-contiguous parcels, ranging in size from 0.05 ha up to 0.40 ha, with median as well as modal parcel area equal to 0.20 ha. All nine parcels are within 10 minutes' walking distance from the Lorenzo family house.

Table 7 shows that this fragmentation of the Lorenzo farmland is typical of all the farmers in the sub-sample. Except for one atypical farm in Laoag B with three large parcels totaling 1.33 ha, the land of all other large tenant farmers is fragmented into at least eight small parcels. Moreover, in the most extreme case, one large tenant farmer in Dingras farms 1.73 ha of land that consists of a total of 42 separate parcels, the largest of which is only 0.23 ha in size. In addition, even the land of small tenant farmers is similarly fragmented into small parcels, fewer in number and also generally smaller in size than those of the large tenant farmers. All small tenant farmers farm at least two parcels, and two small tenant farmers farm land broken into as many as 13 individual parcels. Likewise, the land of both small and large owner-tillers also exhibits similar fragmentation. Although one of the three small owner-tillers farms only one parcel, at the opposite extreme another small owner-tiller farms land broken into 16 small parcels. The two large owner-tillers farm land consisting of 11 and 12 parcels each. Figure 11 shows an example of one of these small parcels.

Table 7. Mean number of parcels, parcel size and total land area of sub-sample farms.

Farm type and location	Number of farms	Parcels/farm			Area/parcel (ha)			Total area/farm (ha)		
		Tenanted	Owned	All	Tenanted	Owned	All	Tenanted	Owned	All
Small tenants										
Dingras	6	4	1	5	0.10	0.01	0.10	0.45	0.02	0.46
Laoag A	4	7	1	8	0.08	0.04	0.08	0.59	0.02	0.61
Laoag B	5	8	1	8	0.05	0.01	0.05	0.40	0.01	0.41
All	15	6	1	7	0.07	0.03	0.07	0.47	0.02	0.48
Large tenants										
Dingras	6	18	4	22	0.10	0.05	0.09	1.82	0.23	2.05
Laoag A	4	10	2	12	0.21	0.11	0.19	2.08	0.25	2.32
Laoag B	2	9	0	9	0.28	0.00	0.28	2.52	0.00	2.52
All	12	14	3	17	0.15	0.07	0.13	2.02	0.20	2.22
Small owner-tillers (all)[z]	3	1	6	7	0.03	0.05	0.06	0.08	0.32	0.39
Large owner-tillers (all)	2	1	11	12	0.20	0.20	0.20	0.10	2.18	2.28

[z] Mean number of owned parcels includes two parcels in which the farmer owned two-thirds of the parcel and had tenant rights on the remaining one-third. In computing the areas/parcel of tenanted and owned land, owned and tenanted portions of a parcel were counted separately. In computing the area/parcel of all parcels, however, such part-owned, part-tenanted parcels were counted only once.

The Lorenzo farm follows two basic cropping patterns: the double cropping of rice, and rice followed by other crops. Every year at the start of the rainy season, all or nearly all of the land is planted in rice, usually in June or July but occasionally as late as August. Following harvest of the first rice, usually

* Fictitious names have been given to the individual farmers whose farms are described in this report.

