Volume 14 Number 2, December 2008

Journal of ISSAAS

The International Society for Southeast Asian Agricultural Sciences

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Contributed Papers

J. ISSAAS Vol. 14, No 2:1-11 (2008)

ESTIMATION, VALUATION AND PRICING OF RAW WATER AS A STRATEGY TOWARDS SUSTAINABLE WATERSHED MANAGEMENT

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(Received: September 26, 2007 ; Accepted: July 24, 2008)

ABSTRACT

In the past, water has tended to be considered as a free and public or commonly owned resource. Hence, consumption leads to wasteful use. Irrigation water, which is by far the largest kind of water use, is practically free, while industrial water and domestic waters are highly subsidized. However, the imperatives of sustainable development calls for appropriate water pricing that would capture the water's true economic cost and value. Economic valuation of water has become a forefront issue in the need to manage water supply.

This study was conducted in the Kaliwa Watershed. It is a forest reserve covering an area of 27,596 ha located in the municipality of Tanay in Rizal Province, and in the town of General Nakar in the province of Quezon, Philippines. The watershed can become a good alternative water source to supply the water needs of Metro Manila. The study sought to: identify and evaluate the different on-site and off-site water users of the Kaliwa watershed; determine and evaluate the level of awareness of on-site stakeholders on the importance, use and problems of the Kaliwa watershed; evaluate the willingness to pay of on-site users for watershed management; and estimate a price for raw water in the Kaliwa Watershed. Two evaluation methods were used to estimate, value and price the raw water from the Kaliwa Watershed, namely, the contingent valuation and the cost recovery methods. Several recommendations were also suggested by the study to sustainably manage a natural resource like the Kaliwa Watershed.

Key words: water pricing, contingent valuation method, cost recovery method, raw water, watershed management

INTRODUCTION

Water is truly a valuable resource and it plays a critical role in overall economic development. The water scarcity problem today is exacerbated by the increasing competition from irrigation, industrial and domestic uses, and the alarm over the degradation of the forest and natural resources. Hence, the economic valuation of water is an important concern in water resources management. Raw water is defined as surface or groundwater that is extracted, pumped or piped from the source and that no treatment has been done yet prior to its use. In the past, water was viewed as a free and public or commonly owned resource. Consumption therefore has lead to wasteful use. Irrigation water, which is by far the largest kind of water use, is practically free, while industrial and domestic waters are highly subsidized. Traditional water pricing only takes into account the financial and direct costs of water production, treatment and distribution. This has led to the following problems: wasteful use of water not only by the final consumers but by the water distributors; intersectoral misallocation of raw water in favor of less valuable uses; high levels of water pollution;

and lack of investment planning to ensure timely water supply expansion. To capture the true economic cost and value of water, therefore, remains an important concern.

An economic analysis was done on the water resources of the Kaliwa Watershed. The Kaliwa Watershed is a forest reserve covering an area of 27,596 ha located in the municipality of Tanay in Rizal Province, and in the town of General Nakar in the province of Quezon, Philippines. Certain portions of the watershed are also within the provinces of Bulacan, Rizal, Quezon and Laguna which were declared as National Park and Wildlife Sanctuary/Game Refuge by virtue of Proclamation No. 1673 dated April 10, 1977. It is also centrally located between the slopes of the Sierra Madre range. The watershed is one of the primary sources of domestic and irrigation water for the provinces of Rizal and Quezon. It is also being considered as a water source to augment the water supply deficit of Metro Manila. Given the potential contribution of the watershed to the overall economic development of the areas within and adjacent to it, the Kaliwa Watershed needs to be managed and developed with urgency and sustainability. The concepts and tools of proper watershed resources management will have to be applied. As demands for fresh water grow against the finite supply, studies on the estimation, valuation and proper pricing of raw water become indispensable in investment decisions and in the formulation of policies and programs for the improvement of the Kaliwa Watershed management.

The main objective of this study was to provide an empirical estimate of the price of water in the Kaliwa Watershed. The study sought to pursue the following specific objectives: (1) to identify and evaluate the different on-site and off-site water-users of the Kaliwa Watershed; (2) to evaluate and determine the level of awareness of on-site stakeholders on the importance, use, and problems of the Kaliwa Watershed; (3) to evaluate and determine the willingness to pay of the on-site water users for watershed management; (4) to estimate a price for raw water in the Kaliwa Watershed; and (5) to draw policy recommendations for the institutionalization and adoption of raw water pricing.

Existing practices of raw water pricing

As the demand for water increases, the need to manage the water supply efficiently becomes greater. Although the amount of available water exceeds the demand on a national scale, water scarcity is already a serious problem in some parts of the country. The challenge for the water sector is therefore to balance the availability of water supply with the demand through efficient water distribution and management. All water users are currently subjected to two forms of water charging. These are: (1) National Water Resources Board (NWRB) water permit charges and annual water charges. The water charges are based on the rate of water withdrawn, diverted or extracted from the natural source for domestic, municipal, industrial, power generation, irrigation or other uses, and on the surface area for the use of surface water at its natural location (e.g. fish culture) (Table 1).

Table 1. Current schedule of NWRB annual water charges.

Withdrawal Rate	Charge for every liter per second (lps) (P)
Base Cost (Water permit)	500.00
• 30 lps or less	2.75
• 30 to 50 lps	4.25
• over 50 lps	5.50
Use of surface water at its natural location for fish culture	
• For surface area below 15 ha	110.00/ha
• For surface are greater than 15 ha	1,650.00 plus 65.00/ha in excess of 15 ha.

The water charges are very nominal and it does not reflect the realities of scarcity or abundance of water with minimal attention on the economic value of water. Consequently, it does not

serve the function of allocating the scarce resource to the most productive uses and does not provide economic incentive for efficient use and conservation of water (Barba, 2006). (2) Water tariffs set by water providers (ex. Water districts, LLDA, Maynilad Water, Manila Water) which are designed to recover the cost of supplying water to users such as treatment, pumping and distribution.

Another form of water charging currently implemented in the Philippines is the arrangement between the Laguna Lake Development authority (LLDA) and the Ayala Properties, Inc., a private subdivision association in Metro Manila. Raw water is sold to Ayala Properties, Inc. by the LLDA at a rate of ₱2.13 per cu. m. to a maximum volume of 100,000 cu. m. per year. The authority is empowered to grant surface water rights for any project or activity in or affecting the Laguna de Bay Region. All the fees collected shall be used for the management and development of the Lake and its watershed areas. The charges applied by the LLDA are not based on any form of economic pricing policy. There is also another mode of raw water pricing between the Department of Environment and Natural Resources (DENR) and the Zamboanga Water District. They have a Memorandum of Agreement (MOA) which requires the Water District to pay a DENR corporation, the Natural Resources Development Corporation (NRDC), ₱0.20 per cu. m. of water extracted from the Pasonanca River. The fees collected will be used in the maintenance of the watershed area. Again, as will be noted in the example, the level of water charges does not have any economic pricing rationale.

In summary, the current practice of raw water pricing in the Philippines is limited in its application, is not based on the economic value of water, and does not reflect the scarcity of water. As a result, the present water pricing scheme does not promote the allocation of a scarce resource to the most productive use and does not provide any economic incentive for its efficient use or conservation.

The economics of full-cost water pricing

The basic principles in pricing water property are as follows:

(1) On the supply side, the full cost of supplying water is composed of the financial costs (including operation and maintenance and capital costs); opportunity costs (such as the costs borne by those deprived of water); economic externalities (ex. impact on production or consumption); and the environmental externalities (such as the effects on the ecosystem that are not translated into production and consumption effects).

(2) On the demand side, the value of water to different stakeholders would include: the value of water to users in terms of consumptive or domestic use, and non-consumptive uses such as transport and swimming; the net benefits from return flows, such as the recharge of the ground water table; the net benefits from indirect uses such as that for habitat; and adjustments for societal objectives and intrinsic values.

(3) Both supply and demand considerations should determine the appropriate water price. Full-cost pricing thus entails discerning the values of water to different stakeholders, noting that each group will have a particular demand for water, as well as full costs associated with providing such water inclusive of financial, economic and environmental costs (de los Angeles and Francisco, 2000).

Ascribing the right economic value to a natural resource like water is vital. Economic pricing has several considerations. It includes incorporating the value of water itself to the consumers and correcting the current practice of average (financial) cost pricing to marginal cost pricing. Average cost pricing has been the traditional pricing policy used by water utilities. Conventionally, this kind of water pricing policy is based on financial or accounting costs. In this case, the policies will just be concerned with raising sufficient sales revenues to meet operating expenses and debt service requirements, while providing for a reasonable contribution towards the capital required for future water system expansion (Munasinghe, 1992).

Economic pricing of raw water therefore should reflect the cost of extraction and any environmental costs involved in extraction and use. The costs of extraction and harvesting are measured by their marginal cost (MC), which is the cost of taking one extra unit of the resource.

METHODOLOGY

Household survey was done by geographical stratification. Interviews were carried out in the nine barangays covering the whole watershed. In each of the barangays, a cluster of 5 to 10 interviews were conducted. This procedure gave a total sample size of 185 households. Key informant interviews were likewise conducted. Knowledgeable people were interviewed such as those at the municipal and provincial agricultural offices; the water district office in Tanay, Rizal; the Metropolitan Water and Sewerage System (MWSS); the National Irrigation Administration and the National Water Resources Board. Data were analyzed and evaluated using descriptive analysis and economic valuation methods.

Data sources for estimating raw water price

The Laiban Dam in the Kaliwa River had been the subject of a feasibility study to tap the river as an additional water source to meet the present and future water requirements of Metro Manila (Fig. 1). As early as 1979, the Laiban Dam-Kaliwa River Project was studied and designed in detail. Known as the Manila Water Supply III Project (MWSP III), the Laiban Dam was envisioned to supplement 45 percent of the long-term water supply requirements of Metro Manila. The dam was expected to provide an additional water supply of 1,900 million liters per day (MLD). This was equivalent to 693,500,000 cu.m. of water per year. The project was initiated in 1984. Negotiations and even payments were made for the relocation of some 1,637 households in the seven barangays expected to be inundated by the dam construction.

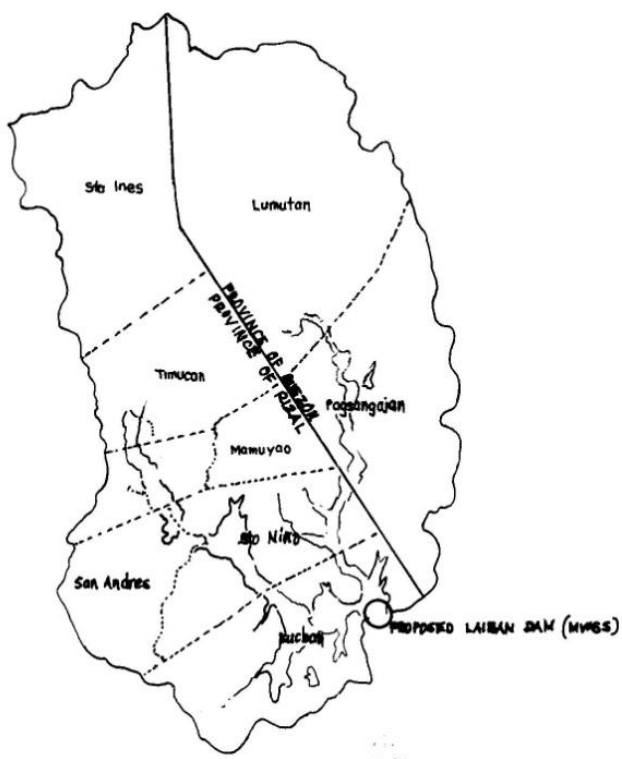

Fig. 1. Kaliwa Watershed showing the proposed Laiban Dam Project of the MWSS (REECS, 1999).

Certain project headwork had already been constructed like the access roads to the dam site, diversion tunnels including stop log gates and hoist, with the construction starting in 1982 to 1984. However, the new administration in 1986 opted to undertake the Umiray-Angat transbasin scheme or the Angat Water Optimization Project thus temporarily halting the Laiban Project. Another important information needed to estimate the raw water price is the financial amount expended on the project by the government. On this aspect, this study relied on the Development and Management Plan for the Kaliwa Watershed.

Economic valuation methods

The study used two valuation methods to estimate, to value and to price the raw water from the Kaliwa Watershed: the contingent valuation and the cost recovery method.

Contingent valuation method (CVM)

The CVM was used to determine how much the people would be willing to pay to reforest, rehabilitate and manage the Kaliwa Watershed as important source of water not only for the residents but for other off-site users as well. The CVM is a technique that aims to place a value on non-marketable goods such as environmental quality through personal interviews to derive expressions of willingness to pay by individuals. This technique seeks to measure individual's preferences for environmental improvement or individual's loss of well-being from losing an environmental asset. This is measured in the concept of willingness to pay (WTP). It involves direct questioning of respondents by describing a simulated market and then asking them directly their willingness to pay. It is called contingent valuation because people are asked to state their WTP, contingent on a specific hypothetical scenario. The major concern with the use of the contingent valuation method is the potential for survey respondents to give biased answers. The four types of potential biases include: (a) strategic bias; (b) information bias; (c) starting point bias; and (d) hypothetical bias. Strategic bias arises when the respondent provides a biased answer in order to influence a particular outcome. Information bias may arise whenever respondents are forced to value attributes with which they have little or no experience. Starting point bias may arise in those survey instruments in which a respondent is asked to check-off his answers from a pre-defined range of possibilities. How that range is defined by the designer of the survey may affect the resulting answers. Hypothetical bias occurs when the respondent is being confronted by a contrived, rather than an actual set of choices. Since he will not have to actually pay the estimated value, the respondent may treat the survey casually, providing ill-considered answers (Tietenberg, 1992).

Many experimental studies have been done on contingent valuation to determine how serious these biases affect the estimate. Results showed that biases can be made acceptably small with properly designed survey instruments (AGO, 2004; Alberini, Veronesi and Cooper, 2005; Young, 1996). In this study, the questionnaire was carefully formulated and had undergone rigorous pre-testing to assure that the intended meaning of the research is being conveyed to the respondents. The interviewers were also selected, trained and supervised by the researchers.

The respondents for this study were the households living within the Kaliwa Watershed. They were asked as to their willingness to contribute in any form (money or rendering of free labor) towards the rehabilitation and management of the watershed as an important source of water supply. The resulting valuations are in money terms because of the way in which preferences revelations is sought --- i.e. by asking what people are willing to pay, or by inferring their willingness to pay through other means. The use of money as the measuring rod is a convenience; it happens to be one of the limited number of ways in which people express preferences (Pearce, Whittington and Georgiou, 1994). To prepare the respondents for the contingent valuation question, they were first asked about their level of awareness on the importance and uses of the watershed to their family and to the

surrounding communities. They were also given background information on the problem of rehabilitation, development and management of the watershed. Because of the sensitiveness of the issue on the impending dam construction by the MWSS, the contingent valuation questions were carefully handled. Questions were focused mainly on the water drawn from the watershed. The respondents were then asked if they would be willing to help to ensure the protection and development of the Kaliwa Watershed. If they were willing to help, they were asked how much they were willing to contribute. If the respondent was not willing to pay, he was asked to explain his reason for his unwillingness.

Cost recovery method

The study used the cost recovery method to estimate the price of raw water in the Kaliwa Watershed. Raw water is operationally defined in the study as the water – surface or groundwater – that is extracted, pumped or piped from the source and that no treatment has been done yet prior to its use. The cost recovery method was used to estimate the water use fee that would be charged. This method determines how much of the government's expenditures shall be recovered from the project beneficiaries (Gittinger, 1982). The primary issue in the cost recovery method is whether the project will generate sufficient funds to reimburse the government for the resources expended on the project. It should also be emphasize that the initial two-year period of the project implementation will come from the loan proceeds funds from the World Bank loan. From the water user fees to be collected from the project beneficiaries, the capital investment in the project must be recovered and all the operation and maintenance costs of the project must be paid. It is only through appropriate cost recovery policies can the government recoup the money expended on a project for reinvestment in other projects that will benefit other members of the society.

The formula used to determine the annual cost that would be recovered is:

$$a = V_o \frac{i(1+i)^n}{(1+i)^n - 1}$$

where,

a	=	cost that will be recovered every year
V_o	=	present value of the total investments for watershed rehabilitation
i	=	discount rate
n	=	number of years corresponding to the lifespan of the dam

The assumptions used in computing the cost to be recovered per year are:

1. The investment costs are based on the estimated expenses for the rehabilitation of the watershed as contained in the Development and Management Plan of the Kaliwa Watershed.
2. The costs are compounded to the Year 2013 using a discount rate of 15 percent. This is the year when the Laiban Dam is projected to be operational, and when water from the Kaliwa Watershed will be commercially utilized. The value of the investment costs for the year 2013 will become the amount to be recovered (V_o).
3. The lifespan of the Laiban Dam is assumed to be 50 years.

RESULTS AND DISCUSSION

Characterization and evaluation of key on-site and off-site stakeholders

The key on-site stakeholders are the households residing within the watershed numbering about 7,000 at the time of the study. They are largely dependent on the various goods and services offered by the watershed. With limited opportunities for gainful employment, majority of the

interviewed households are into land-based farming systems including settled agriculture and *kaingin* system. The households recognize the consequences of their farming practices as evidenced by their admission that deforestation, soil erosion, loss of wildlife, drying up of rivers and springs, and forest fires, are the common problems confronting the protection and conservation of the Kaliwa Watershed.

At present, there are no major off-site users of the watershed. The local water district or the local National Irrigation Authority (NIA) office is not drawing water from Kaliwa. But the potential key off-site stakeholders will be the Metro Manila residents who will be supplied with the Kaliwa water once the Laiban Dam is constructed and become operational. The Laiban Dam is a proposed project by the MWSS to source out water from Kaliwa to augment the water needs of Metro Manila.

Water is the primary goods derived from the watershed aside from the food and forest products like fuelwood, lumber charcoal and rattan. Many of the households within the watershed source their water for washing clothes and bathing directly from spring and river. In fact, all of the nine barangays within the watersheds are not serviced by the local water district. Very few of the households are even serviced by the Level 1 facility of the public water supply system. Level 1 facility is a point-source system installed in rural barangays which utilizes groundwater springs with conveyance pipes and one communal faucet. More than half of the respondents or 57% have observed decreased water level during the summer months. Water quality on the other hand was qualitatively measured by the respondents based on the changes in taste and color of water. According to the majority of the respondents, there was no significant decline yet in the quality of water in the watershed. Whatever changes they have observed may be due to their unsustainable farming practices which include the thinly dispersed timber poaching, continuous grazing and forest fires.