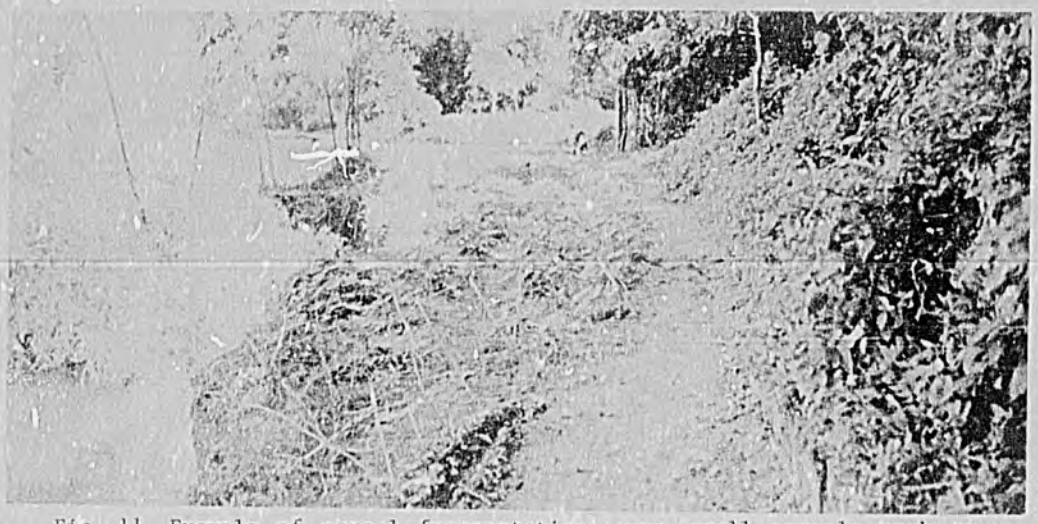

Fig. 11. Example of parcel fragmentation: even small parcels such as this one along the river bank are planted by farm households.

in October, a second crop of rice is then planted on approximately half of the land and other crops planted on the remaining half. Table 8 shows the kinds and acreages of crops planted on the Lorenzo farm during the four cropping years from 1976-77 through 1979-80.

Examination of the Lorenzo farm's cropping pattern during the four-year period in question provides concrete examples of the trends towards greater experimentation with planting dates and crops and greater economic orientation observed in the attitudinal responses of large tenant farmers and owner-tillers, as described in the previous bulletin (20). In 1976 and 1977, farmer Lorenzo experimented with cabbage for two years. Especially significant is the fact that in the second year he did not plant rice on one parcel of 0.02 ha, in order to plant the cabbage at an earlier date, in September, because of higher prices. Figure 12 shows another similar small parcel of cabbage in the Laoag A recommendation domain. In 1979, however, he planted watermelon instead of cabbage, and took 0.05 ha out of rice production in order to plant part of the watermelon early, because he believed that it could be more easily marketed than cabbage.

Increasing interest in watermelon production is also apparent in the case of Basilio Mercado, another large tenant farmer who is from the other Laoag A sample village. The Mercado family farms 1.52 ha of land consisting of 12 non-contiguous parcels. The family owns 0.58 ha of the land which it farms and is a tenant on the remaining 0.94 ha. The farm's parcels range from 0.04 ha to 0.50 ha. Like the Lorenzo farm, all 12 of the Mercado farm's parcels are also within 10 minutes walking distance of the house.

The Mercado farm follows the same basic cropping patterns as the Lorenzo farm. Every year in June all of the land is planted in rice. Then, following harvest of the main rice crop in October, a second rice crop is planted on part of the land and most of the remainder is devoted to a host of other crops. During a four year period, the Mercado farm has steadily increased the area of land and number of parcels planted in watermelon, because it "produces more money." At the same time, the farm has gradually decreased not only the area devoted to other crops, but more significantly, in the last two years also the area planted to second rice. In fact, in the 1979-80 cropping year, for the first time farmer Mercado split the large 0.50 ha owned parcel. In the previous three years, that parcel had been planted entirely in second rice, but in 1979 rice was planted on only one-half of the parcel, and the other half was used for watermelon. Table 9 shows the above changes in the Mercado farm's cropping pattern.

Table 8. 1976-80 land use and cropping pattern on the farm of Eusebio Lorenzo, a large tenant farmer in Laoag A.

Year	First planting			Second and third plantings		
	Crop	Time	Area (ha)	Crop	Time	Area (ha)
1976-77	Rice (C4)	Early June	0.20	Cabbage	Early Oct.	0.20
		Mid June	0.35	Garlic	Mid Nov.	0.34
		Late June	1.35	Rice (C4)	Mid Nov.	1.14
				Mungbean	Early Feb.	0.30
					Late Feb.[z]	0.20
				Corn	Early Feb.	0.10
1977-78	Rice (C4)	Early June	0.18	Cabbage	Early Sept.	0.02
		Late June	1.70	Garlic	Mid Nov.	0.34
				Rice (IR1561)	Mid Nov.	1.14
				Mungbean	Early Feb.	0.30
					Late Feb.[z]	0.20
				Corn	Early Feb.	0.10
1978-79	Rice (IR1561)	Early June	1.10	Bell pepper	Early Oct.	0.20
		Late June	0.80		Early Dec.	0.10
				Garlic	Mid Nov.	0.23
				Rice (IR1561)	Mid Nov.	1.14
				Corn	Early Dec.	0.10
				Tomato	Early Jan.	0.13
1979-80	Rice (IR1561)	Early June	0.90	Watermelon	Mid Oct.	0.05
		Early August	0.95		Mid Feb.[y]	0.03
				Rice (IR1561)	Mid Nov.	0.52
				(IR30)	Mid Dec.	0.67
				Garlic	Mid Nov.	0.11
				Bell pepper	Mid Dec.	0.10
				Cotton	Mid Dec.	0.10
				Corn	Mid Jan.	0.20
				Peanut[x]	Early Feb.	0.05
				Mungbean	Early Feb.	0.15