Evaluation of willingness to pay (WTP) by on-site stakeholders for watershed management

The study used the CVM to elicit estimates of the households' willingness to pay for the rehabilitation, development and management of Kaliwa Watershed. The respondents were asked directly how much they will be willing to pay if they were in a situation where a project for the reforestation/revegetation of the Kaliwa Watershed will be implemented. The WTP bids measure the individuals' preferences for environmental improvement or conservation. More than half of the interviewed households (50%) answered positively when asked on their willingness to pay while 41 percent said they are unwilling to pay or help in the rehabilitation of the watershed (Table 2).

Table 2. Responses as to the willingness to pay for the protection and rehabilitation of the Kaliwa Watershed.

Response	Number Reporting	Percent
Yes	109	59
No	76	41
If **Yes**, mode of payment of fund to be set aside for the protection/rehabilitation of the watershed		
One-time payment	30	28
Annual payment	6	5
Monthly payment	26	24
Willing to pay and work for free at the watershed	10	9
Render fee labor	37	34

The most preferred mode of payment by the respondents is not in monetary terms but in kind wherein they will devote a certain number of working days in the project area. Their labor in the project area was given an implicit value. Their labor is valued at P150 per day, the on-going labor

rate in the area at the time of this study. This resulted into a higher WTP bid as compared to other valuation studies in other watershed areas. The most preferred mode of payment is the one-time payment and on the average, it is equal to P344. The second most preferred mode of payment is the monthly payment and it is computed as P955 on the average. The least preferred is the annual payment. WTP bid is on the average P317 (Table 3). The values when translated into the communities' WTP amounted to a one-time payment of 2.5 million pesos, or a monthly payment of 7 million. Conversely, the WTP would mean that the said amount is the monetary value the Kaliwa residents would attach to the watershed as an important source of water supply.

Several respondents who are unwilling to pay for the rehabilitation and management of the watershed cited that they have no money (92%) although they were given assurance that the bids they will place are not actual money payments. Other reasons given were as follows: no time or too busy with other work (5%); others will be benefited and not them (1%); and there is no need to manage/rehabilitate the watershed (1%) (Table 4).

Table 3. Willingness to pay estimate by mode of payment, Kaliwa Watershed.

WTP Bid (P)	**Number Reporting**		
	One-Time Payment	**Monthly Payment**	**Annual Payment**
Less than 300	28	3	5
300 – 500	20	2	0
501 – 700	3	8	0
701 and above	6	15	1
Total Reporting	57	28	6
Average (P)	343.86	954.64	316.67
Range (P)	50 – 1,800	50 – 2,400	100 – 1,000

Table 4. Reasons for the respondents' unwillingness to pay, Kaliwa Watershed.

Response	**Number Reporting**	**Percent**
No money	70	92
No time; too busy with other work	4	5
Others will benefit, not us	1	1
There is no need to manage/rehabilitate the watershed	1	1

Estimation of raw water price based on cost recovery method

The estimate of the price for raw water was based mainly on the investment costs for the revegetation and sustainable management to restore the productive and protective functions of the Kaliwa Watershed. In the Development and Management Plan for the Kaliwa Watershed, these different activities were scheduled for implementation in four years. These activities were valued on a per-hectare basis to come up with the 4-year budgetary requirements for the Kaliwa Rehabilitation and Management Project.

Two scenarios were used in the computation of the price of raw water. Scenario 1 is a case where the total investment cost necessary for rehabilitating the watershed will be recovered (Table 5). This cost includes the expenditures of pre-project implementation, community organizing, nursery operations, plantation establishment, construction of the structural soil conservation measures, trail construction, protection and maintenance, and project management. Scenario 2 is a situation where only the total direct investment cost for the establishment, protection and maintenance of the

plantation in the watershed for the 4-year period is considered. The direct cost is aimed to be recovered and charged as user fees.

Table 5. Budgetary requirements of the Kaliwa Watershed Rehabilitation and Management Project

Year	Scenario 1 (in million pesos)	Scenario 2 (in million pesos)
1	109.43	82.59
2	77.11	56.17
3	26.91	22.07
4	11.62	8.51

Source: REECS. 1999.

The raw water price under the two scenarios were derived (Table 6). For each of the scenarios, a discount rate of 15 percent was used. Discounting is the usual method used to add and compare costs and benefits that occur at different points in time. The method involves summing across future time periods the net costs (or benefits) that have been multiplied by a discount rate. Thus, discounting provides a basis for analyzing and comparing future streams of investment costs and benefits by reducing them to their equivalent present value. The rationale behind discounting is that one would attach less weight to a benefit or cost that would occur in the future than they do to the same benefit or cost incurred now. The discount rate is thus referred to as the opportunity cost of capital or market discount rate.

Table 6. Derivation of the price of raw water of the Kaliwa Watershed

Scenario	Present Value of Investment Cost (P/Year)	Annual Cost to be Recovered (P/Year)	Price of Raw Water (P/cu m)
1	1,447,092,969	217,264,437	0.31
2	1,087,656,490	163,299,166	0.24

The present value for Scenario 2 is lower since it was assumed that only the plantation establishment, protection and maintenance will be recovered and passed on to the different project beneficiaries. The price of raw water was obtained by dividing the annual investment cost for each scenario by the projected volume of water to be supplied per year which stands at 694 million cu m per year. Thus, the prices of raw water under the first and second scenarios were derived which amounted to P0.31 per cu m and P0.24 per cu m, respectively. It must be clearly noted that these values refer mainly to the price of raw water at extraction which excludes the costs of treatment, distribution, and other relevant costs. For example, a household consuming 30 cu.m. of water every month will pay an additional P9.30 or P7.20 per month for watershed protection and conservation under scenarios 1 and 2, respectively.

The raw water price represents the amount that the MWSS should pay the agency that will be contracted to manage the Kaliwa Watershed for the recovery of the government's investment in rehabilitating the watershed to enable it to sustainably generate water for Metro Manila. Expectedly, this price will be passed on to the water distributors (*i.e.* Maynilad Water Services and/or Manila Water Company), and ultimately to the final water users. It is noteworthy that the principle of economic pricing of a resource such as water is made clear here. The raw water price which represents the cost of water extraction is determined. This value should then be collected and spent for the rehabilitation of the watershed so that it could regenerate itself for future water harvest. After all, sustainability is the goal of raw water pricing.

RECOMMENDATIONS

In the light of the findings of the study, the following recommendations were drawn:

A. An appropriate policy instrument or mechanism for a raw water pricing should be institutionalized. The legal framework as well as the operational mechanism for collecting water user fees for Philippine watersheds should be established. Although the importance of water user fees has long been recognized in many important documents, no relevant mechanisms have been established yet. No single agency has taken concrete steps to implement raw water pricing. Coming up with a water use fee requires many preparatory activities and studies and this cannot proceed by the mere recognition of its importance.

B. Corollary to the above recommendation, concrete actions must be taken to formulate a more integrated and holistic approach in addressing the inherently interrelated issues of water supply and demand management, pollution control, watershed management, rehabilitation, protection and maintenance, and protection of groundwater resources from unregulated extraction. This recommendation recognizes that there are more than 20 government agencies presently involved in the different aspects of water resources development and management which could give rise to fragmented and weak institutional structure to oversee planning and operations on water resources.

C. Adopt a water pricing policy that reflects full economic costs such as direct investment cost or financial cost of water production, groundwater extraction, distribution, opportunity cost of water where there are competing users, and the cost of negative environmental impacts.

D. Government revenues to be generated from raw water charges must be plowed back into the management and rehabilitation of the watershed.

E. Create a multi-sectoral body that will oversee the management of the Kaliwa Watershed and will administer the funds to be collected for watershed rehabilitation and protection. This body should ensure that the revenues to be generated from raw water charges will be plowed back for the Kaliwa Watershed. The revenues that will be generated should also finance livelihood projects for residents to deter them from doing destructive farming. The revenues should also finance the IEC activities that are an important component of watershed management.

ACKNOWLEDGEMENT

The authors would like to thank the College of Forestry and Natural Resources, University of the Philippines Los Baños for giving us the opportunity to conduct this study under the Watershed Research and Development Support Project for Kaliwa Watershed.

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J. ISSAAS Vol. 14, No 2:12-19 (2008)

SEQUENCE ANALYSIS OF THE MOVEMENT PROTEIN GENE OF *Soil-borne wheat mosaic virus* VARIANTS THAT CAUSE DISEASE SYMPTOMS AT HIGHER TEMPERATURES

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(Received: May 28, 2008; Accepted: August 27, 2008)

ABSTRACT

Generally, *Soil-borne wheat mosaic virus* (SBWMV) causes systemic symptoms at temperatures below 20°C. One of the reasons of this low temperature requirement for SBWMV infection is known to be the temperature dependency of the replication of RNA. Here, variants of two SBWMV strains (SBWMV-NE, Nebraska isolate of U.S. strain and SBWMV-JT, JT isolate of Japanese strain), which cause disease symptoms at temperature shifting (17°C to 22°C to 25°C), were examined. Sequence analysis showed that, in the movement protein gene in the 3'-terminal region of RNA1, amino acid substitutions of Thr-174 to Met or Ser and of Thr-172 to Ala were observed in independent variants of SBWMV-NE and SBWMV-JT, respectively. These results suggest that mutations of the movement protein gene of SBWMV may be associated with symptom development at higher temperatures.

Key words: Adaptive mutation, sequence analysis, temperature sensitivity

INTRODUCTION

Soil-borne wheat mosaic virus (SBWMV), the type species of the genus *Furovirus*, contains a bipartite positive-stranded RNA genome (RNA1 and RNA2) encapsidated in separate rod-shaped particles. The vector that transmits this virus in soil is a plasmodiophoraceous protozoan, *Polymyxa graminis* (Shirako and Wilson, 1993). The RNA1 of genomic RNA, which is 7099 nucleotides (nt) in the U.S. strain-Nebraska isolate (SBWMV-NE) and 7226 nt in the Japanese strain- JT isolate (SBWMV-JT), codes two N-terminally overlapping putative replicase proteins in the 5'-terminal region (150 and 209 kDa for SBWMV-NE, and 152 and 211 kDa for SBWMV-JT) and a 37-kDa cell-to-cell movement protein (MP) in the 3'-terminal region. The C-terminal 59-kDa regions of the 209- or 211-kDa proteins are expressed by translational readthrough. In the 3'-terminal region of RNA1, the 37-kDa MP is probably expressed from subgenomic RNA. RNA2 (3593 nt in SBWMV-NE and 3574 nt in SBWMV-JT) codes the 19-kDa capsid protein (CP) in the 5'-terminal region; an 83-kDa protein that is a readthrough product of the 19-kDa protein, which is hypothesized to be required for transmission of the virus by the vector *P. graminis* (Shirako and Brakke, 1984); and a 19-kDa cysteine-rich protein in the 3'-terminal region. In addition to these proteins, RNA2 codes a 24-kDa protein that has 40 amino acids extension towards the N-terminus of the CP. The initiation codon of the 24-kDa protein was identified as a CUG (Shirako, 1998).

The optimum temperature for the propagation of this virus is 17°C, and systemically infected plants can recover from the virus if the temperature increases (Rao and Brakke, 1970). The inoculation of infectious *in vitro* transcripts of RNA1 and RNA2 into barley mesophyll protoplasts

showed that the CP mainly accumulated at 17°C, but was undetectable at 25°C (Ohsato *et al.*, 2003), suggesting that replication of the virus is temperature sensitive. However, little is known about the involvement of the movement protein in the temperature sensitivity of SBWMV. Considering that cell-to-cell movement of *Tobacco mosaic virus* (TMV) RNA is temperature-dependent (Boyko *et al.* 2000a) and mutations in the MP gene of TMV have been reported to be involved in temperature sensitivity (Boyko *et al.*, 2000b; 2007), thus, it could be possible that both replication and cell-to-cell movement of the virus are implicated in SBWMV temperature sensitivity.

Under laboratory conditions, when the infected plants are subjected to a shift in temperature (17°C to 22°C to 25°C), both plants without symptoms (i.e., plants recovered from the viral infection) and plants retaining the symptoms appear (Shirako, 2005). The latter plants are thought to harbor SBWMV variants with altered temperature sensitivity. Mutations were examined that could occur in the MP gene of variants that can propagate under higher temperatures in order to determine the possible involvement of mutations in the MP gene of SBWMV in temperature sensitivity. Two isolates, SBWMV-NE and SBWMV-JT, which are genetically related and belonging to a single species have been examined by Miyanishi (2002).

MATERIALS AND METHODS

Plant materials and temperature shifting

Wheat cv. Fukuho (65 plants) and barley cv. Ryoufu (80 plants) were seeded into pots, kept at 17°C for 10 days until the two-leaf stage, and then used for mechanical inoculation of SBWMV-NE. Temperature was shifted from 17°C to 25°C as described by Shirako (2005) with minor modification by keeping the plants at each temperature for one month. Inoculated plants were kept at 17°C for 1 month, transferred to and kept at 22°C for 1 month, and finally transferred to and grown at 25°C for 1 month. The plants that still had disease symptoms at 25°C were used for virion purification. In the case of SBWMV-JT, 4 barley plants (cultivar Mokusekko provided by Barley and Wild Plant Resource Center, Research Institute for Bioresources, Okayama University, Kurashiki, Japan) were seeded into pots followed by mechanical inoculation and temperature shifting as described for SBWMV-NE.

Western blotting

Ground plant tissue or purified virus in sample buffer (0.05 M Tris-HCl, pH 9.0, 2% SDS, 15% sucrose, 0.05% bromo-phenol blue, 5% 2-mercaptoethanol) was treated at 95°C for 3 min and used for SDS-PAGE and Western blots. A 10-µl aliquot of sample per lane was loaded onto 12.5% SDS-polyacrylamide gel. After electrophoresis, the proteins were electroblotted onto a nitrocellulose membrane (MACHEREY-NAGEL, Düren, Germany). The CP of SBWMV was detected using anti-SBWMV CP as the primary antibody (raised against SBWMV-NE or SBWMV-JT) and goat anti-rabbit IgG-alkaline phosphatase-conjugated antibody as the secondary antibody and visualized by BCIP (bromo-chloro-indryl phosphate) and NBT (nitro blue tetrazolium), as described previously (Ohsato *et al.*, 2003).

Virus purification

Leaf tissue (100–300 mg) were ground with a mortar and pestle in 5 ml of 0.5 M sodium borate buffer (pH = 9.0) containing 1 mM EDTA, followed by centrifugation at 4000 rpm for 5 min. One-tenth volume of 20% Triton X-100 was added to the supernatant and centrifuged at 38000 rpm for 2 h. The pellet was resuspended in 250 µl of water to prepare the purified virion solution.

RNA extraction

Purified virion was used for RNA extraction. A solution containing 50 µl of the virus suspension, 350 µl of TE (10 mM Tris-HCl, pH 7.5, 1 mM EDTA), 20 µl of 25X STE (2.4 M NaCl, 0.48 M Tris-HCl, pH 7.5, 25 mM EDTA, pH 8.3), and 80 µl of 10% SDS was prepared and heated at 70°C for 5 min and then placed on ice. This solution was then treated twice with phenol/chloroform-isoamyl alcohol and once with chloroform-isoamyl alcohol. RNA was then prepared by ethanol precipitation (Sambrook and Rusell, 2001).

RT-PCR

Reverse transcription-polymerase chain reaction (RT-PCR) of the 3'-terminal 1.8-kb region of RNA1 was performed using the one-step RNA LA PCR kit (AMV; Takara Bio). To amplify the sequences, primers TN16 (5' CAA GTT CGC ACC TGA TC 3') and TN202 (5' TGC TCT AGA TGG GCC GGA TAA CCC TCC GG 3') were used for SBWMV-NE, and primers TP3 (5' ACT GCT GCT CTG ATT GC 3') and TP25 (5' TCT ACT AGT GGG CCG GAT AAC CCT CCG G 3') were used for SBWMV-JT (Fig. 1). Thermal conditions for amplification were 50°C for 15 min and one cycle at 94°C for 2 min followed by 28 cycles of 94°C for 30 s, 60°C for 30 s, and 72°C for 1.5 min; and 25°C for 1 min. The products were cloned into pGEM-T (Promega) to examine the sequence of the MP gene of the independent variant or were sequenced directly.

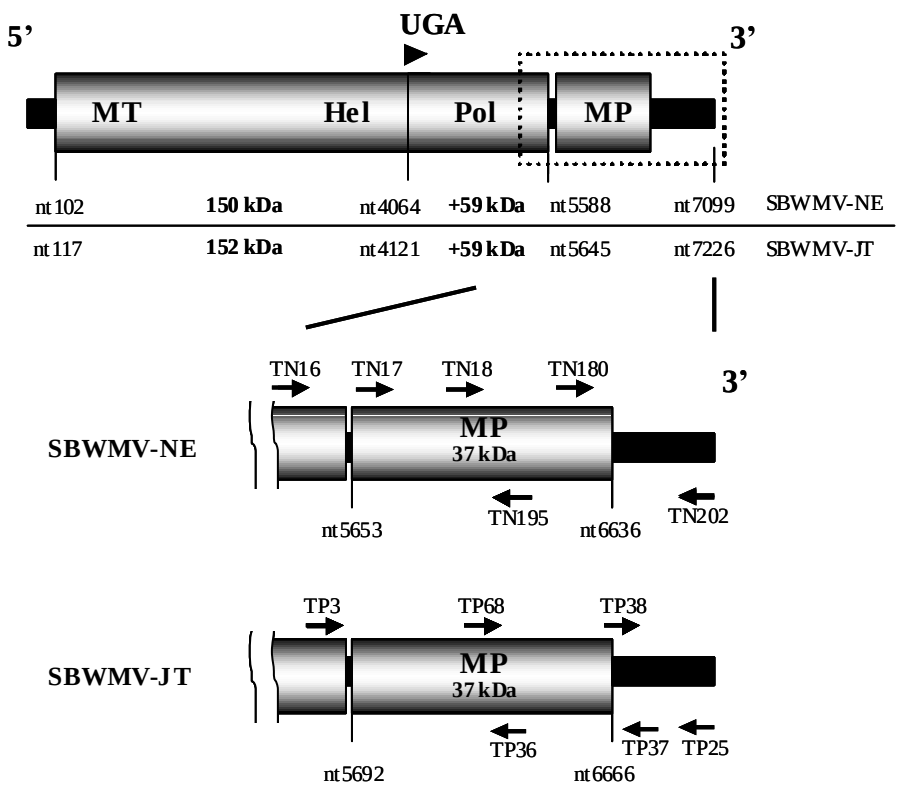

Fig. 1. Schematic diagram of the position of the MP gene in RNA1 of SBWMV and the primers used for sequencing (as indicated). The leaky UGA codon of readthrough is indicated by an arrowhead.