[z] Third planting following garlic.
[y] Intercropped with garlic for first month.
[x] Third planting following watermelon.

Fig. 12. Farmer planting of cabbage in September 1979.

Table 9. Changes in 1976-80 land use on the farm of Basilio Mercado, a large tenant farmer in Laoag A.

Crop	Area (ha)			
	1976-77	1977-78	1978-79	1979-80
Watermelon	0.04 (1 parcel)	0.17 (1½ parcels)	0.27 (4½ parcels)	0.65 (7½ parcels)
Eggplant	0.02	0.02	0.02	--
Bell pepper	--	0.04	--	--
Edible jute (saluyot)	0.02	0.02	0.02	--
Garlic	0.29	0.42	0.33	0.42
Yam bean (singkamas)	0.25	--	--	--
Cowpea	0.10	0.06	--	0.04[y]
Mungbean	--	0.04[z]	0.04[z]	0.25[x]
Peanut	--	--	0.13	0.13
Second rice	0.72 (4 parcels)	0.72 (4 parcels)	0.58 (2 parcels)	0.33 (1½ parcels)
Fallow	0.08	0.08	0.08	--

[z] Third planting in February folowing garlic.
[y] Third planting in February following watermelon.
[x] Third planting in February following watermelon, peanut, and garlic.

The Mercado farm's shift to watermelon production because of its income-producing potential takes on more significance in light of the high level of purchased inputs which farmer Mercado uses in its production. Farmer Mercado sidedresses the watermelon with 16-20-0 and urea at one month and applies not only insecticide (Thiodan or Sevin) but also fungicide (Manzate) three times in the field. Both of the other two Laoag A large tenant farmers who planted watermelon also sidedressed and applied insecticide, although neither applied fungicide.

The above data provide an indication of how farms in more receptive strata might gradually integrate new, high input vegetable production into their existing cropping pattern. Although not all Laoag A sub-sample farms in the large tenant farmer and owner-tiller strata exhibited as much variation in time or variety of crops as did the two farms whose cropping patterns were examined in detail here, the other two large tenant farmers also showed more variation than did any of the sub-sample small tenant farmers. One of those latter two large tenant farmers also planted watermelon, and the other tried cotton for the first time. Only the one sub-sample small owner-tiller had not varied cropping patterns during the four-year period in question.

In contrast to the sub-sample large tenant farms, none of the four sub-sample small tenant farmers in Laoag A showed any significant variation in cropping patterns over the four-year period in question. Moreover, none had planted one of the high cash value but also high input vegetable crops of cabbage, bell pepper, or watermelon. All four followed the basic pattern of rice planted in June or July and harvested in October, followed by a second crop of rice planted on a portion of their land and other crops, including eggplant, tomato, pumpkin, garlic, peanut, mungbean, yam bean, corn, cassava, sugarcane and balangeg (a sweet potato relative, Ipomoea reptans, grown for tips only), planted on the remainder of their land.

The above examples show that large tenant farmers may reduce considerably the area planted in second rice and may even take a small amount of land out of main rice crop production, in order to plant a high cash value vegetable crop. Nevertheless, because of the importance of rice as the "staff of life" in the diet, it is more realistic to consider the present rainy season cropping pattern as being essentially fixed. Using the example of the Lorenzo farm, it would be reasonable to assume that a farm household would be willing initially to take only 0.02 ha of land out of main rice crop production in order to plant a vegetable crop in the rainy season (as the Lorenzo farm has done once before

for cabbage). The question which then arises is, when is there sufficient labor available for planting and harvesting a rainy season vegetable crop?

Figure 13 shows that in 1979 the working members of farmer Lorenzo's family (two males and two females) were willing to work approximately the same number of hours per half-month segment throughout the year except in two periods: April and early May (the hottest, driest time of the year), and late August and September (after all planting of the main rice crop is completed). In addition to family labor for farm crop work, farmer Lorenzo also used a portion of his family working time to care for animals (2 draft buffalo, 4 pigs raised for sale, and 40 chickens), haul rice (usually twice a month), and cut wood (in September). Farmer Lorenzo further supplemented family labor with hired labor for rice planting and harvesting. As a result, the Lorenzo farm labor budget shows considerably reduced or negative surplus labor (the difference between available labor and labor use) in early June, early August, and the period from late October through November (note, however, that farmer Lorenzo's responses in Table 8 indicate that in the three years prior to 1979, the early August reduction in surplus labor would have come in late June).

Labor budgets were also constructed for three of the four small tenant farmers in Laoag A (it was not possible to obtain complete labor use data from the fourth farmer). Five males and four females constituted the working members of the three families. In addition to using labor for farm crop work on their total of 1.81 ha of land, these three families used a portion of their labor to manage their animals (each owned one draft animal and a pig being raised for sale; two owned a horse; and one had two goats). All three farms also cut their own wood; two hired themselves out to harvest rice; and one operated a horsedrawn carriage tax (kalesa). One farmer further supplemented family labor with hired labor for the planting, weeding, and harvesting of rice and for the harvesting of peanuts.

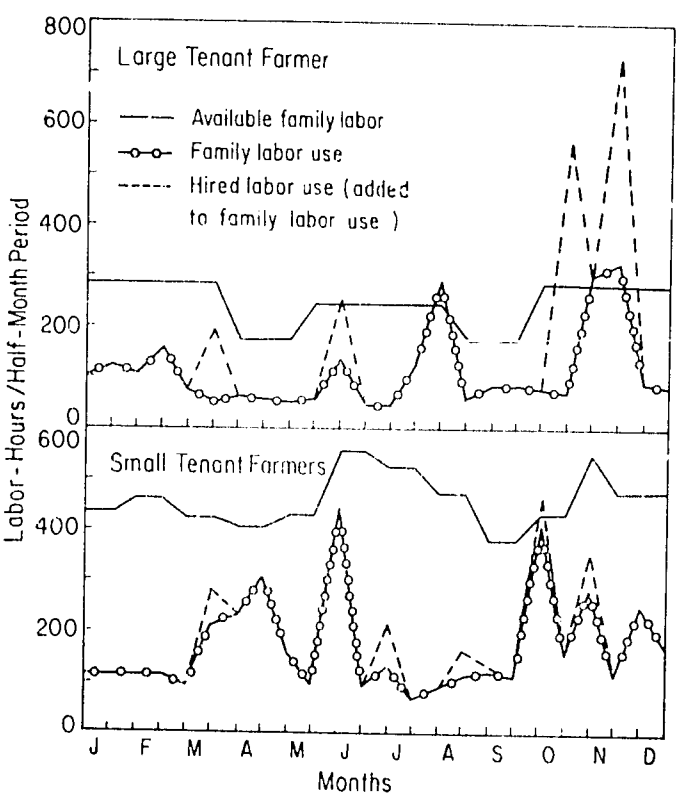

Fig. 13.

Labor availability and use by a large tenant farmer and three small tenant farmers in Laoag A.

Figure 13 shows that in the aggregate, the working members of these farmers' families were most willing to work during the months of June, July, and October. Figure 13 also shows that the months in which their farm and non-farm activities required the most labor were March, April, June, October, and November. As a result, their aggregate labor budget shows considerable reduced surplus labor (the difference between the upper and lower lines) in those months, and especially in June and October.

It is apparent from a comparison of the upper and lower portions of Figure 13 that times of peak labor use generally coincide for both farmer Lorenzo and the three small tenant farmers. On the other hand, the months of May and July are times of reduced labor use for all of these farm households. Analysis of weather data (20) also showed that these are times when land preparation and planting would be feasible. Thus, planting either in early to mid May before the onset of the heavy rains or in a dry period in early July (as in the 1979 experiment) would not conflict with labor requirements for main rice crop production. Planting at either date would result in harvest of all or much of the crop in September prior to rice harvest in October and November.