Preparation of independent sequence clones

RT-PCR products were cloned into the pGEM-T vector according to the manufacturer's instructions. The ligation products were introduced to strain MC1061 of *Escherichia coli* to obtain clones of the sequence of the MP gene from the independent mutants.

Plasmid DNA preparation

Colonies were cultured in LB medium containing ampicillin and collected by centrifugation at 4000 rpm for 10 min. The pellet was suspended in 0.8 ml of STET (8% sucrose, 5% Triton X-100, 50 mM Tris-HCl, pH 8.3, 50 mM EDTA, pH 8.3) and lysozyme (10 mg/ml, 80 µl) was added. The mixture was heated at 95°C for 1 min, centrifuged at 13000 rpm for 20 min, and the pellet was removed with a toothpick. After this centrifugation, 3 M NaOAc, pH 5.4 (80 µl) and 2-propanol (0.5 ml) were added to the supernatant and further centrifuged at 13000 rpm for 3 min. The pellet was dissolved in 100 µl of TE (10 mM Tris-HCl, pH 7.5, 1 mM EDTA), followed by purification using the GFX Micro Plasmid Prep Kit (GE/Amersham/Pharmacia). About 50-90% of extracted plasmids of *Escherichia coli* (depending on each isolate) had insert, which was showed after running on the gel (data not shown).

Sequence analysis

The RT-PCR products of the MP gene region of the virus or the pGEM-T plasmids containing the cloned MP gene sequence were sequenced using the BigDye Terminator v3.1 Reaction mix (ABI). The primers used for sequencing were: TN195 (5' CTG TTC CTG ATT GTG TA 3'), TN17 (CAT GGG CTC ACA GGA TG), TN18 (CAC AAA TGA TGG AGC TG), and TN180 (AAG TGT CAT CGA TCT TA) for SBWMV-NE; T7-73 (5' TGC AAG GCG ATT AAG TT 3') and SP6-61 (5' GAA TTG TGA GCG GAT AA 3') for the cloned sequence; and TP3 (5' ACT GCT GCT CTG ATT GC 3'), TP68 (5' AGC ATA CCG ATC AAC GA 3'), TP36 (5' TGC GTC CAG TAA GTG TA 3'), TP38 (5' ATC AGC GTG AGC ATC AG 3'), and TP37 (5' AAT GTA TGA CAC ATG CA 3') for SBWMV-JT (Fig. 1). Sequence data were analyzed by the ABI PRISM sequence analysis program and assembled using the ABI Auto Assembler (Perkin Elmer).

RESULTS AND DISCUSSION

Symptom development of SBWMV by temperature shifting

Sixteen out of 65 wheat cv. Fukuho plants and 3 out of 80 barley cv. Ryoufu were systemically infected with SBWMV-NE at 17°C among which, 3 wheat plants (F22, F30, and F63) and 1 barley plant (R80) kept the symptoms at 25°C and were selected for viral purification followed by SDS-PAGE and Western blotting. Wheat plants with virus (*i.e.*, F30 and F63) and wheat plants recovered from the virus (F39) are compared (Fig. 2). Symptom severity was increased at higher temperatures (such as yellow mosaic of the leaves and severe stunting of the plants at 25°C comparing to the green mosaic and minimal stunting at 17°C) (data not shown). This may be due to prolonged growth of systemically infected plants in growth cabinet, which causes deletion mutations in the RNA2 of readthrough (RT) region (Fig. 2, F30 and F63) associated with symptom severity (Chen *et al*. 1994). In the case of the JT isolate, all of the 4 inoculated barely plants that showed disease symptoms at 25°C were further analyzed.

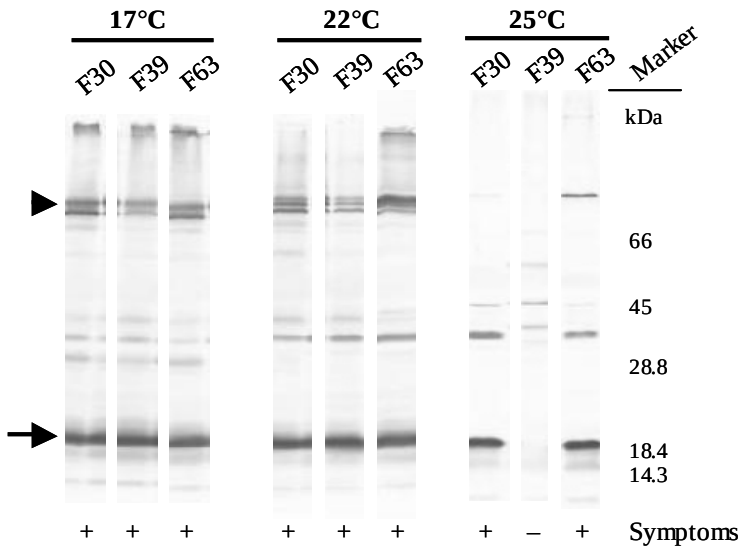

Fig. 2. Western blots of three wheat (cv. Fukuho) plants infected with SBWMV-NE. The arrowhead indicates the 83-kDa readthrough protein, and the arrow indicates the 19-kDa CP. + indicates symptom and – indicates no symptom.

Determination of the sequence of the 3'-terminal region of RNA 1 containing the MP gene of SBWMV-NE

In the case of SBWMV-NE, purified RT-PCR products from variants, F22, F30, F63 and R80 were sequenced directly. Amino acid substitutions were observed in the variants propagated in wheat F30 and F63 and in barley R80, whereas only a silent mutation was observed in the variants in F22 (Fig. 3). In the variants in F30, nucleotide 5831, which was originally adenine (A), was changed to a mixture of A and guanine (G). These changes contained a mixed population of the variants that have glutamine or arginine as the 60th amino acid (Gln-60 or Arg-60) in the MP (Fig. 3). Also, a mutation of G to A at nt 6483 was observed, which is a silent mutation. In the variants in F63, C at nt 6173 (C6173) was mutated to T, causing amino acid substitution of threonine at position 174 (Thr-174) to methionine (Met) (Fig. 3). In R80, the variants had a mixture of A and G at nt 5759, which leads Gln-36 to become a mixture of Gln and Arg. Also, a mixture of A and T at nt 6172 was observed, indicating the presence of a mixture of variants harboring Ser or Thr at position 174.

To confirm the relevance of the direct sequence analysis, the RT-PCR products of the variants in R80 were cloned into the pGEM-T vector, and the sequences of the independent clones were examined. Seven out of 18 clones showed a mutation of A5759 to G, and two of these 18 clones showed a mutation of A6172 to T, confirming the relevance of the direct sequencing analysis (data not shown).

The amino acid substitutions observed in these variants may play a role in changing the temperature sensitivity of SBWMV-NE, especially the substitution at amino acid position 174, which occurred in variants of two independent plants (F63 and R80). However, considering that the variants in F22 only had a silent mutation in the MP gene, mutations of another gene(s) of SBWMV-NE may also be involved in changing the temperature sensitivity of this virus.

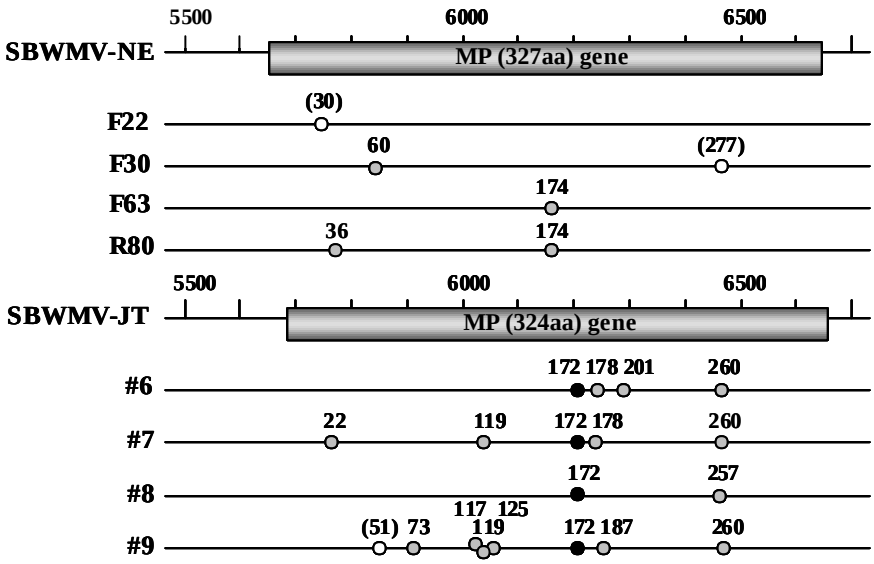

Fig. 3. Mutations observed in variants of the two isolates of SBWMV. Mutations causing changes in amino acids are indicated by closed gray circles, with the number of the substituted amino acid in the MP; silent mutations are indicated by open circles, with the number (in parentheses) of the unchanged amino acid. The closed black circles in the JT variants at amino acid 172 mean that 63–90% of the cloned sequences had the mutation.

Determination of sequence of the 3'-terminal region of RNA 1 containing the MP gene of SBWMV-JT

For mutations in SBWMV-JT, the sequences of independent clones (10–11 clones for each virus sample) of the RT-PCR products of the MP region of each virus sample (#6–9) were analyzed. Among the various mutations observed in the independent clones, most clones showed a mutation from A to G at nt 6205, which caused a Thr-172 to Ala substitution (Fig. 3). Seven out of 11 clones of #6, 8 out of 10 clones of #7, 9 out of 10 clones of #8, and 7 out of 10 clones of #9 had this mutation. These results strongly suggest the possible role of the amino acid substitution of Thr-172 to Ala-172 of the MP in the change in temperature sensitivity of SBWMV-JT.

Comparative alignment of the partial amino acid sequence of the mutation area of MP gene of Furoviruses

Alignments of the amino acid sequence of the MP around amino acid positions 174 (SBWMV-NE) and 172 (SBWMV-JT), along with the alignment of other furoviruses, were carried out using the AliBee-Multiple alignment tool (http://www.belozersky.msu.ru/services/malign_reduced.html). Amino acid 174 of SBWMV-NE MP and amino acid 172 of SBWMV-JT MP are Thr, but their positions are different (Fig. 4). The present findings are similar to results obtained in case of TMV (Boyko *et al.*, 2000, 2007). The mutations in TMV MP are Pro-154 to Ser of the Ls1 mutant, Gly-151 to Val of the GV1 mutant, or Arg-144 to Gly of the Ni2519 mutant, which are similar to the presented results for SBWMV. Partial alignment of the MP region of viruses in the genus *Furovirus* (Fig. 4) indicates that most have Thr at position 174, whereas *Sorghum chlorotic spot virus* (SCSV), which replicates and infects plants most efficiently at 25°C (Kendall *et al.*, 1988), carries Lys at this position (in the case of SCSV, amino acid 183). Considering this, the substitution of Thr-174 (SBWMV-NE) to Lys, Met, or Ser (except in *Oat golden stripe virus*, Accession number: NC_002358), and/or Thr172 (SBWMV-JT; position of amino acid 172 of SBWMV-JT corresponds to

amino acid 171 in SBWMV-NE) to Ala may change the MP conformation/activity to facilitate the movement of the virus at high temperatures.

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SBWMV-NE       161  SKGMSVMNVYSYWT  QRQGHLSAYSEPQRST  190
SBWMV-JT       162  .PK.......T...  ....Y..L........  191
SBWMV-NY       161  .............T  ................  190
CWMV           161  N.........T..T  ....DH.S........  190
SBCMV          162  ..K..........T  .K.....V.T......  191
OGSV           166  ..H.......A..H  VKSNF..S.P...K..  195
SCSV           170  NSS....T.FA..K  VSFNFR.T.YK.....  199
SBWMV-NE.25v   161  .............M/S................  190
SBWMV-JT.25v   162  .PK.......A...  ....Y..L........  191
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Fig. 4. Partial alignment of Furoviral movement proteins using the AliBee-Multiple alignment tool (http://www.belozersky.msu.ru/services/malign_reduced.html). Amino acid position 174 in SBWMV-NE.25v and 172 in SBWMV-JT.25v are compared with wild type SBWMV-NE and SBWMV-JT and other Furoviruses and shown in bold underlined.

SBWMV-NE: Soil-borne wheat mosaic virus-US strain, Nebraska isolate (Accession number: L07937)
SBWMV-JT: Soil-borne wheat mosaic virus-Japanese strain, JT isolate (Accession number: AB033689)
SBWMV-NY: Soil-borne wheat mosaic virus-US strain, New York isolate (Accession number: AF361641)
CWMV: Chinese wheat mosaic virus (Accession number: NC_002359)
SBCMV: Soil-borne cereal mosaic virus (Accession number: NC_002351)
OGSV: Oat golden stripe virus (Accession number: NC_002358)
SCSV: Sorghum chlorotic spot virus (Accession number: NC_004014)
SBWMV-NE.25v: Nebraska isolate variant
SBWMV-JT.25v: JT isolate variant

CONCLUSION

Single base changes occur as a result of error-prone RNA-dependent RNA polymerase, which lacks proofreading activity. It is estimated that the occurrence of mutations in MP gene is due to lack of exonuclease proofreading activity of RNA polymerases produced by viral genome which in some cases is accompanied by recombination. A high mutation rate increases the capacity of adaptation to new environmental condition by quickly making the advantageous mutations. RNA- dependent RNA polymerase is assumed to contribute to the evolution of RNA viruses and could be a phenomenon to support more strongly these experimental results. Here, it is suggested that the mutation of Thr174 (in SBWMV-NE) or Thr172 (in SBWMV-JT) occurred due to the adaptation of the virus to the new environment (higher temperature) for cell-to-cell and long-distance movement as well as complete systemic infection.

ACKNOWLEDGEMENT

I am indebted to Professor Taizo Hogetsu for his encouragement and suggestions. I was supported by a scholarship from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. The entire work was done and the materials were provided in the Laboratory of RNA Virology and Resistance Mechanisms, ANESC, University of Tokyo, Japan.

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J. ISSAAS Vol. 14, No 2:37-48 (2008)

IMPACT OF THE *MAUNLAD NA NIYUGAN TUGON SA KAHIRAPAN* PROGRAM IN SELECTED COCONUT COMMUNITIES IN BATANGAS, BILIRAN, DAVAO CITY AND DAVAO ORIENTAL, PHILIPPINES

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(Received: October 1, 2008; Accepted: November 29, 2008)

ABSTRACT

This paper attempted to assess the impact of the *Maunlad Na Niyugan Tugon sa Kahirapan* program on the farmer-beneficiaries' coconut area planted, farm diversification (i.e., practice of intercropping and livestock/poultry integration), net farm income, quality of life, and poverty incidence in four *Maunlad* program sites in the Philippines, namely: Batangas, Biliran, Davao City and Davao Oriental. Multiple regression models were estimated in this study to determine the overall effect of this program using a single program dummy together with other explanatory variables on real net farm income. To ascertain which of the different program components contributed significantly to the increase in real net farm income, multiple regression analysis for the "before and after" program analysis was likewise conducted. Regression results for the "before and after" the *Maunlad* program analysis using a time dummy variable for program implementation showed that the real net farm income of the farmer-cooperators after the program was implemented was significantly higher than that before the implementation of the program. Empirical results indicated that the program components such as the training aspect, intercropping, livestock integration, and provision of material and technical assistance exhibited a significant and positive effect on real net farm income. These program components, therefore, should be adopted in implementing similar development programs in the future. Using household income data consisting of non-farm income and net farm income, the proportion of poor households decreased from 62.5 percent before the implementation of the *Maunlad* Program to 52.1 percent after the implementation of the *Maunlad* Program.

Key words: intercropping, livestock integration, real net farm income, poverty threshold

INTRODUCTION

The coconut industry is regarded as one of the most important sub-sectors in the Philippine economy. Its importance is not only reflected in terms of the total land area planted to coconut, but also in terms of the labor force employed in the sub-sector and its substantial contribution to the country's foreign exchange earnings. About 3.5 million families work in the coconut farm sector and another 24 million are indirectly dependent on the industry such as traders, exporters and processors including their employees. Coconut products continue to be the largest agricultural export of the Philippines. In 2006, the coconut industry contributed 1.64 percent of the country's merchandise exports (Department of Trade and Industry, 2007).

Although coconut is one of the leading agricultural export crops in the country, more than two million coconut farmers continue to live below the poverty line (Aragon, *et al*., 2002). This could be mainly attributed to the large proportion (70%) of coconut lands which are not intercropped and the stagnant coconut productivity despite the substantial number of coconut technologies generated by Philippine Coconut Authority (PCA) researchers. To uplift the plight of the poor coconut farm

households and enhance food security, PCA launched the *Maunlad Na Niyugan Tugon Sa Kahirapan (Progressive Coconut Farming to Alleviate Poverty)* Program starting in 1999. This is a poverty alleviation program implemented by PCA which used model coconut farm modules to showcase improved coconut practices such as intercropping and livestock and poultry integration in various provinces in the country. A model coconut farm is a small but contiguous cluster of small coconut farms, totaling 15 to 20 hectares in area, owned and/or operated by small coconut farmers within the Strategic Agriculture and Fishery Zones.

To attain the program's objectives of increasing farm income and reducing poverty in coconut farming communities, PCA introduced various intervention measures to the model coconut farm modules such as the distribution of free material inputs (e.g., planting materials), livestock, tools and equipment, and shallow tube wells) and the provision of technical support through the conduct of training programs in order to encourage the coconut farmers to practice intercropping and livestock and poultry integration. Another form of support provided in some program sites was the provision of assistance to farmer-cooperators in preparing their farm plans and budget. The participatory approach in program planning, implementation and monitoring was adopted in the *Maunlad* program in four program sites in the Philippines.

This paper assesses the impact of the *Maunlad* program on the farmer-beneficiaries' coconut area planted, farm diversification (i.e., practice of intercropping and livestock integration), net farm income, quality of life, and poverty incidence in four *Maunlad* program sites in the Philippines.

METHODOLOGY

Complete enumeration was employed in determining the number of *Maunlad* farmer-cooperators covered in the impact evaluation analysis. This means that all the *Maunlad* farmer cooperators were included in the analysis. The total number of farmer-cooperators in the four *Maunlad* program sites (i.e., San Juan, Batangas; Biliran, Biliran; Tugbok, Davao City; and Sta. Cruz, Davao del Sur) was 48. Two sets of data were collected from *Maunlad* farmer-cooperators. The first set was the baseline data which were gathered prior to the start of the *Maunlad* Program (i.e., 1999) and the second set of data was the impact evaluation data which were gathered after the implementation of the program (i.e., 2003). The two-period data used in this paper (i.e., before and after the program) came from the same individual farmer-recipients.