Design of a Pilot Program to Increase Acceptability of Rainy Season Common Cabbage Production: Coordination of FSIP and On-Farm Trial FSR/E

In light of the results of the analysis of market potential, a pilot program to test rainy season common cabbage production in the Laoag A recommendation domain would need a strong FSIP component. It would need first to determine if rainy season cabbage production in the target area could be profitably linked to other markets. This would provide a back-up market outlet, and increase market depth. This would mean coordination with national market development planning. The pilot program would also need to be done in the context of a provincial development plan which encouraged different specializations among villages. Otherwise, targeting a few villages in the Laoag A domain for cabbage would introduce inequalities in the province. It might also be self-defeating. If cabbage production were successful in the first year in the targeted villages, other villages might enter and oversupply result in the following year.

Supplying current rainy season demand in the province through local production would also be in accordance with national objectives of decentralizing vegetable production and freeing highland areas which currently supply off-season vegetables for lowland areas to concentrate on high-quality vegetable production for the metropolitan Manila and Singapore export markets (personal communication, Bureau of Plant Industry Baguio Experiment Station and Philippine Council for Agriculture and Resources Research, 1979).

In the target villages, farms would be selected for on-farm trials of the "upstream" semi-high, mulched bed production technology, to determine what modifications would be needed to increase acceptablility of the technology. This would also promote close technician-farmer interaction. The extension technicians were identified as the major source of new information on vegetable production by farmers, and several farmers who were more expressive in their responses added that technicians should live in the village (rather than commuting from town) and teach them by participating in farm work on farmers' fields (18). In essence, these farmers were asking for cooperation through on-farm trials. In conjunction with more active farmer-technician interaction, the program could also include support for pesticide and fertilizer purchase in the initial years, in order to reduce high input costs and enable farm families to gain confidence in intensive cabbage production before they assume all production risks. Full support might be given for the first 1-2 years of researcher-managed trials, and farm households allowed to decide themselves how rapidly to reduce support over the following 2-3 years of farmer-managed trials and a pilot production program.

The importance of active technician participation and initial input support is highlighted by the responses of several farmers relating to the difficulty of

work and availability of resources for common cabbage production. The reason given by farmer Mariano de la Rosa for not having planted cabbage in May exemplified in particularly expressive form the responses of a number of farmers in this category: "It (cabbage) is hard to take care of because you have to go to the field every day."

In one of the conversations with farmers during the census, one farmer explained the advantage of growing mungbean using traditional methods in terms which express essentially the inverse side of this reluctance to engage in the intensive type of management which cabbage production requires. This farmer said that mungbean was a good crop to grow because, "All you have to do is throw out [broadcast] the seed, and you're finished with it."

The traditional planting sequence and production method for mungbean enables farm families to maintain a stock of an important supplementary food or sida, mungbean, over much of the year without conflicting with production of the staple crop, rice (20). Traditional methods, in other words, have enabled farm families using a minimum input of both labor and purchased inputs to meet subsistence needs more or less adequately as they have been culturally defined.

The key element here is not that cabbage production requires intensive labor. Farm family members work extremely intensely to prepare and transplant rice every year in June and July (for the main rice crop) or October and November (for the second rice crop). At those times, farmers may even rise with the moon at two in the morning every day for a week in order to plow the field before the heat of the day.

What distinguishes the type of intensive management required for both vegetable production as well as modern rice production from the occasional intensity of work in traditional rice production is instead that it is a sustained intensity of conscious, precise attention to the crop. Goodell, working in Central Luzon, has documented how this type of sustained intensity was baffling to many of the farmers she observed. Particularly relevant is her observation that even for rice production, visiting the field each week after transplanting was a radical departure from the farmers' experience. Likewise also significant is her observation that farmers have traditionally enjoyed a 23-week leeway during which they could choose when to put out the intensive burst of effort of rice planting, whereas the new rice production technology requires monthly, and even weekly, scheduling of transplanting, fertilizer application, and irrigation (34).

When technology adoption involves only the dissemination of new seed, the new technology is already largely "packaged" in the seed through breeding. The farm family need only plant the new seed, and even without changing their production practices, they can often still obtain an improvement in yield (for example, due to increased disease resistance). In contrast, changes in production, especially important for vegetables, require a more all-embracing, consciously-calculated departure from previous experience. On-farm trials represent a way to introduce those changes incrementally, and work together with farm family members to choose, adapt, and learn more intensive techniques (38).