To assess the impact of the *Maunlad* program, the "before and after" program analysis was employed. Descriptive statistics such as frequency counts and percentages were used to determine the proportion of *Maunlad* farmer-cooperators who adopted intercropping under coconut and livestock integration before and after program implementation. The t-test of means for paired samples was conducted to determine if there were significant differences in the mean values of selected impact variables (i.e., area planted to coconut, intercropped area, real annual net farm income, and real annual net income per hectare) before and after program implementation. Prior to conducting the t-test of means and the multiple regression analysis, the annual nominal net farm incomes of the *Maunlad* farmer-cooperators were first expressed in real terms to remove the effect of inflation. Real net farm income in a given year was computed by dividing annual nominal net farm income by the consumer price index in that year multiplied by 100. The base year was 1999 ($CPI_{1999} = 100$). Annual net farm income consisted of income coming from all farm sources such as coconut production, intercropping practices, and livestock production in a given year.

A major limitation of the t-test of means is that the results would merely indicate whether the mean values of a selected impact variable are significantly different between the before and after *Maunlad* program situation. Other factors that might account for the variation in real annual net farm income among the farmer-respondents were not considered. Hence, the t-test of means may not provide accurate estimates of the *Maunlad* Program. Given the limitations of the t-test of means, multiple regression analysis was also used to estimate the impact of the *Maunlad* program. The

regression approach is a more appropriate method to estimate the program effect than the t-test of means because it allows one to isolate the program effect holding other factors affecting the outcome constant.

In the regression analysis, the data gathered from the 48 respondents before (i.e., 1999) and after (i.e., 2003) the program were pooled and a time dummy variable was introduced as one of the explanatory variables. Hence, the total number of observations used in the regression analysis was 96.

Two multiple regression models were estimated in this paper. The first regression model was estimated to examine the overall impact of the *Maunlad* program on real annual net farm income (*RNFI*). A single *Maunlad* impact dummy variable measured in terms of a time dummy variable for *Maunlad* program implementation (*T*) was included as one of the explanatory variables in the first regression model. Coconut area (*Cocoarea*), real material expense (*Rmatexp*) and labor employed in man-days (*Labor*) per farm were other explanatory variables included in this regression model. The first multiple regression model is shown below:

$$RNFI = a + b_1 T + b_2\, Cocoarea + b_3\, RMatexp + b_4\, Labor \qquad \text{(Reg Eqn 1)}$$

In the second regression model, the effects of multiple impact parameters based on the components of the *Maunlad* program on real annual net farm income were determined. In the specification of this regression equation, the program impacts were decomposed based on the main components of the program as follows: (1) a livestock/poultry integration dummy (*Lvstck*); (2) a training participation dummy (*Training*); (3) a dummy for receipt of free planting materials (*Recdmat*), (4) dummy for receipt of technical assistance (*Recdtech*), (5) intercropped area utilized (*Intercarea*), and 6) dummy for membership in a cooperative/farmers' organization (*Coop-FO*). Other explanatory variables included in the second regression model, which were non-program components, were as follows: coconut area (*Cocoarea*), real material expense (*Rmatexp*) and labor employed (*Labor*) per farm. The second regression model is specified as follows:

$$RNFI = a + b_1 Lvstck + b_2\, Trng + b_3 Recdmat + b_4\, Recdtech + b_5\, Interarea + b_6 Coop\text{-}FO + b_7\, Cocoarea + b_8\, RMatexp + b_9 Labor \qquad \text{(Reg Eqn 2)}$$

To assess whether the *Maunlad* program has reduced the incidence of poverty among the farmer-cooperators, the proportion of the 48 farmer-cooperators who were below the poverty line before and after the implementation of the *Maunlad* program was estimated and compared. Poor farmer-households are those households whose annual per capita income (in nominal or current terms) falls below the poverty threshold or the required annual per capita income to provide for the household's minimum basic food and non-food requirements. This paper also determined the percentage contribution of annual net farm income to the total household income from all sources before and after program implementation to find out whether the reduction in the incidence of poverty among the farmer-cooperators could be largely attributed to the increase in annual net farm income resulting from their participation in the *Maunlad* program rather than from increases in their non-farm income. Moreover, the impact of the *Maunlad* program on the quality of life of the farmer-cooperators was examined in this paper**.**

RESULTS AND DISCUSSION

Impact on Area Planted to Coconut and Intercropped Area

Using pooled data gathered from 48 *Maunlad* farmer-cooperators in the four program sites, results of the t-test of means show that the mean area planted to coconut increased significantly at 1 percent probability level from 1.98 hectares before the implementation of the *Maunlad* program to

2.39 hectares after the program was implemented (Table 1). The farmer-cooperators attributed their decision to expand their area planted to coconut to the different forms of assistance provided by PCA such as the distribution of free seed nuts of high-yielding coconut varieties, the training program on coconut production that PCA conducted, and the work animals provided by PCA for their land preparation activities.

Table 1. Mean total coconut area, intercropped area, coconut yield and annual net income per farm and per hectare before and after the *Maunlad* Program, 48 farmer-cooperators in four program areas in the Philippines.

Item	Before the Program	After the Program	Mean Difference
Coconut area (Ha)	1.98	2.39	0.41***
			(4.25)
Intercropped area (Ha)	0.58	0.90	0.32***
			(5.42)
Coconut yield (Nuts/Ha)	5,119	8,592	3,473***
			(4.09)
Annual real net farm income PhP)	22,934	49,443	26,509***
			(3.67)
Annual real net income per hectare (PhP)	11,583	20,687	9,104***
			(3.31)

Figures in parenthesis are t-values

*** means significant at 1% probability level.

Another impact of the *Maunlad* program was the increase in area planted to intercrops under coconut. As shown in Table 1, the average intercropped area of the 48 *Maunlad* farmer-cooperators significantly expanded at 1 percent probability level from 0.58 hectare before program implementation to 0.90 hectare after the *Maunlad* program was implemented. The common factors that influenced their decision to expand the area planted to existing and new intercrops were the training programs on intercropping that they attended, the free planting materials of various annual and perennial crops that they received from PCA and the Department of Agriculture (i.e., PCA's cooperating agency in the implementation of the program), the technical assistance provided by the PCA extension personnel and the technical consultants, and the shallow tube wells donated by the National Irrigation Administration (NIA), another cooperating agency. About 37.5 percent of the 33 farmer-beneficiaries expanded the area planted to existing intercrops and planted at the same time new intercrops, 29.2 percent increased the area grown to existing intercrops only and 40 percent planted coconut intercrops for the first time (Table 2).

Impact on Coconut Yield

Results of the t-test of means for paired samples using coconut yield data gathered from the 48 *Maunlad* farmer-cooperators show that the mean coconut yield of the farmer-cooperators after the implementation of the *Maunlad* program (8,592 nuts/hectare) was significantly higher than that before program implementation period (5,119 nuts/hectare) at 1 percent probability level (Table 1). The application of fertilizers on intercrops under coconut could have partly contributed to the increase in coconut yield. The increase in intercropped area resulted in the application of more fertilizers, which likewise benefited the coconut trees.

Table 2. Impact of the *Maunlad* program on farmers' intercropping practices, 48 farmer- cooperators in four program areas in the Philippines.

Intercropping Practice	Number of *Maunlad* Farmers Reporting	Percent
Expanded area planted to existing intercrops and at the same time planted new intercrops	18	37.5
Expanded area planted to existing intercrops	16	33.3
Practiced intercropping for the first time due to the *Maunlad* program	14	29.2
Total	48	100

Impact on the Adoption of Livestock/Poultry Integration

Of the 48 *Maunlad* farmer-cooperators, 28 (58.3%) were already raising livestock (e.g., hogs) before the implementation of the *Maunlad* program. After the *Maunlad* program was implemented, the total number of coconut farmer-cooperators who integrated livestock under coconut increased to 30 (62.5%). Table 3 shows that 33.3 percent of the 48 farmer-cooperators decided to expand their existing livestock enterprise while only 25 percent decided to engage in a new livestock/poultry enterprise (e.g., goat and *sasso* chicken raising). Two coconut farmer-cooperators (4.2%) raised livestock for the first time. Such changes were brought about by the training courses/programs on livestock production that they attended and facilitated by the PCA extension personnel and the free animals (e.g., piglets, goats and *sasso* chicks) that they received from PCA under the *Maunlad* program.

Table 3. Impact of the *Maunlad* program on farmers' practice of livestock/poultry integration, 48 farmer-cooperators in four selected provinces in the Philippines.

Livestock Integration Practice	Number of *Maunlad* Farmers Reporting	Percent
Expanded number of existing animals	16	33.3
Engaged in another livestock/poultry enterprise	12	25.0
Raised livestock for the first time due to to the *Maunlad* program	2	4.2
Did nor raise livestock [a]	18	37.5
Total	48	100.0

[a]Twenty farmers did not raise livestock before the implementation of the program. Two of the 20 farmers decided to engage in a livestock enterprise due to the animal dispersal component under the *Maunlad* program

Impact on Real Net Farm Income and Real Net Income Per Hectare

Of the 48 *Maunlad* farmer-cooperators, 34 (71%) reported increases in their net farm income which they attributed to: (1) the expansion of the area planted to existing annual intercrops under coconut trees by the farmer-cooperators who received free planting materials from the PCA and the DA; (2) the improvement in coconut yield resulting from increased fertilization of intercrops, the

practice of improved cultural management practices (e.g., pruning and disease control methods) for existing fruit trees planted as intercrops under coconut, and the use of shallow tubewell to irrigate their coconut intercrops; (3) planting of new/additional and more profitable annual intercrops; and (4) the higher proportion of *Maunlad* farmer-cooperators who practiced livestock/poultry integration, which were among the program interventions that the PCA aggressively promoted with the cooperation of the DA and local government units (LGUs) in the four program sites.

It is noteworthy to mention that income derived from practicing intercropping during the evaluation period was solely from annual intercrops. As regards newly planted fruit tree seedlings, income was not yet realized at the time of the impact evaluation survey. It is expected that with the anticipated harvests from these new plantings of perennial crops in the foreseeable future, there would be a significant increase in the net farm income that the *Maunlad* farmer-cooperators would receive 5-10 years from now.

Fourteen (29%) of the farmer-cooperators indicated that their net farm income remained the same since they planted fruit tree crops/perennial crops which were not yet bearing fruits during the evaluation survey. These farmer-cooperators did not raise livestock before and after the implementation of the program since they lacked capital to purchase commercial feeds. Hence, their farm income was solely derived from their coconut harvest.

Results of the t-test of means reveal that the mean annual real net farm income of the 48 farmer-cooperators improved significantly at 1 percent probability level from PhP22,934 before the *Maunlad* program to PhP49,443, or by PhP26,509 after the implementation of the program (Table 1). On a per hectare basis, the mean annual real net income of the *Maunlad* farmer-cooperators was also found to be significantly higher at 1 percent probability level after the implementation of the program (PhP20,687) as compared to that before the program implementation period (PhP11,582).

Results of Regression Analysis Showing the Overall Impact of the *Maunlad* Program on Real Net Farm Income

Regression results using a single program dummy in Regression model 1A shows the overall positive impact of the *Maunlad* program on real net farm income. In this model, the regression coefficient of the time dummy variable for *Maunlad* program implementation is positive and significant at 5 percent probability level, indicating that the real net farm income of the *Maunlad* farmer-cooperators after the program was implemented is significantly higher than that before the implementation of the program, other factors held constant (Table 4). This result is consistent with the results of the t-test of means presented earlier. Labor utilized and material expenses in real terms were found to have a significant effect on real net farm income and their regression coefficients exhibit logical signs. As expected, labor has a positive regression coefficient while that of real material expenses was negative. In the four program areas, farm labor was mostly contributed by family members. More family labor contribution resulted in higher crop yields and in turn, higher net farm income. In contrast, higher material expenses resulted in lower net farm income. The regression coefficient of coconut area has an illogical sign and insignificant due to multicollinearity problem. It is highly correlated with the time dummy variable, labor, and real material expenses based on the Pearson correlation analysis conducted.

When Regression model 1B was run with time dummy and coconut area as the only explanatory variables, the effect of coconut area became significant and positive while that of the time dummy variable was insignificant. Overall, Regression models 1A and 1B are highly significant at 1 percent probability level based on the F-test. Regression model 1A is the preferred regression equation because it has a better fit than Regression model 1B as indicated by its higher R^2 value of

0.55. This means that all the explanatory variables included in this regression model explain 55 percent of the variation in real net farm income.

Table 4. Results of multiple regression analysis showing the effects of the *Maunlad* program and other selected factors on real net farm income using pooled data (96 observations) before and after program implementation, four program sites in the Philippines.

	Regression Model 1	
Item	**A**	**B**
Intercept	6732.83^{ns}	-39367.00^{ns}
	(1.15)	(-3.90)
Regression Coefficients of Explanatory Variables:		
Time dummy for *Maunlad* program Implementation	12919.98**	13550.49^{ns}
	(2.17)	(1.33)
Real material expenses	-.41**	
	(-2.34)	
Labor	.74***	
	(6.58)	
Coconut area	-3912.22^{ns}	31445.55***
	(-1.55)	(8.73)
F-value	27.72***	41.53***
R^2	(0.55)	(0.47)

Figures in parenthesis are t-values.

***, ** - indicate significant at 1% and 5% probability level, respectively

Ns means not significant at 10% probability level.

Results of Regression Analysis Showing the Effects of Selected *Maunlad* Program Components on Real Net Farm Income

To ascertain which of the different *Maunlad* program components contributed significantly to the increase in real net farm income, regression results for the "before and after" program analysis are presented in Table 5. The only program components that have a positive and significant effect on real net farm income in Regression models 2A and 2B are livestock/poultry integration and intercropping as measured by intercropped area. Other explanatory variables (i.e., non-program components) that have a significant effect on real net farm income are labor and real material expenses. As regards other program components, training dummy, received material expense dummy, and received material expense dummy have insignificant influence on real net farm income in these regression models due to the presence of multicollinearity problem. It is apparent from the results of the Pearson correlation analysis in Appendix Table 1 that the training participation dummy is highly correlated with received material assistance dummy, livestock/poultry integration practice dummy, received technical assistance dummy, and membership in a cooperative/farmers' association dummy. On the other hand, received material assistance dummy is highly correlated with training participation dummy, livestock integration practice dummy, received technical assistance dummy, and membership in cooperative/farmers' association dummy. Received technical assistance dummy is correlated with training assistance dummy, livestock integration practice dummy, received material assistance dummy, and membership in cooperative/farmers' association dummy.

Table 5. Results of multiple regression analysis showing the effects of the different components of the *Maunlad* Program and other factors on real net farm income using pooled data (96 observations) before and after program implementation

	REGRESSION MODEL 2					
ITEM	**A**	**B**	**C**	**D**	**E**	**F**
Intercept	873.39^{ns}	873.39^{ns}	23767.69^{ns}	22934.54**	22934.54**	-34122.1^{ns}
	(0.11)	(0.11)	(1.40)	(2.40)	(2.40)	(-3.61)
Regression Coefficients:						
Training participation	-3815.52^{ns}	-3815.52^{ns}	122381.06*			
Dummy	(-.23)	(-.23)	(1.72)			
Real material expenses	-0.40***	-0.40***				
	(-2.21)	(-2.21)				
Labor	-0.83***	-0.83***				
	(-7.17)	(-7.17)				
Coconut area	180.87^{ns}	180.87^{ns}				32145.24***
	(0.07)	(0.07)				(8.98)
Intercropped area	5700.22**	5700.22**				
	(2.30)	(2.30)				
Membership in cooperative dummy	6189.02^{ns}	6189.02^{ns}				
	(0.73)	(0.73)				
Livestock/poultry integration practice dummy	12737.46*	12737.46*				
	(1.91)	(1.91)				
Received material		12159.24^{ns}		26508.67**		
assistance dummy		(0.76)		(1.96)		
Received technical	12159.24^{ns}				26508.67**	
assistance dummy	(0.76)				(1.96)	
F-value	16.28***	16.28***	2.96*	3.85**	3.85**	80.63***
R^2	0.60	0.60	0.30	0.39	0.39	0.46

Figures in parenthesis are t-values.

***, **, and * - indicate significant at 1%, 5% and 10% probability level, respectively

Ns means not significant at 10% probability level.

When Regression model 2C with training participation dummy as the only explanatory variable was run, a positive and significant regression coefficient of this explanatory variable was obtained at 10 percent probability level. When Regression Models 2D and 2E were estimated using

received material assistance and technical assistance as the only explanatory variable in each regression equation, respectively, the effects of these variables on real net farm income also became positive and highly significant at 5 percent probability level. Coconut area's effect on real net farm income in Regression models 2A and 2B is also insignificant due to the presence of multicollinearity problem (i.e., highly correlated with intercropped area, real material expense, and labor). The effect of coconut area on real net farm income became significant at 1 percent probability level in Regression model 2F, which includes coconut area as the only explanatory variable. All the estimated regression models in Table 4 are highly significant based on the F-test.

Impact on the *Maunlad* Program on Poverty Alleviation

The *Maunlad* program was envisioned to be a poverty-reduction program. To assess whether the Program has indeed reduced the incidence of poverty, the proportion of the 48 farmer-cooperators who were below the poverty line before and after the implementation of the *Maunlad* program was estimated and compared. Of the 48 *Maunlad* respondents, the proportion of poor households slightly decreased from 62.5 percent before the implementation of the *Maunlad* program to 52.1 percent after the *Maunlad* Program (Table 6).

Table 6. Proportion of poor *Maunlad* households before and after the implementation of the program in four selected provinces in the Philippines, 48 *Maunlad* respondents.

Item	Before the *Maunlad* Program	After the *Maunlad* Program
Number of poor *Maunlad* households	30	25
Proportion of poor *Maunlad* households (%)	62.5	52.1

To have a clearer picture of the impact of the *Maunlad* program on poverty alleviation, the percentage contribution of total net farm income to household income before and after the implementation of the program was compared. As shown in Table 7, the contribution of net farm income to household income rose from 33.75 percent before the implementation of the *Maunlad* program to more than 48.75 percent after the implementation of the program in the four program sites while the contribution of non-farm income declined from 66.25 percent before the start of the program to 51.25 percent after the program was terminated. These figures show that significant increases in the net farm income of the majority of the *Maunlad* farmer-cooperators in the four program sites had greatly contributed to poverty reduction in these areas.