In addition, changes in production practices often require more inputs from outside the traditional farming system. As Farmer Honorio Garcia pointed out in his reason for not planting cabbage, "We don't have [a] complete [range of] pesticides like the government." It is precisely the high cost of those inputs that farmers cannot obtain within their traditional system, particularly pesticides, which farmers identify as their greatest common cabbage production problems. A program of testing would need to recognize these concerns. A first step, for example, might be on-farm trials with reduced levels of pesticide input. At the same time, policy and infrastructure support would be needed to insure availability of necessary chemicals.

Finally, focusing initial efforts on large tenant farmers would contribute to the overall objective of the betterment of the well-being of rural people in the target region for several reasons. First, large tenant farmers made up a substantial fraction (38%) of the rural population in the Laoag A recommendation

domain (20). Second, integration of rainy season vegetable production by large tenant farmers into the existing cropping pattern could utilize labor of small tenant farmers (as well as landless laborers who make up 6% of the households of the Laoag A villages) at a time when such labor is not fully utilized, thus providing an additional source of employment in the community.

In addition, although the introduction of local rainy season cabbage production would benefit only a small portion of the whole province's farm households and farm laborers through increased income in target villages, increased supply could result in a cabbage price high enough to support production but lower than current rainy season prices. A decrease in rainy season cabbage prices would benefit both the estimated 30% who consume cabbage at current high prices in the rainy season, through an income effect, and an additional percentage of consumers who now do not consume cabbage during the rainy season but would in response to lower prices.

PART III: IMPLICATIONS FOR FUTURE FSR&D WORK WITH VEGETABLES

Summary

This case study has illustrated a methodology to integrate survey and experimental results (Figure 1). The problem was limited availability of vegetables in the rainy season, in an area where vegetables are important in the diet. Survey data and observations were combined with rainfall pattern data and previous crop management research to select four crops for "upstream" production experiments. The four crops were common cabbage, tomato, mungbean, and sweet potato.

Yield results were evaluated first in terms of a comparison of production capability and demand. The comparison indicated where future development priorities should be placed. For the crop with the best combination of production capability and demand, cabbage, further analyses were done. First, survey data on product prices, labor costs, and input costs were combined with experimental yield, labor, and input use data to estimate net economic benefit from the most promising treatment combination, semi-high mulched beds. Next, survey data on overall cash resources were compared with experimental labor and input use data to evaluate the risk associated with investment costs for semi-high mulched beds. Then, consumption and product price survey data were used to assess market depth. Market depth was found to be limited, suggesting that careful targeting of a production area would be essential to avoid oversupply.

Other survey data were used to select the potentially most receptive domain: owner-tillers and large tenant farmers in coastal, more diversified Laoag A villages. Examples of these farmers' integration of cabbage and watermelon into their cropping patterns over a four-year period suggested a feasible route for introduction of rainy season cabbage production. Comparison of survey labor budget data with experimental data on labor use and environmental data on dry periods favorable for bed preparation suggested compatibility with existing farming system labor availability.

The project concluded with recommendations for a pilot program to test rainy season common cabbage production in the Laoag A domain. The suggested pilot program would coordinate FSIP and on-farm trial FSR/E. The FSIP component would involve linkage with national market development planning and a provincial village specialization plan, to increase market depth and avoid oversupply. The on-farm trial FSR/E component would both respond to farmer requests for increased interaction with extension technicians in their own fields, and provide a learning environment for incremental adaptation and change in production practices.

Lessons from the Case Study

This case study was done as a special project within the Bureau of Plant Industry. Today, the Philippines has integrated the previously separate

bureaus into Regional Integrated Agricultural Research Systems (RIARS) (61). This reorganization can facilitate FSR&D.

The research agenda in this case study started from a generalized problem, low availability of vegetables in the rainy season. It sought to address this problem in the context of the "farmer's system" (17). Today, FSR&D is more "downstream" in orientation. In a national program like RIARS, each municipality can prioritize local problems. Local problems amenable to adaptive research can set the local research agenda. Those problems needing "upstream" research backstopping can then be transmitted to a regional research coordinating committee. The generalized problem of this case study is an example of the type of problem that might reach a regional research coordinating committee.

The survey techniques used in this study had strengths and weaknesses. Their strengths were in the use of secondary data, both environmental and market. Their weaknesses were over-reliance on formal methods and inadequate use of more open-ended questioning. Open-ended questioning within an interview guide format allows better insight into farm family member perceptions, while retaining a useful degree of structure and comparability (21, 52).

In this study, an informal survey preceeded the formal survey, but the informal survey was used primarily for determining recommendation domains, rather than for designing a simpler formal verification survey. Considerable informal information was also obtained during the formal surveys. The informal information provided qualitative insight into farm family goals and constraints, as in the rationale for mungbean planting dates described in the previous technical bulletin (20), or farmer perceptions of the difficulties related to cabbage production discussed in this report. Survey work by a regional research coordinating committee on a generalized problem would want to use the informal methods of FSR&D, such as the sondeo or other types of rapid rural appraisal, and carefully target any formal survey work based on the informal surveys (55). Informal methods have been shown to yield results that are a good approximation of those yielded by formal methods, but at reduced cost (29).

This study focused on the main farmer of each farm household. With the exception of a few female-headed households, this meant only the male "farmer." The term used at the conception of this study, "farmer's system," reflected that focus. The woman-in-development literature has shown that focusing only on male "farmers" often misses both alternative family goals affecting production choices, and home garden production (10, 32, 56). In both informal and formal survey work, whether at the local level or at the regional level, care should be taken to include all family members, both male and female, and both field and garden production. This is especially important for vegetable crops. Garden production of vegetables by female family members may make significant contributions to family diets. Female family members may also have developed valuable intensive production skills in home garden production. These skills can be drawn upon for small-scale, intensive market production as well, as in the pilot program suggested by this study.

The economic analysis of this study is an example of what is now called "ex ante" analysis in FSR&D. That is, the economic analysis is done "ex ante" (meaning "prior to") a program of on-farm trials. "Ex ante" analysis is valuable because it can identify constraints, such as limited market size in this study, prior to involving cooperating farm families in on-farm trials. The "extension" term in Farming Systems Research/Extension, or FSR/E, reflects the fact that on-farm trials can have an extension effect at the same time as they provide research results. That is, successful research treatments can have extension demonstration value. The demonstration effect can be counter-productive, however, if too many farm families become enthusiastic when the market is limited.

To do good "ex ante" analysis requires realistic data. In this case study, as suggested in the discussions on investment costs and pesticide use level,

some management practices were higher than farmers would likely have used. Non-treatment variables should be placed at the farmer level even in "upstream" research. Information from farmers can also be used to generate a more realistic "average farmer practice" treatment or treatment combination to compare experimental treatments against (22). In this study, for example, flat bed culture might have been a better "average farmer practice" treatment.

Several on-farm sites should also be included even in "upstream" or exploratory research. These will provide more realistic data on labor and input use in the treatments compared in "ex ante" economic analysis. With more realistic data and a better "average farmer practice" treatment, the economic analysis could be extended to include marginal returns to investment (net economic benefit divided by the increase in variable cost) in moving from "average farmer practice" to treatments with higher undominated net benefit levels (53).

Plot design is also important in obtaining realistic labor and input data for "ex ante" analysis. In this study, the inclusion of subplot fertilization treatments increased the size of the main plots, and sub-subplot mulch labor was measured over main plots. One approach for a better design would have been to place the fertilization treatments on subplots equivalent to the sub-subplots used for the mulch and combine factorial combinations of beds and mulch in larger main plots.

Alternatively, mulched, semi-high beds could be placed on a larger plot for labor measurements, and smaller plots used for the single factor mulched low beds and unmulched semi-high bed treatments, by modifying a design used in rice cropping pattern trials (33). Another large plot would be used for labor measurements of farmer practices.

A third approach would be to use an incomplete block design with partial supplementation of key treatments (22, 35). This might also be combined with the above changes in plot arrangements.

By using several on-farm sites together with an on-station site, replications per site could be reduced to two or three, data pooled, and farm-by-treatment interactions also assessed. The on-station site would represent the researchers' "farm" (39). Figure 14 and Tables 10-11 show a possible design incorporating these ideas.