Table 7. Average percent contribution of non-farm and net farm income to household income, 48 Maunlad farmer-cooperators, four selected program sites in the Philippines.

Item	Mean Annual Household Income from All Sources (PhP)	Percent Share	
		Non-Farm	Farm
Before M*aunlad*	84,613	66.25	33.75
After *Maunlad*	142,063	51.25	48.75

Impact on the Quality of Life of the *Maunlad* Farmer-Cooperators

Other positive impacts of the *Maunlad* program are reflected in terms of some changes in the farmer-cooperators' quality of life. Of the 34 farmer-cooperators who reported that their income increased as a result of their participation in the *Maunlad* program, 18 percent mentioned that they used their additional income to purchase household appliances (e.g., television set, radio, stove, and VCD player); 12 percent to repair their house using permanent construction materials; six percent to defray for household expenses; and nine percent to construct a new house, a pig pen and a flush toilet as a replacement for the open-pit toilet (Table 8). Only one farmer-cooperator (3%) indicated a change in his household's food consumption pattern (i.e., increase in the frequency of eating meat/meat products per week) as a result of the increase in his net farm income.

Table 8. Ways by which additional income was utilized, 34 farmer-cooperators who reported increases in their net farm income as a result of their participation in the program, four selected program sites in the Philippines.

Form of Income Utilization	Number of *Maulad* Respondents Reporting	Percent
Defray for household expenditures	2	6
Purchase of household assets	6	18
House improvement/expansion	4	12
Construction of flush toilet	1	3
Construction of new house	1	3
Construction of pig pen	1	3
Defray for more meat expenses[a]	1	3

[a]Change in food consumption pattern

Depending on the amount of income earned by the *Maunlad* farmer-cooperators from their involvement in the program, their household expenses and other purchases were either fully or partially covered by their *Maunlad* income.

CONCLUSION AND RECOMMENDATIONS

Empirical results of this evaluation study have shown that the *Maunlad* program has a statistically significant and positive impact on real net farm income of the program participants. In light of the positive effect of the program on real net farm income, findings of this study also reveal that the implementation of the *Maulad* program has contributed to the reduction of poverty and improved the quality of life of the program participants.

Moreover, regression results also indicate that the program components such as the training aspect, intercropping, livestock integration, and provision of material and technical assistance exhibit a significant positive effect on real net farm income. These program components, therefore, should be adopted in similar development programs in the future. Continuous monitoring and evaluation of the *Maunlad* program should be conducted considering that most of the program participants have newly planted coconut seedlings of improved varieties and fruit tree seedlings as intercrops and therefore, the program impact on their income would take a couple of years to materialize. Thus, it is expected that the impact of the program would be substantial in the long-term.

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J. ISSAAS Vol. 14, No 2:49-60 (2008)

SOCIO-ECONOMIC ASSESSMENT OF ORGANIC FARMING IN BOGOR, WEST JAVA, INDONESIA

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(Received: January 22, 2008; Accepted: November 22, 2008)

ABSTRACT

Adoption and implementation of Green Revolution Technology, the so called Conventional Agriculture (CA), has increased agricultural production. However, the application of chemical fertilizers & pesticides under CA has resulted in some problems: falling biodiversity, soil degradation, soil & water pollution, and human health problems. In response to these problems, some people demand safer foods which are produced under Organic Agriculture (OA).

Demand for organic products – particularly rice and vegetables - steadily increases in some big cities of Indonesia, especially in Java. The demand for these products is quite small compared to total demand of the conventional products. Due to small demand and under-developed market for organic products, the farmers are reluctant to produce the organic products. Could Organic Agriculture (OA) produce comparable or even higher yields and incomes? Would OA empower the farmers, reduce rural poverty, and improve their livelihood?

Field research in Bogor indicated that organic rice yield steadily increased with planting season and approaching that of conventional one. But, this trend was not applicable for organic vegetables. Organic vegetable yield was still lower than that of conventional one and very sensitive with the weather conditions, pests and diseases. From economic point of view, organic rice was economically feasible. It resulted in higher incomes, due to higher prices, than those of conventional ones. However, organic vegetable was still infeasible. Market for organic products was also very specific. This has made the farmers reluctant to adopt organic agricultural system. Some programs are suggested in developing the organic farming system in the region: expansion of the organic products markets through the development of market networks and farmers' cooperation; and improvement of government supports for agricultural development, including technical training on organic farming and provision of extension workers.

Key words: conversion to organic farming, farm yield and income, marketing system

INTRODUCTION

Demand for food increases over time with the number of population and level of incomes. To meet these growing demands, since 1960s Indonesia had intensified its rice and vegetable production systems, from low-input traditional system to intensive production system, which applied high yield varieties, chemical fertilizers and pesticides, and supported by the provision of irrigation water and agricultural extension programs. Since then, both rice and vegetable production have gradually increased. The main objective of these programs was to achieve food self-sufficiency, particularly rice, by expanding the cultivation of rice paddy. The government has developed a total 4.75 million ha of paddy fields with full-control irrigation. By doing such development, combined

with land development and irrigation rehabilitation, and crop intensification programs, Indonesia achieved rice self-sufficiency in 1984. Due to rapid rate of fertile agricultural land conversion to non-agricultural use (at an average rate of 50,000 ha/year), climate changes (prolonged drought and flood periods), environmental degradation, reduced subsidies of agro-inputs and agricultural extension activities, Indonesia rice self-sufficiency began unstable. Since 1994, Indonesia started to import rice whether to meet the demand or to maintain a national buffer stock for market operation in case of rice scarcity. However, due to continuous efforts in increasing food production, currently Indonesia could reach almost 100% of its rice requirements. Import level is significantly low (less than 2% of total national rice production in 2006) compared to the previous levels. Total harvested area of paddy in 2006 was 11.84 million ha and produced 54.55 tons of paddy rice (BPS, 2007).

Production of vegetable crops in Indonesia increased at 5.65% per annum in the period of 2000-2004. In 2004, total vegetable production was estimated at 9.06 million tons. Statistically, there are six important vegetables in Indonesia, in terms of their total production: shallot, spring onion, potato, cabbage, mustard green, and carrot (BPS, 2007). Production of organic vegetables is still very small, less than 1%, and its demand is limited at certain big cities in Indonesia.

However, the steadily increase in rice and vegetable production in Indonesia under the conventional farming system, in fact, have resulted in negative side effects, including the presence of chemical residues on foods, and destruction of land fertility and productivity due to long-term chemical fertilizers and pesticides applications. These conditions have been raising environmental problems and, up to some point, human health problems.

In developed countries, consumers' and farmers' demands for environmentally friendly and healthy foods have created the organic agricultural movement (Scialabba, 2000a). Lampkin (1994) defined organic agriculture as an approach to agriculture where the aim is to create integrated, humane, environmentally, and economically sustainable agricultural production systems, which maximize reliance on farm-derive renewable resources and the management of ecological and biological processes and interactions, so as to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed. Similarly, Organic Farming Research Foundation (2001) defined organic agriculture as an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people. Organic farming system is sometimes understood as a farming system that does not use toxic chemical pesticides or fertilizer to produce fiber and food. Instead, it is based on the development of biological diversity and the maintenance and replenishment of soil fertility. Prevention is the key strategy of organic farmers in controlling pests and diseases.

Organic agriculture (OA) offers environmental improvements over conventional agriculture across a wide range of environmental indicators. Lampkin (1994) stated that OA has the potential to provide benefits in terms of environmental protection, conservation of non-renewable resources, improved food quality and safety, solve the other problems associated with conventional agricultural practices, and the reorientation of agriculture towards areas of market. IFOAM (2001) stated that OA is an agricultural system that is ecologically sustainable, economically feasible, and socially just. OA includes all agricultural systems that promotes the environmentally, socially, and economically sound production of food and fiber. More specifically, USDA National Organic Standards Boards (1997) defined OA as "an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain, or enhance ecological harmony". The

primary goal of OA is to optimize the health and productivity of interdependent communities of soil life, plants, animals, and people.

Organic agriculture activities in Indonesia were started in 1970s. OA was experiencing a slow growth. In terms of land area, OA occupies about 0.09% of total arable land in 2000. Three phases can be distinguished (Fatoni, cited by Syariefa 2004) in the development of OA in Indonesia. First, the 1970s pioneer phase i.e., people who believe in the concept of organic farming as a natural balance philosophy, with the likes of Elsener Agatho, the founder of Yayasan Bina Sarana Bhakti. Second, the 1980s phase, characterized by the rise of non government organization (NGO) movements which developed OA with foreign aid, particularly from FAO. The most popular program in this phase is Integrated Pest Management (IPM). Third, the 2000s hobbyist farmers. These farmers turn into OA because they see business opportunities.

The Indonesian Ministry of Agriculture in 2000 had declared "Indonesia Organic 2010". The mission of this policy was to realize the eco-agribusiness development, while its objective was to increase food security and social welfare (Budianta 2004).

Problem Statement

Consumers' demands for environmental quality and healthy agricultural products have resulted in growing demands of organic products. Scialabba (2000a) argued that, in both developed and developing countries, organic agriculture has grown outside public support, and in some cases despite government antagonism. The willingness of farmers to experiment and of consumers to pay premiums on organic food represents a major private investment in this sector.

Farmers' acceptance of the organic agricultural system or other types of farming system, including low-input rice farming system, depends mainly on its profitability. Scialabba (2000b) reported that, in developed countries, the financial cost of inputs on organic farms can be lower than on many non-organic farms, although the magnitude differs between enterprises and countries. The difference is generally greatest in those enterprises where inputs can be readily substituted by low-cost alternatives, as fertilizers by nitrogen-fixing crops or manure. These conditions have raised a query, whether it is profitable to cultivate organic crop compared to conventional one. The condition whether the farmers will benefit from the change will be the most important factor in making a decision to adopt that farming system.

Farmers will probably experience losses of yields and/or incomes when converting their farm operations from conventional to organic production system. The degree of yield and income losses vary, however, with biological attributes of the farm, farmers' expertise, the extent to which synthetic inputs were used under the previous management system, and the prices of both inputs and outputs (FAO, 1999a, 1999b).

The two above agricultural systems, conventional and organic agriculture, in fact, are not a choice problem, since both can be co-existed. Basically, full range analysis of the process of conversion from conventional to organic farming system includes four types of research questions: (1) technically sound?, (2) environmentally friendly?, (3) socially acceptable?, and (4) economically feasible?

This research will focused on the third and fourth research questions. The specific research questions are: is OA profitable? And could conversion to OA empower the farmers and improve their livelihood?

Objectives of the Paper

The purpose of this paper is to share our experience in conducting field-experiments on rice and vegetables under organic, conventional, and low-input farming systems in the district and city of Bogor, West Java. The specific objectives of this paper are as follows: (1) to evaluate rice and vegetable yields under organic, conventional and low-input farming systems; (2) to compare the net incomes resulted from rice and vegetable under those farming systems; and (3) to compare rice and vegetable marketing systems under those farming systems.

RESEARCH METHOD

These rice and vegetable experiments are both under the Academic Frontier Research Project (AFRP) of Tokyo University of Agriculture and Bogor Agricultural University (IPB). The experiments were conducted in two different locations. Rice experiment was conducted at Situ Gede village in the City of Bogor, close to IPB campus. The research was started in 2004. Total area of the research field is about 8,000 m^2, which is divided into three parts: organic and low input system in one side, and conventional system on the other side of the road. Each farming system was applied with four replications. Since the irrigation water is available over the year, the rice can be grown up to three times per year. Specification of the rice research is presented in Table 1.

Table 1. Technical details of the rice experiment

Component	Conventional	Low Input	Organic
Seed Variety	Bondoyudo	Bondoyudo	Bondoyudo
Fertilizer:			
Urea	200 kg/ha	100 kg/ha	0
TSP	100 kg/ha	50 kg/ha	0
KCl	100 kg/ha	50 kg/ha	0
Compost	0	3 ton/ha	5, 10 ton/ha
Pesticide	Chemical	Less Chemical (IPM)	Botanical & Bio-agents
Soil Management	Common Practice	Common Practice	Common Practice

Vegetable research is located at Suka Galih Village, sub-district of Mega Mendung, in the district of Bogor. At an elevation of about 800 meters above sea level, the village is suitable for growing vegetable. Total area of research is 4,500 m2, which is divided into three big plots i.e., organic, conventional, and low-input; each with four replications. Tomatoes and cabbages were selected for the research since they are the most popular crops in the region. Both crops were grown under monoculture and mix cropping. The experimental details of the two crops are presented in Table 2. Farmers in the village mostly grew vegetables in addition to bananas and papaya. Some farmers have involved in growing vegetable organically, two of them are considered as big hobbyist farmers who have access to regularly supply organic vegetables to their customers: individual consumers, supermarkets, and stores.

RESULTS AND DISCUSSION

Rice

Since irrigation water is available along the year, rice can be grown up to three times a year. This practice is common in the area, particularly in the areas close to the irrigation canals. Up to the end of 2006, rice had been grown for six times. However, this paper would report the results of rice experiment up to the 5th season. The average rice yields under different farming systems were presented in Fig. 1. The data on Fig. 1 showed that the average rice yields under different farming systems fluctuated, but there was an increasing trend. In the first three seasons, rice yields under organic farming systems, with 5 and 10 tons per hectare of compost, were lower than those of conventional system. However, in the 4th and 5th growing seasons, the average rice yields under organic farming system were higher than those of conventional one.

Table 2. Technical details of vegetable experiment

Component	Conventional	Low Input	Organic
Seed Variety:			
Cabbage	Grand-11	Grand-11	Grand-11
Tomatoes	Martha	Martha	Martha
Fertilizer:			
NPK	400 kg/ha	200 kg/ha	0
Compost	10 ton/ha	30 ton/ha	50 ton/ha
Pesticide	Chemical	Less Chemical (IPM)	Botanical & Bio-agents
Land Management	Common Practice	Common Practice	Common Practice

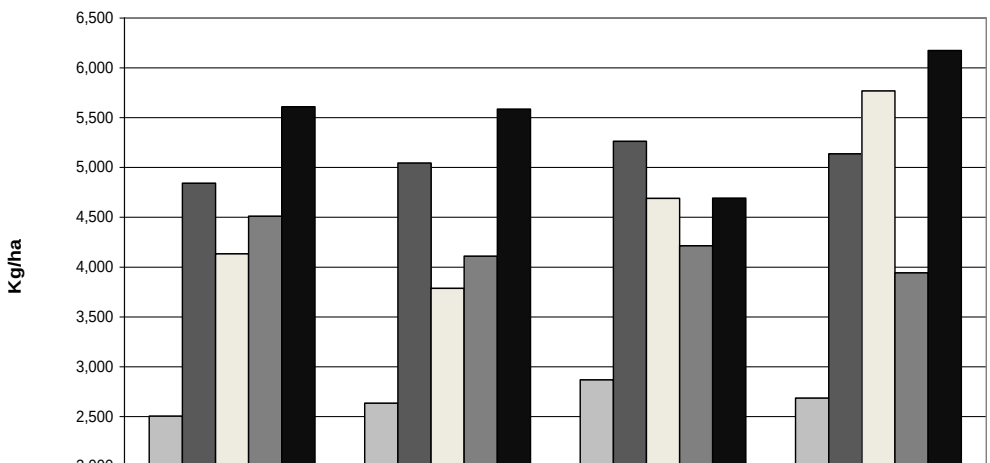
The first growing season resulted in the lowest yields in all farming systems. The highest rice yields was under organic farming system, which were 5,609 kg/ha with a 5 ton/ha of compost ("Organic-5") and 5,585 kg/ha with a 10 ton/ha of compost ("Organic-10"), both were in the 5th growing season. The highest rice yields under conventional and low input farming systems were, respectively, 5,253 kg/ha (in the 2nd growing season) and 6,174 kg/ha (in the 5th growing season). These meant that the organic rice yield had passed the yield of the conventional one, and that the low-input system resulted in the highest yield.

Both "Organic-5" and "Organic-10" showed the same yield patterns in each season and their yields were statistically insignificantly different. These mean that a 5 ton/ha additional compost didn't result in a significant improvement in rice yield. Therefore, the additional application of a 5 ton/ha of compost i.e., the "Organic-10" is technically inefficient.

Organic rice yields with 5 ton/ha of compost ("Organic-5") also resulted in the highest net incomes compared to the other farming systems (Fig. 2). This was due to two conditions i.e., the continuous increase in yields and the higher prices of organic rice than that of conventional one. Since the processed organic rice was directly sold to the IPB community, the farmers could accept a 25 percent premium price than the conventional one. Organic rice with a 10 ton/ha of compost was economically inferior compared to that of 5 ton/ha. This occurred because marginal value product of the additional 5 ton/ha of compost i.e., the economic values of the additional outputs due to the application of the additional 5 ton of compost, was lower than its marginal factor costs i.e., the costs of the additional 5 ton of compost.

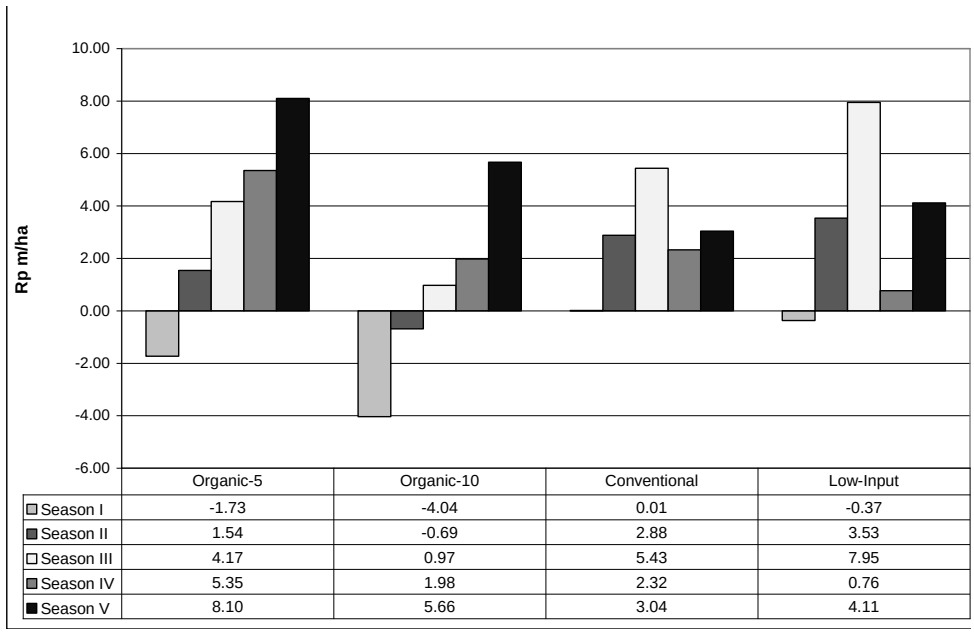
Profitability of rice under different farming systems was presented in Fig. 3. Profitability meant the ratio between the net incomes (i.e., the difference between total revenues and total costs) and the total costs. Based on this criterion, all rice farming systems were economically profitable, at least in the last three growing seasons, and the organic rice with 5 ton/ha of compost ("Organic-5") resulted in the highest profitability in the last two growing seasons.