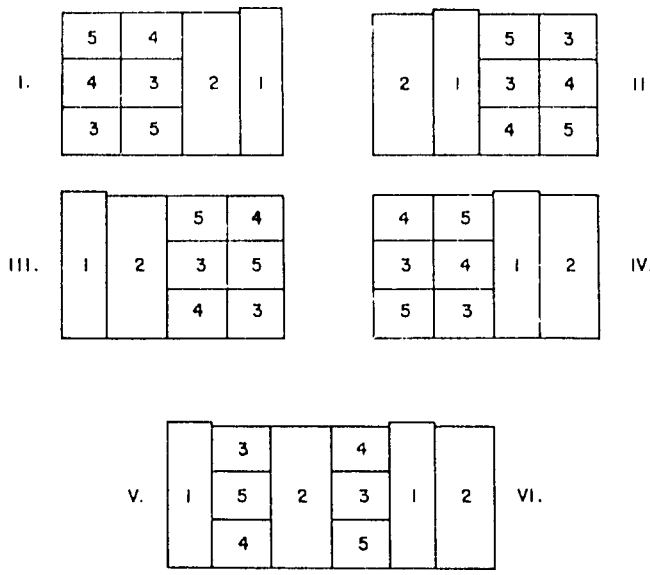

Fig. 14. Plot layout for an "upstream" trial with four on-farm sites and an on-station site with two complete replications.

Table 10. Treatment combinations for design combining on-farm and on-station sites.

Treatment combination		Treatment level			
No.	Name	Beds	Mulch	Fertilizer rate	Pesticide frequency
1.	Farmer	Low (flat)	None	Average farmer practice	Average farmer practice
2.	Package	Semi-high	Mulched	Higher rate	Higher frequency
3.	Minus mulch	Semi-high	None	Higher rate	Higher frequency
4.	Minus fertilizer	Semi-high	Mulched	Average farmer	Higher frequency
5.	Minus pesticide	Semi-high	Mulched	Higher rate	Average farmer practice

Table 11. Plot sizes and sources of yield and labor data for design combining on-farm and on-station sites.

A. Plot sizes

Treatment combination	Plot dimensions: (m x m)	Beds/ plot	Bed dimensions (m x m)	Rows/ bed	Plants/ bed
1	19.2 x 6.0	4	19.2 x 1.5	2	96
2	18.9 x 8.0	4	18.9 x 2.0	3	126
3,4,5	6.3 x 8.0	4	6.3 x 2.0	3	42

B. Sources of yield data

Treatment combination	Harvest area
1	Two areas of 4.0 m length on inner 2 beds
2	Two areas of 3.6 m length on inner 3 beds
3,4,5	Inner 3.6 m length of inner 3 beds

C. Sources of labor data

Treatment combination	Basis
1	Whole area
2	Whole area
3	Mulch labor adjusted from No. 1, fertilizer and pesticide labor adjusted from No. 2
4	Fertilizer labor adjusted from No. 1, mulch and pesticide labor adjusted from No. 2
5	Pesticide labor adjusted from No. 1, mulch and fertilizer labor adjusted from No. 2

Finally, the case study showed the importance of including both FSIP and consumption considerations for vegetable-based FSR&D. This can only be done through a team approach, as the conclusions of the original study indicated (18). The FSR&D approach provides an orientation for more effective team interaction of biological and social scientists. FSR&D provides a common goal, solving production problems, that transcends disciplines. This study has shown ways in which biological and survey data can be combined, both to determine research priorities and to design pilot programs. It has also suggested ways in which the needs for more realistic labor and input data could modify the experimental design of biological experiments.

Since the time of the study, methods for multi-disciplinary team needs assessment, design, and testing of alternative solutions have been presented in the FSR&D literature (22, 39, 55). Effective interaction of biological and social sciences is important at the regional level, as suggested by this study. AVRDC economics and crop management specialists could support that interaction, through consultation, training, and technical assistance in the application of FSR&D methodology to vegetable-centered problems identified in national programs. Through such support to national programs, AVRDC economics and crop management specialists would at the same time acquire better first-hand information on priority problems requiring the specialized research capabilities of AVRDC.

This study was one forerunner of FSR&D methodology, and it provides a vegetable-centered example of how FSR&D can be appropriate for the tailoring of vegetable production technology to meet farm family constraints and needs. This study, the general FSR&D literature, and the works of Calkins and colleagues together provide ideas and tools for national programs personnel and AVRDC specialists to further advance the state-of-the-arts of vegetable-centered FSR&D.

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