Based on the above indicators, the organic rice farming system with a 5 ton/ha of compost ("Organic-5") resulted in slightly lower yield, but the highest net incomes compared to that of conventional farming system. Its profitability was 136.7 percent, indicating that its net income was even higher than its total cost of production.



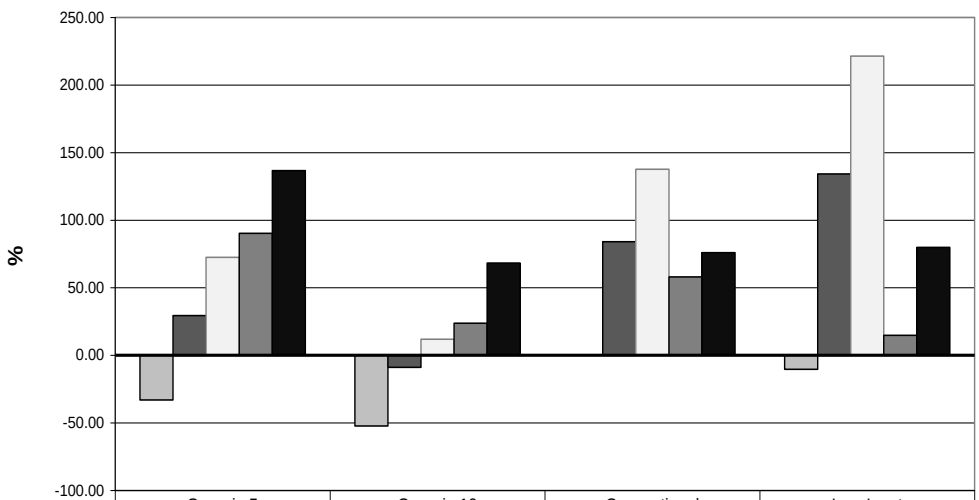
	Organic-5	Organic-10	Conventional	Low-Input
Season I	2,503	2,633	2,868	2,684
Season II	4,841	5,044	5,263	5,136
Season III	4,134	3,786	4,689	5,769
Season IV	4,510	4,110	4,214	3,942
Season V	5,609	5,585	4,691	6,174

Fig. 1. Average rice yields under different farming systems, 2005-2006 (in kg/ha)



	Organic-5	Organic-10	Conventional	Low-Input
Season I	-1.73	-4.04	0.01	-0.37
Season II	1.54	-0.69	2.88	3.53
Season III	4.17	0.97	5.43	7.95
Season IV	5.35	1.98	2.32	0.76
Season V	8.10	5.66	3.04	4.11

Fig. 2. Rice net incomes under different farming systems, 2005-2006 (in Rp million per ha).



	Organic-5	Organic-10	Conventional	Low-Input
Season I	-33.08	-52.26	0.29	-10.31
Season II	29.45	-8.93	83.97	134.22
Season III	72.45	11.95	137.74	221.37
Season IV	90.29	23.80	58.02	14.81
Season V	136.65	68.24	75.91	79.83

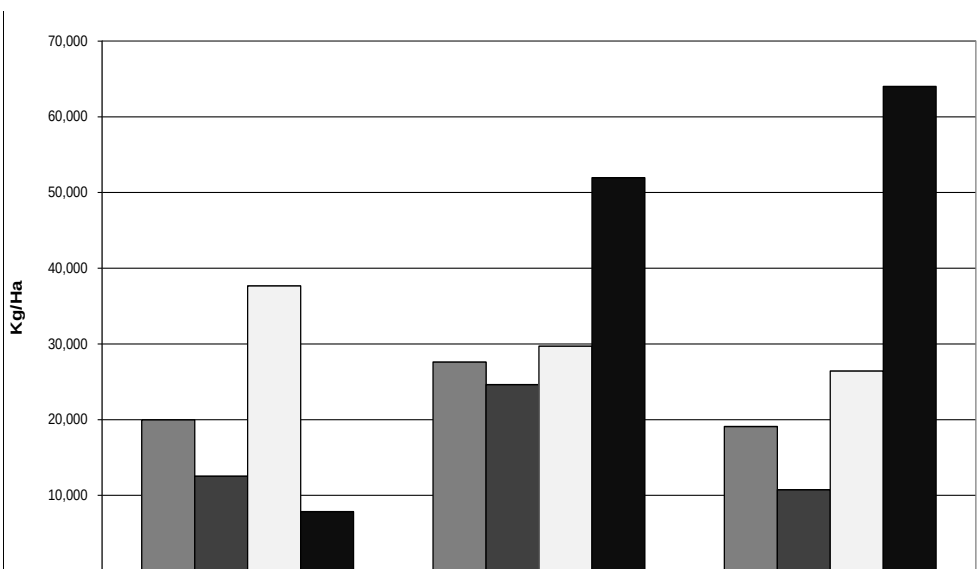
Fig. 3. Profitability of rice under different farming systems, 2005-2006 (in percent)

Vegetables

The yields of the vegetable were presented in Fig. 4. Types of vegetables grown in the fields are cabbage (planted monoculturally and mixed with tomatoes) and tomatoes. The yields here referred as total crops (cabbage and tomatoes) production per hectare. Both cabbage and tomatoes yields, in general, were very sensitive to weather conditions, and pest and diseases. Crop yields under organic farming system were still lower than those of conventional and low-input systems. Only in the 3rd cropping season, dry season, organic vegetables resulted in higher yields than the other two alternatives. In this season, both cabbage and tomatoes yields were relatively high.

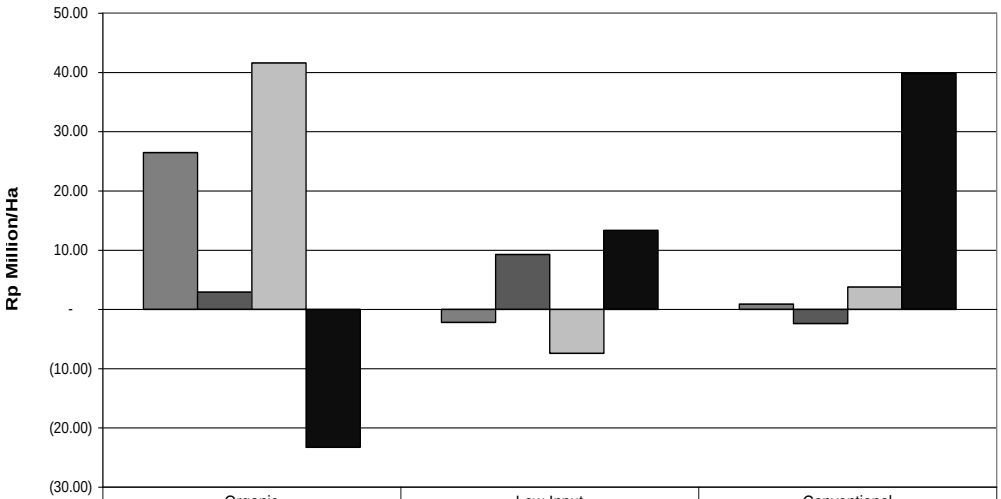
In terms of net incomes, organic vegetables, though produced lower yields, resulted in higher net incomes than the other two alternatives in the 1st, 2nd, and 3rd growing seasons (Fig. 5). But, in the 4th growing season, it resulted in negative income because the yield was very low due to pests and diseases. Even under the conventional system, vegetables net incomes were relatively low in the first three seasons. In contrary to the organic system, vegetable under conventional system resulted in a relatively high income in the last season (the 4th season), with a 156 percent of profitability (Fig. 6).

The above experiment results indicated that vegetable yields highly fluctuated over the four growing seasons. They were very sensitive to weather conditions, and pests and diseases. Organic farming system still resulted in inferior productivity compared to the conventional one. Though it resulted in 8 to 76 percent of profitability, in the first three seasons, it could not definitely stated that vegetables under organic farming was economically feasible, since the risks involved, particularly risks that affected productivity and quality of the products, were very high. A longer research period and more research treatments were required to result in a more predictable and stable organic vegetable yields.



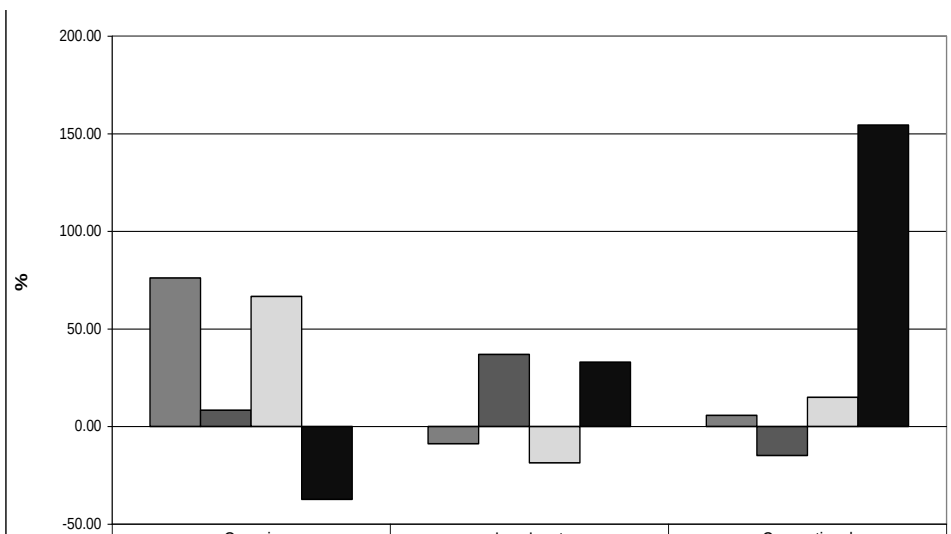
	Organic	Low-Input	Conventional
Season I	19,977	27,593	19,066
Season II	12,520	24,608	10,719
Season III	37,650	29,694	26,418
Season IV	7,828	51,950	63,984

Fig. 4. Average vegetable yields under different farming systems, 2005-2006 (in kg/ha)



	Organic	Low-Input	Conventional
Season I	26.46	(2.18)	0.89
Season II	2.92	9.25	(2.40)
Season III	41.60	(7.42)	3.76
Season IV	(23.27)	13.34	39.82

Fig. 5. Average net incomes of vegetable under different farming systems, 2005-2006 (in Rp million per ha).



	Organic	Low-Input	Conventional
Season I	76.08	-8.78	5.77
Season II	8.41	36.94	-14.82
Season III	66.66	-18.54	14.98
Season IV	-37.29	33.00	154.46

Fig. 6. Average profitability of vegetable under different farming systems, 2005-2006 (in percent).

Development of Marketing and Distribution Systems

Promoting trade in organic products was a means to improve small farmers' incomes to access the organic premium prices. In many developed and developing countries, organic products were sold at impressive premiums, often 20% higher than identical products produced on non-organic farms (FAO, 1999). However, to enter this lucrative market was not easy, since reliable market information to sell the organic products was difficult to obtain. Market for organic product in Bogor was controlled only by certain individuals or companies who had access to sell their products to certain supermarkets or consumers. Through these agents, the farmers could sell their products as 'organic' ones and obtain premium prices. Otherwise, their products will be bought by regular traders as 'regular' or 'conventional' products with 'regular' prices.

Marketing and distribution systems of organic products are different than those of non-organic ones. Since organic vegetables are considered to be 'special products', their marketing and distribution systems were more specific. A case study by Theresia (2006) at Yayasan Bina Sarana Bhakti (YBSB), an organic-vegetable grower foundation at Tugu, Bogor indicated that farmers who were cooperated with the foundation could sell their products directly to the customers who came to their sites or through three alternative media i.e., vegetables agents, supermarkets, and vendors (Fig. 7). In contrast, non-organic vegetables produced by the farmers in the same region were sold through conventional marketing channels i.e., village traders and retailers.

This case study also showed that farm gate prices of organic vegetables were higher than those of conventional system. However, in term of farmer' share i.e., proportion of farm gate price relative to consumer price, the share of organic products was lower than that of conventional, indicating that there was a large marketing margin received by the traders for organic products. This indicated that the higher proportion of the added value was obtained by the traders (supermarket and other agents) than the farmers themselves. Based on the above situation, development of marketing networks was important to the farmers, particularly to the organic farmers, to be able to sell their organic products at the premium prices, and not considered as "regular" product. To do this, the farmers should empower themselves by creating a farmers' cooperation to improve their bargaining position and make cooperation with other traders, such as whole-sellers, or directly with supermarkets who could purchase their product at rational prices.

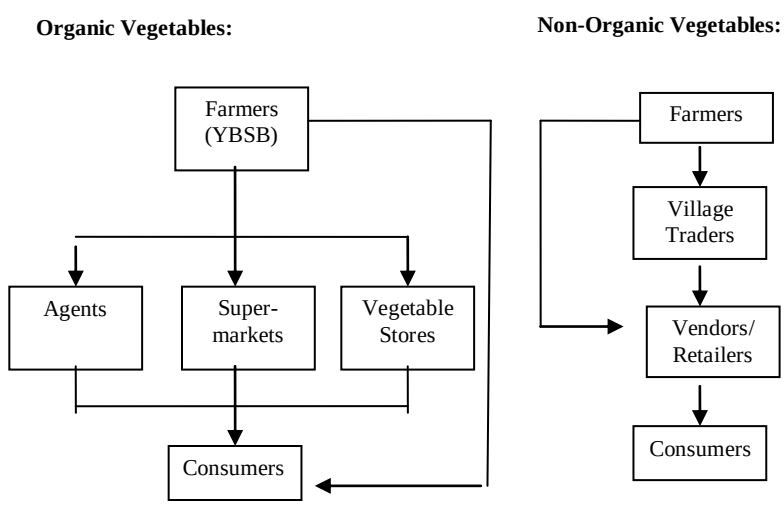


Fig. 7. Marketing Systems of Organic and Non-Organic Vegetables in Tugu, Bogor

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Organic rice yield steadily increases with the cropping seasons. The yield was comparable to that of conventional one after a two-year period. However, organic vegetable yield was still lower than that of conventional one and very sensitive with the weather conditions, pest and diseases along a two-year field research. More research efforts should be put on both rice and vegetable field experiments to find out the strategies to result in high and stable yields.

Though their productivities were lower, rice under organic farming system is economically feasible. It resulted in higher incomes, mostly due to its higher prices, than that of conventional one. On the contrary, vegetable under organic farming system still resulted in inferior productivity compared to the conventional one. A longer research period and more research treatments were required to result in a more predictable and stable organic vegetable yields.

Market for organic products was quite small and specific i.e., at supermarkets or specific stores, which were located far away from the production fields. This market was controlled only by some individuals or companies. Thus, small farmers were still reluctant to adopt organic agricultural system.

Recommendations

Government supports for agricultural development, including organic agriculture, were required. Currently the government did not provide any direct support to the farmers. Local government should provide technical training on organic farming by reactivate the extension workers who were currently transferred to be administrative staffs at the local government offices. The training should be on the techniques to make organic fertilizers, and crop and pest management.

Extension of the markets for organic products was required to capture more organic products. To achieve this objective the farmers should develop a cooperative or an association to improve their bargaining position and to expand their market networks.

ACKNOWLEDGMENT

This paper is based on the results of rice and vegetable research in the City and District of Bogor, West Java, a collaborative research between Bogor Agricultural University (IPB) and Tokyo Agricultural University (TUA) under the Academic Frontier Research Project (AFRP). IPB Research Team includes Dr Dadang, Dr Gede Suastika, and Dr Asih Nawangsih of the Department of Plant Protection, Faculty of Agriculture IPB, and Dr Yusman Syaukat of the Department of Resource and Environmental Economics, Faculty of Economics and Management IPB. Funding for this research is provided by the AFRP TUA.

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J. ISSAAS Vol. 14, No 2: 61-70(2008)

FACTORS AFFECTING THE DECISION-MAKING OF FARMERS ON CORN STORAGE IN MOC CHAU DISTRICT, SON LA PROVINCE, VIETNAM

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(Received: July 20, 2008; Accepted: November 25, 2008)

ABSTRACT

A survey of corn farmers in Moc Chau district was undertaken to examine the factors affecting their decision on corn storage. Qualitative choice models (binomial logit) were used to determine whether farmers' choices of storing and non-storing options were significantly affected by their individual characteristics and other socio-economic factors. The factors found to be significantly affecting farmers' decision on corn storage were price of corn after storage, corn quantity produced, storage costs, total annual household income, number of years in farming experience, crop season, and extension training. Other factors like equipment required for corn storage, gender of the household head and ethnicity were insignificant.

Key words: Binomial logit model, corn storage, Moc Chau district

INTRODUCTION

In Vietnam, corn is the second most important staple crop next to rice (Ha et al., 2004; Ha, 2006). Over the last decade, a rapid increase in corn production has been observed. Total corn production has almost tripled, from 1.17 million tons in 1995 to 3.5 million tons in 2005 (FAOSTAT, accessed on 15 April 2006). At present, corn production is highly concentrated in upland regions and only small land area is planted to corn in the deltas.

Storage is an important component of the post-harvest handling operations of agricultural products. Identification of the post-harvest activities for corn farmers have been the focus of continuing study by agricultural economists. However, the individual characteristics and other socio-economic factors that affect farmers' decisions on corn storage are not well understood, especially in Vietnam. A better understanding of the factors that affect farmers' decision on corn storage will yield at least two benefits. First, university extension educators can design storage education programs that are targeted to meet the specific needs of farmer-clients. Second, applied researchers can use this information to provide comparative results and testable hypotheses in future marketing research efforts. These research and extension efforts will ultimately benefit corn farmers in making decision on whether to store corn or sell the crop immediately after harvest.

The main objective of this paper is to determine how the economic and non-economic factors affect farmers' decision on corn storage. The paper is divided into four sections. The first section presents a brief review of related literature. The second one highlights the methodology used

including the conceptual framework, data collection and samples, and analytical procedure. The third section discusses the empirical findings and the last one focuses on conclusions and recommendations.

REVIEW OF LITERATURE

Previous studies have focused on the factors that affect the decision on corn storage for farmers. The authors recognized that both the prices and the non-price variables can affect the behavior of farmers on corn storage. Grewal and John (1970) and Garcia (1978) found that farmers' decision to sell their produce is clearly influenced by the level of prevailing prices relative to the prices realized in the preceding marketing season while Sharma and Gupta (1970), from their study in Bajra, concluded that the most significant variables affecting the decision-making on corn storage were production and family size, accounting for 93% of the variation. These results are in agreement with those presented by Garcia (1978) from his study in Mexico.

Schermerthorn (1976) analyzed the problem of food loss reduction from an individual farm standpoint. The keystone of his argument is the concept of profit. According to him, the most important factors affecting the decision-making process about whether to adopt managerial and technical procedures for reduction of such losses are the costs and returns of the action. Briggs and Johnston (1991) pointed out that while decisions about on-farm grain handling and storage seemingly involve a large number of variables, many of which are uncertain, in reality the number of variables facing an individual grower at a particular point is far fewer. Zulauf et al. (1999) recognized that corn storage decisions and returns depend on an individual producer's cost of storage, aversion to risk and local market conditions.

Other relevant studies by Asplund and co-workers (1989) and Makus *et al.* (1990) have examined farmers' forward pricing practices using futures hedges and either forward contracts or options. Schroeder *et al.* (1998) surveyed agricultural producers to determine their perceptions about futures markets, price forecasting, market risk management and market timing signals.

Logit analysis has been used as an analytical tool in a number of studies relating to agricultural decision-making. These include Schnitkey *et al.* (1992); Skaggs *et al.* (1994); Jensen and Saupe (1987); McClintok *et al.* (1991); Bhattacharyya *et al.* (1998); and James *et al.* (2000).

METHODOLOGY

Theoretical Framework

The process of deciding on the part of farmers whether to adopt or not a particular technology is quite complex. This decision problem is similar to the type of decision-making facing corn farmers (a choice between two discrete options). After harvest, corn farmers are faced with two options, that of selling their produce immediately or storing it for a specific period. Bearing this concept in mind, farmers now decide on what to do to their produce and stock, respectively. The decision to store corn will occur when farmers have incentives to perform the corn storage and at the same time overcome the constraints to realize storing. The review of relevant studies on corn storage gives a huge body of information on factors affecting farmers' decision on corn storage. Those factors have been classified into different types. In this paper, the factors affecting farmers' decision on corn storage are classified into four categories, namely: physical; economic; social; and institutional as presented in Figure 1.

By estimating the effects of the different factors and increasing awareness of the farmer on the additional revenue and additional cost in storage, a decision can be made whether to store the corn for a certain period of time or sell immediately the produce.

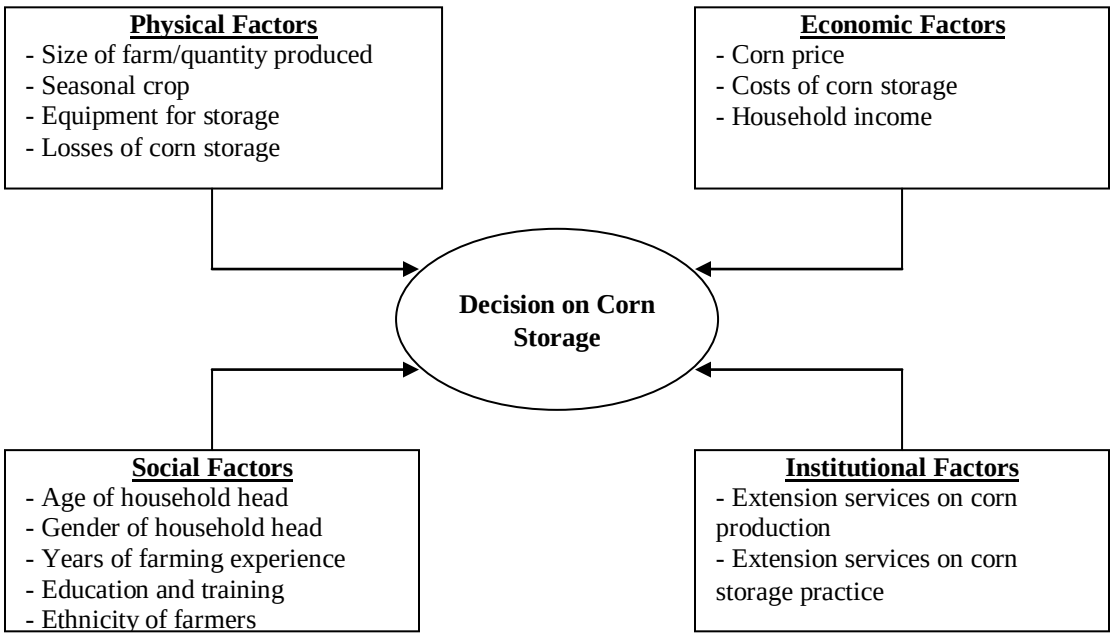

Fig. 1. Factors affecting the decision-making of farmers on corn storage

Data Collection and Samples

A survey was conducted in two communes of Moc Chau district, namely, Muong Sang and Chieng Hac. The study sites were chosen for the following reasons: (1) these areas exhibit interesting cases of corn production and trading; (2) inhabitants of these study sites include both Kinh people and ethnic people who have established a tradition of corn cultivation; and (3) corn storage (for sale of the crop later) have been adopted by farmers in these areas.

Primary data covering 2006-2007 crop seasons were gathered through personal interviews of corn farmers. Additional information related to the study was also collected from various agricultural institutions and local municipalities. The information gathered include: (1) general information of household, corn production, equipment for performing corn storage, selling price of corn, costs of corn storage, household gross income, income from corn production, and attendance in extension training; (2) information on corn prices and markets; and (3) information on corn storage practices. Ninety-nine corn farmers consisting of those who stored corn and those who did not were chosen through stratified random sampling. Secondary data were collected from the Government Bureau of Agriculture and Management District, Regional Offices, and Centers of Extension Services. Both primary and secondary data were used in the analysis and evaluation of decision on corn storage for farmers.

Table 1 presents the socio-economic characteristics of the 99 corn farmers who were interviewed. Of this total, 53 corn farmers stored their produce and the rest did not.

Table 1. Socio-economic characteristics of 99 corn farmers

ITEM	CORN FARMER		COMPARISON	
	Without Storage	With Storage	Difference	Ratio
	(1)	(2)	(1)-(2)	(1)/(2)
Age of the household head (yrs)	43.79	43.77	0.02^{NS}	1.00
Education level of the head (yrs)	9.38	9.69	-0.31^{NS}	0.95
Family size (person)	5.26	4.88	0.38^{NS}	1.08
Farm labor (person)	2.85	2.47	0.39^{NS}	1.16
Gross income (mil. VND)/yr	23.8	28.9	-5,1^{NS}	0.82
Farm size (ha)	2.19	2.95	-076*	0.81
Years in corn farming	19.8	21.5	-1.7*	0.92

Source: Computed on the Basis of Household Data Survey, 2007
Note: * refers to significant at 10% probability level
^{NS} refers to not significant

Analytical Procedure

Because of the categorical nature of the dependent variables in this analysis, a qualitative choice analysis tool was used. The logit function was used to analyze farmers' decision on corn storage and measure the extent of storage benefits. The qualitative response and limited response models deal with dependent variables that are usually dichotomous, qualitative and categorical. Examples are the outcomes of a decision. Farmers can decide to sell immediately or to continue holding their produce. In this application, binomial logit model was used to analyze how respondents' discrete and categorical choices on corn storage practice were affected by their individual characteristics and other socio-economic factors. A description of binomial logit analysis, its underlying theoretical and distributional assumptions, and the relationship between binomial logit, probit, and linear models are given by McFadden (1974, 1981), and Pindyck and Rubinfeld (1981).

Applying the case of the farmer's behavior option, the model helps to predict likelihood that a storage performer will decide to store for a specific period (the dependent variable is assigned a value of 1) with given set of related factors (independent variables).

The logit regression model is specified as follows:

$$P = F(\alpha + \beta X) = \frac{e^{(\alpha+\beta X)}}{1+e^{(\alpha+\beta X)}} = \frac{1}{1+e^{-(\alpha+\beta X)}} \qquad (1)$$

where: P is the vector of probabilities of behavior option;
e is the base of natural logarithms;
X is the vector of independent variables;
α is the constant; and
β is the vector of other estimated coefficients of corresponding X in the model.

In order to apply a linear form, the function above can be written as follows:

$$Ln[P_i/(1-P_i)] = \alpha + \beta_i X_i + \varepsilon_i \qquad (2)$$

where: i presents the individual ith; and
ε is the error term.

The parameters are then estimated by maximum likelihood technique.

To determine partial effect of factor X_i on P_i, the marginal effects of X_i on P_i is calculated by taking partial derivative of P_i with respect to X_i. In logit model, marginal effect represents the change in probability caused by a unit change in X_i, ceteris-paribus. Initially, the factors affecting decision-making of farmers on corn storage are classified into categories (Fig. 1). The study aims to test the statistical relationships embodied in all categories and the dependent variable. In the logit model, decision to store or not store corn is used to analyze the factors affecting farmers' decision on corn storage. This model helps measure the effects of economic and non-economic variables that may influence farmers' decision, which means estimating marginal effects of the probability of decision for the corn farmers in Moc Chau District. The variable decision was actually a dichotomous variable with the following values: the variable decision = 1 if the farmer stores corn with the vector of probabilities of decision (P); the variable decision = 0 if the farmer does not store corn with the vector of probabilities of non-decision (P - 1). The specification of this model is as follows:

Logit (P) = f(physical, economic, social, institutional variables) = f($\alpha + \beta X$) (1)

The STATA7 program was used to estimate the empirical model of decision on corn storage for farmers. Empirical model used was the logit regression model. This model was run for the farmer group that included both who stored corn and those who did not. The probability of decision to store corn was calculated for the model, then compared and evaluated. The empirical model for the farmer group using the logit function form is presented as follows:

$$Z_i = Ln\left[\frac{P_i}{(1-P_i)}\right] = \alpha_0 + \alpha_1.production + \alpha_2.equipment + \alpha_3.price + \alpha_4.storage\_\text{cost} + \alpha_5.gross\_income$$
$$+ \alpha_6.\exp erience + \beta_1.ethnicity + \beta_2.gender + \beta_3.season + \beta_4.extension + u_i \quad (3)$$

where: α_i (i = 1 to 6) = the coefficient of independent variables 1, 2, …, 6.
β_j (j = 1 to 4) = the coefficient of dummy variables 1, 2, …, 4; u_i = error term.

Table 2 describes the independent variables included in the logit model.

Table 2. Independent variables for farmer's corn storage model

Independent Variables	Variable Descriptions
PRODUCTION	Corn quantity produced (kg)
EQUIPMENT	Equipment required for performing corn storage (thousand VND)
PRICE	Farm price of corn (thousand VND per kg)
STORAGE_COST	Costs of corn storage (thousand VND)
GROSS_INCOME	Annual household gross income (thousand VND)
EXPERIENCE	Number of years the household head is engaged in corn production
ETHNICITY	0/1 variable for farmers who belong to Kinh group or other ethnic minorities
GENDER	0/1 variable for the head of the household who is female or male
SEASON	0/1 variable for indicating the crop season is summer or winter
EXTENSION	0/1 variable for farmer who is given extension training or not

EMPIRICAL ANALYSIS

According to the interviews made with the corn farmers in Moc Chau district, there are mainly two cropping seasons for corn in one whole year. The winter season is from February to July, when there is relatively low harvest. The harvest is considerably abundant in the summer season than during August to January. These two seasons are further divided into harvest and non-harvest periods. The first two months of each season account for the harvest period and the remaining four months for the non-harvest period. Corn farmers began to store their crop right after harvest in the winter and summer seasons (February and August, respectively) until the third month of the non-harvest period of the said seasons (June and December). Most of the farmers used polypropylene or plastic sacks for packaging as a substitute for expensive jute sacks. The average length of storage for farmers was about two months because they were worried about maintaining moisture content of corn. Farmers stored corn either in a place in the house or private warehouse after harvesting.

The volume of corn handled by farmers varied not only due to the capacity of the storage houses but also due to weather conditions and the prevailing season in general. On the average, the monthly volume of corn sold by farmers reached 1,134 kg and 2,064 kg for the winter and summer seasons, respectively. The diagram below shows that during the winter season, farmers harvested corn on the first month and sold their crop from the harvest period until the third month (June) of the non-harvest period. (Fig. 2) However, during the summer season, there is a slight difference in the behavior of corn farmers as some of them sold their produce until the last month of the season.

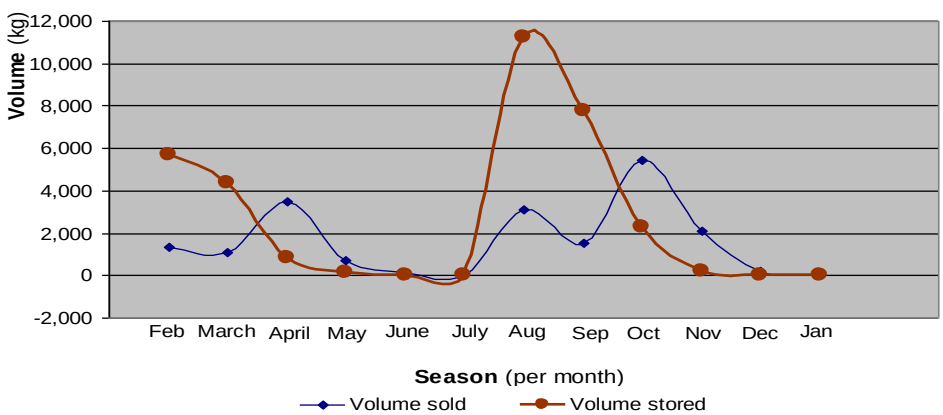

Fig. 2. Average corn volume sold and stored by farmers per season of harvest in selected communes, Moc Chau District, Son La Province, Vietnam, 2007

The logit model was used to estimate the probability that farmers will adopt storage practice as a function of physical, socio-economic characteristics and institutional factors. Among the independent variables, corn production, equipment for corn storage, corn price, cost of corn storage, total annual household income, number of years in farming experience, ethnic group, gender's head of household, crop season, and extension training were determined in the logit model on decision of corn storing for the farmer group. The logit model assumes that the error term is independent and follows the student distribution. The logit model also supposes that a binary dependent variable takes on values of zero for farmers who have decided not to store and one for those who have stored corn. Logit regression analysis was done to determine the factors that affect farmers' decision on corn storage.

The logit equation was estimated using parcel-level data from the 99 sample respondents. Results of the logit regression analysis explained farmers' decisions on their corn storage practices. On average, corn storage was estimated at 53.54%, holding other things constant. These indicators were statistically significant at 1% level. Coefficients were estimated through the maximization of a likelihood function. It was weighted by factors that depend on the values of all regressors in independent variable. The estimated coefficients of the storage model for the farmers which was ran on all sample farms are shown in Table 3.

To measure the goodness of fit of the model, the ratio of LR chi^2 was used to test the estimated parameters in the logit model. The logit model on corn storage for farmers was significant at 1% level implying that majority of the independent variables could influence the decision of corn farmers on whether to store their crop or not. On the other hand, Pseudo $R^{2,}$ a likelihood ratio index, was also computed. It is analogous with the R^2 of ordinary least squares (OLS) regression, although it does not have the same interpretation of variance explained. Pseudo R^2 gives different answers and thus provides different measures of fit when applied to the other models. It should be used only as a rough measure of the improvement in goodness of fit in comparing models with the same dependent variable.

Table 3. Estimated coefficients of the logit model on corn storage practices of farmers

Variables	**Coefficients**	**T-value**
CONSTANT	-13.36693^{***}	(0.000)
PRODUCTION	$.0000714^{*}$	(0.090)
EQUIPMENT	$.00000074^{NS}$	(0.748)
PRICE	$.3286178^{***}$	(0.001)
STORAGE_COST	$-.1588945^{**}$	(0.011)
GROSS_INCOME	$.0137513^{***}$	(0.005)
EXPERIENCE	$.0005980^{*}$	(0.096)
ETHNICITY	$.0468245^{NS}$	(0.618)
GENDER	$-.0769525^{NS}$	(0.349)
SEASON	$.0199260^{***}$	(0.007)
EXTENSION	$.0234431^{***}$	(0.007)
Pseudo R^2	.5836	
LR chi^2 (10)	75.06^{***}	(0.000)
Number of obs	99	

Note: ***, ** and * refer to significant at 1%, 5% and 10% probability levels, respectively
^{NS} refers to not significant
Pseudo $R^2 = R^2 = 1 - (LL_{UR}/L_0)$, where: L_{UR} = Log likelihood function, L_0 = Restricted log likelihood

Independent variables differently affected farmers' decisions on corn storage. These effects were represented by separate coefficients in the model. Table 3 shows clearly the effects of the different coefficients.

Among the factors considered in the logit model, seven were found to have significantly influence corn farmers' decision-making to store their produce. These included the quantity of corn

harvested (PRODUCTION), corn price (PRICE), costs of corn storage (STORAGE_COST), total annual household income (GROSS_INCOME), number of years in farming experience (EXPERIENCE), crop season (SEASON), and extension training (EXTENSION).

The quantity of corn harvested and number of years in farming experience have positive and significant influence on corn farmers' decision about their storage practices at 10% probability level. However, the effects of these factors on the probability of farmers' decision on corn storage are quite low. The low effects of these factors could be explained by the fact that majority of the farmer's warehouse is sufficient for corn storage based on the floor area. Average floor area of the corn farmer's warehouse is 21.3 square meters and it can contain 20 tons while average productivity harvested is over 15 tons in the summer season. On farming experience, the decision to store corn between farmers who have many years of experience in farming and those who have a few years of experience was significant only at 10% probability level. Corn farmers in the survey areas often imitate the practices and behavior of their neighbors, especially from good farmers. The effects of corn price and total annual household income on the probability of corn farmers' decision-making to store their produce are high. If the PRICE is increased by one unit then the probability of corn farmers' decision to store corn could be increased by 32.86%, ceteris paribus. Corn farmers' behavior on whether to sell corn right after harvest or store it for a while is influenced by the price of corn. They will sell their corn when the price is high and continuously store their produce if they believe the price will still rise.

Similarly, an increase of one unit in GROSS_INCOME would lead to an increase in the probability of corn farmers' decision-making to store their produce by 1.38%, holding all other things constant. This implies that total annual household income largely affects the probability of corn farmers' decision to store corn because of immediate need for cash. Most of corn farmers in Moc Chau district rely mainly on corn production and their income are quite low, about 5.92 million VND/person/year. In many cases, corn farmers are faced with expending pressures that reluctantly compel them to decide selling their produce immediately. This is a big problem particularly in the poverty-stricken rural areas and mountainous regions in Vietnam.

Unlike other variables, only STORAGE_COST showed a negative sign at 5% significant level. If the STORAGE_COST is increased by one unit then the probability of corn farmers' decision to store corn could be decreased by 15.89%, ceteris paribus. This effect is fairly high. It can be simply explained that an increase in storage costs will lead to a decrease in profit. Normally, storage costs that are incurred by corn farmers during storage time include the costs of piling of corn cob, plastic sacks, chemicals, and other items that are non-cash expenditures (e.g., storage losses, family labor, depreciation on warehouse and opportunity cost of capital). Moreover, corn farmers' income in Moc Chau district is quite low so storage costs constrain corn farmers to store their produce. Many corn farmers in the research sites require more capital to finance their next cropping season aside from meeting basic family needs.

The dummy variables such as SEASON and EXTENSION in the model were both positively significant, indicating that these variables favorably influence corn farmers' decision-making to store corn. During summer season, storing corn is more likely to happen than in the winter season. This is attributed to higher corn productivity in the summer season due to favorable weather condition compared to that in the winter season. Regarding the impact of extension, farmers who participated in extension training could clearly understand appropriate corn storage techniques than those who did not. These techniques include applying the right type and dosage of chemicals in preparation for corn storage, proper method of piling corn in the warehouse in order to create enough space for ventilation, maintaining the ideal grain moisture content and relative humidity, effective means of controlling rodents and other grain pests, and appropriate drying of corn, among others.

CONCLUSIONS AND RECOMMENDATIONS

This analysis of a survey of Moc Chau corn farmers finds that their corn storage practices are affected by the economic and non-economic factors. Some factors that have significant impacts on farmers' corn storage practices include price of corn after storage, volume of corn harvested, storage costs, total annual household income, number of years in farming experience, crop season and extension.

Uncertainty in future corn prices, high storage costs and inadequate capital serve as major constraints affecting farmers' decision on corn storage. Inability to predict corn prices has meant a reduction in corn storage or made farmers engaged in corn storage vulnerable. Furthermore, the value of future corn prices has become an important factor to increasing corn storage. Hence, improvements in communication infrastructure to assist in effective dissemination of market information and predicting future prices as well as increasing access to capital should be given priority by the national government to encourage corn storage among farmers.

Lowering the storage costs by reducing chemical application and storage losses due to rodents and other pests can be done through proper pest management and sanitation of the storage facilities, and provision of appropriate storage handling techniques. The government plays an important role in providing extension delivery services through training, seminars and lectures regarding the latest technical know-how to improve farmers' access to storage facilities and provide the possibilities for reducing storage costs.

Findings of this study are of practical importance to corn farmers, as well as to applied researchers and extension educators. Corn farmers may be able to make more objective and profitable corn storage decisions as a result of an improved understanding of their corn storage practices and tendencies. These results may be useful as a guide for future studies as well as to the development of a more effective extension educational program on corn storage.

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J. ISSAAS Vol. 14, No 2:71-85(2008)

SUPPLY TREND AND RESPONSE ANALYSIS OF SELECTED SEMI-TEMPERATE AND TROPICAL VEGETABLES IN THE PHILIPPINES

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(Received: October 1, 2008; Accepted: November 29, 2008)

ABSTRACT

This paper examines the supply trend and response of selected tropical and semi-temperate vegetables in the Philippines to various explanatory variables using direct and indirect methods of supply estimation. From 1990 to 2007, cabbage, the country's leading semi-temperate vegetable, exhibited a positive growth in production, area and yield. Despite the declining trend in area planted, domestic production of tomato, a widely-grown tropical vegetable in the country, grew positively due to improvement in yield. At the national level, results of both the direct and indirect supply estimation methods reveal that rising real farmgate price of cabbage the previous year could encourage Filipino farmers to increase production of this vegetable. On the contrary, lagged real wage rate and price of fertilizer have constricted production and area planted to cabbage. Tomato production has responded positively to nominal price of inorganic fertilizer, suggesting that with an increase in price of inorganic fertilizer, tomato growers extensively used organic fertilizer as a substitute to inorganic fertilizer.

Using pooled regional data, results of the direct method show that for cabbage, its real farmgate price and technology have positive effects on production while in the indirect method, a negative relationship between real wage rate and cabbage yield was found. For tomato, nominal wage rate and price of fertilizer, rainfall, technology and region dummy D_4 representing Region X, significantly affected tomato yield. Four region dummies representing Regions I, III, IV-A and X were highly significant in the area supply response function for tomato. These region dummies have positive sign reflecting upward production trend and share to national output of selected vegetables compared to the reference region.

Key words: Direct and indirect methods of supply estimation

INTRODUCTION

The Philippines as an archipelago has diverse agro-climatic conditions ideal for semi-temperate and tropical vegetable production. Among the widely-grown semi-temperate vegetables, cabbage accounts for the bulk of total output while tomato ranks second among tropical vegetables in terms of hectarage. With an annual population growth of 2.04 percent (NSO, 2008) and the increasing number of households that are more health-conscious, it is expected that the demand for these vegetables will continue to rise in the future. The proliferation of supermarkets, hotels, fast-food chains and restaurants in the urban and semi-urban areas also creates a continuous demand for cabbage and tomato in many food preparations throughout the year. In 2006, the country resorted to importation of 121 metric tons (mt) of cabbage valued at US$ 122,588 and 18,670 mt of tomato worth US$11.06 million to augment local production. For the period 2003-2007, average per capita consumption of cabbage and tomato reached 1.06 kilograms and 1.55 kilograms and grew annually at 6.39 percent and 1.69 percent, respectively.

Domestic production of vegetables needs to be improved to satisfy the domestic demand. Knowledge on what factors affect farmers' decision to produce these two types of vegetables would guide policy-makers in providing specific government support to producers to increase semi-temperate and tropical vegetable production.

Currently, there is an apparent lack of updated studies on the supply trends and response analysis of selected semi-temperate (cabbage) and tropical (tomato) vegetables. This paper aims to analyse the supply trends and response of these vegetables to changes in its farm price, price of competing crops, input prices and other supply determinants.

METHODOLOGY

Secondary data on farm prices of cabbage and tomato and their competing crops (e.g., carrot and eggplant), retail price of fertilizer, and wage rate at the national and regional levels were collected from the Bureau of Agricultural Statistics (BAS). Data on annual rainfall, both at the national and regional levels, were gathered from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA). These time-series data covered the period 1990 to 2007 except for annual rainfall with incomplete data for 2007. Regional data pertained to pooled data of the top five producing regions for a specific vegetable.

Trends in national and regional production, area planted and yield per hectare of selected vegetables were analyzed with the aid of graphs and tabular presentation of growth rates. To determine the supply responses of selected vegetables to explanatory variables, multiple regression analysis was employed in linear and double-log forms. Direct and indirect methods of supply estimation have the following general models:

1). Direct Method: $Q_{sVt} = f\,(P_{Vt}, P_{Ct}, P_{Ft}, P_{Lt}, R_t, T_t)$

$Q_{sVt} = f\,(P_{Vt-1}, P_{Ct-1}, P_{Ft-1}, P_{Lt-1}, R_t, T_t)$

2). Indirect Method: $Q_{sVt} = f\,(A_{Vt}, Y_{Vt})$

$A_{Vt} = f\,(P_{Vt}, P_{Ct}, P_{Ft}, P_{Lt})$ or

$A_{Vt} = f\,(P_{Vt-1}, P_{Ct-1}, P_{Ft-1}, P_{Lt-1})$

$Y_{Vt} = f\,(P_{Ft}, P_{Lt}, R_t, T_t)$ or

$Y_{Vt} = f\,(P_{Ft-1}, P_{Lt-1}, R_t, T_t)$

Based on the general models in both direct and indirect methods, the following functional forms were estimated using national level data:

Direct Method

The direct method involves a single supply equation to estimate the supply response of cabbage and tomato. The supply response models in linear and double-log forms are shown below:

a). Linear Form:

$Q_{sVt} = a + b_1 P_{Vt} + b_2 P_{Ct} + b_3 P_{Ft} + b_4 P_{Lt} + b_5 R_t + b_6 T_t + e_t$

$Q_{sVt} = a + b_1 P_{Vt-1} + b_2 P_{Ct-1} + b_3 P_{Ft-1} + b_4 P_{Lt-1} + b_5 R_t + b_6 T_t + e_t$

b). Double-log Form:

$\log Q_{sVt} = \log a + b_1 \log P_{Vt} + b_2 \log P_{Ct} + b_3 \log P_{Ft} + b_4 \log P_{Lt} + b_5 \log R_t + b_6 \log T_t + e_t$

$$\log Q_{sVt} = \log a + b_1 \log P_{Vt-1} + b_2 \log P_{Ct-1} + b_3 \log P_{Ft-1} + b_4 \log P_{Lt-1} + b_5 \log R_t + b_6 \log T_t + e_t$$

where: Q_{sVt} = quantity of vegetable supplied in year t (mt),
P_{Vt} = price of vegetable in year t (P/kg),
P_{Vt-1} = price of vegetable in previous year t (P/kg),
P_{Ct} = price of competing crop in year t (P/kg),
P_{Ct-1} = price of competing crop in previous year t (P/kg),
P_{Ft} = price of fertilizer in year t (P/bag),
P_{Ft-1} = price of fertilizer in previous year t (P/bag),
P_{Lt} = wage rate in year t (P/day),
P_{Lt-1} = wage rate in previous year t (P/day),
R_t = amount of rainfall in year t (millimetres), and
T_t = time as a proxy for technology in year t.
a = the intercept
bi_s = regression coefficients
e_t = error term

Indirect Method:

In the indirect method of supply estimation, area and yield response functions were estimated separately. The area and yield response functions in linear and double-log forms are shown below:

a). Linear Form:

$$A_{Vt} = a + b_1 P_{Vt} + b_2 P_{Ct} + b_3 P_{Ft} + b_4 P_{Lt} + e_t$$
$$A_{Vt} = a + b_1 P_{Vt-1} + b_2 P_{Ct-1} + b_3 P_{Ft-1} + b_4 P_{Lt-1} + e_t$$

$$Y_{Vt} = a + b_1 P_{Ft} + b_2 P_{Lt} + b_3 R_t + b_4 T_t + e_t$$
$$Y_{Vt} = a + b_1 P_{Ft-1} + b_2 P_{Lt-1} + b_3 R_t + b_4 T_t + e_t$$

b). Double-log Form:

$$\log A_{Vt} = \log a + b_1 \log P_{Vt} + b_2 \log P_{Ct} + b_3 \log P_{Ft} + b_4 \log P_{Lt} + e_t$$
$$\text{lo g } A_{Vt} = \log a + b_1 \log P_{Vt-1} + b_2 \log P_{Ct-1} + b_3 \log P_{Ft-1} + b_4 \log P_{Lt-1} + e_t$$

$$\log Y_{Vt} = \log a + b_1 \log P_{Ft} + b_2 \log P_{Lt} + b_3 \log R_t + b4 \log T_t + e_t$$
$$\log Y_{Vt} = \log a + b_1 \log P_{Ft-1} + b_2 \log P_{Lt-1} + b_3 \log R_t + b4 \log T_t + e_t$$

where: A_{Vt} = area planted to vegetable in year t (ha),
Y_{Vt} = yield per hectare of vegetable in year t (mt/ha)
P_{Vt}, P_{Vt-1}, P_{Ct}, P_{Ct-1}, P_{Ft}, P_{Ft-1}, P_{Lt}, P_{Lt-1}, R_t and T_t have been defined previously.

Apart from the aforementioned national level supply, area and yield response functions, aggregate supply, area and yield response functions using pooled regional data of the top five producing regions of cabbage and tomato were also estimated. Regional dummy variables, designated as D_1, D_2, D_3 and D_4 were added to these models. The region ranking fifth in terms of production, area and yield were set as the reference region for the production, area and yield responses, respectively.

Farm prices of cabbage and tomato and its competing crops, wage rate and retail price of fertilizer were deflated using the consumer price index with 2006 as the base year. Current and lagged prices for one year, in nominal and real terms, of these variables were tested separately to determine which model could provide the best results. More so, the lack of data for the years 1989 and 2007 of

some explanatory variables resulted to a 16-year period of multiple regression analysis from 1991 to 2006.

In selecting the most appropriate regression model in the supply analysis using either direct or indirect method, the following criteria were used: (1) significance of the estimated equation based on the F-value; (2) goodness of fit of the estimated equation based on the coefficient of determination (R^2); and (3) consistency of the signs of the regression coefficients based on economic theories.

REVIEW OF LITERATURE

Past studies have established that changes in prices and other economic, technical and weather factors could affect the supply of a specific commodity. The effects of these explanatory variables are estimated using supply response models at an individual and/or market level. These models could be derived from any of the following: multiple regression analysis employing the direct or indirect methods of supply estimation using time-series data; production function analysis using cross-section data or with observed price variations; profit function estimation; and the use of a Nerlovian model with partial adjustment and price formation.

Grad and Mansour (2008) estimated the supply response of vegetables in Syria using the indirect method. Area and yield responses were first determined after which the production response was estimated. The factors affecting area included lagged area of crops, price of crops, and lagged prices of competing crops while for yield, it included lagged yield of crops, and differences in rainfall and production cost. Lopez and Munoz (1986) also used this method in estimating the supply determinants of tomato in the United States. Empirical findings showed that acreage planting decisions were mainly affected by the expected tomato price, partial adjustment and urban pressures. Weather, tomato price and wages were found to have a significant effect on tomato yield. However, yields were inelastic with respect to changes in tomato price and wages.

Using time-series data covering the period 1980-1997 with marketed output as the dependent variable, Onyango and Bhuyan (2001) found out that the supply of selected vegetables (e.g., cabbage, spinach, eggplant, head lettuce and tomatoes) in New Jersey was positively related to their expected own price, marketed quantity the previous year and weather while an inverse relationship was noted for the price of competing crops.

In the Philippines, findings of Pabuayon et al. (1988) on the indirect method of supply estimation for selected vegetables using multiple regression analysis showed that hectarage devoted to mungbean and eggplant increased with a rise in their own prices. The fertilizer price had a negative effect on mungbean yield. Eggplant yield was negatively related to fertilizer price, wage rate, and heavy rainfall. Diangkinay (2001) in a study on supply analysis of vegetables also in the Philippines from 1983 to 1998 showed similar results for eggplant. Prices of fertilizer and labor and rainfall had a negative influence on eggplant production and yield. For cabbage, only the real price of inorganic fertilizer was significant but exhibited a positive effect on the production and yield of this crop, indicating that some farmers would have continued applying inorganic fertilizer despite the rising fertilizer cost or started substituting organic fertilizer for inorganic fertilizer.

RESULTS AND DISCUSSION

Vegetable Varieties

Cabbage. The country produces several varieties of cabbage, namely: Scorpio, RB, Vigan, FI K-K Cross, FI K-Y Cross, Marion Market, FI Princes No. 39, and FI Stonehead (BAS 2003). Among these varieties, Scorpio is considered as the best type of cabbage with compact head and pointed tip and

average weight of 0.75-2.0 kilograms per piece. RB is classified as a second class cabbage which is round in shape, compact with dark green head, and has an average weight of 0.50-1.5 kilograms per piece. The Vigan variety is widely grown in Ilocos Sur and it is similar to RB in appearance but has light green color. FI K-K Cross and FI K-Y Cross are heat tolerant varieties, flat with compact head and purple pigmentation at the stem, petiole and mid vein. Both have dark green color and the only difference is that the former has bloomed leaf while the latter is loosely enclosed by inward curve of the leaves. Marion market is a temperate variety with round and compact head, resistant to downy mildew, light green and less bloomed leaves. FI Princes No. 39 and FI Stonehead are hybrids with round compact head, light green and less bloomed leaves.

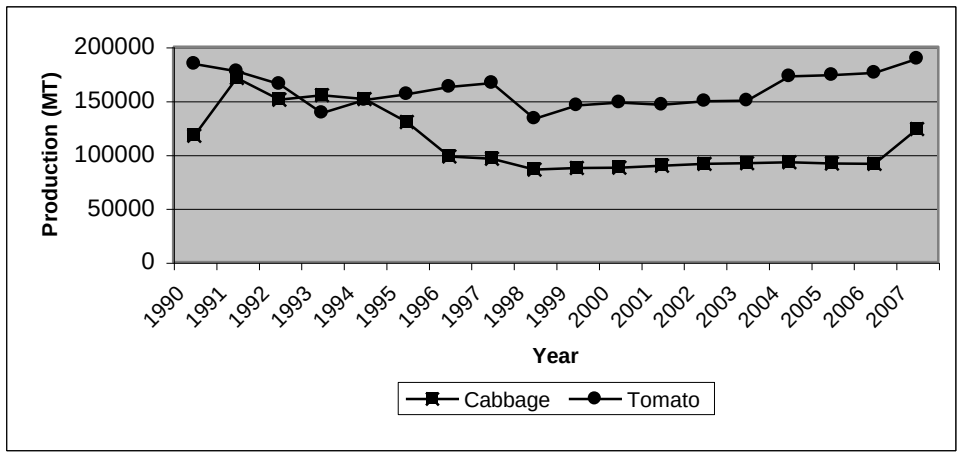
Tomato. The common tomato varieties grown in the Philippines include Apollo (Luzon) or Pope/1833 (Mindanao), California (Luzon) or Del Monte (Mindanao), *Tagalog* (Luzon) or Native (Mindanao). Apollo or Pope 1833 variety is thick skinned, ovate with slight to no ridges, firm, elongated with rounded or pointed end. California or Del Monte variety is characterized by big, round, relatively thick skinned with firm to juicy flesh. Sometimes this tomato variety is called *Bilog* by Manila wholesalers or Baguio tomato by provincial traders. *Tagalog* or native variety has different sizes with thin skin, pronounced ridges, juicy but with short shelf-life. In Pangasinan, this variety is locally termed as *Quatro Cantos* (BAS 2003). Improved off-season tomatoes such as Maligaya, Marikit and NC 11-1 are also introduced in the early 1990s to improve the income of tomato farmers. Other tomato varieties planted in Mindanao include BRCI 403, BRCI 17, BRCI 9, BRCI 13 and BRCI 15 and Diamante variety which is high yielding and less susceptible to pests and diseases.

Supply Trends

Supply trends in this section refer to the domestic production trends for cabbage and tomato.

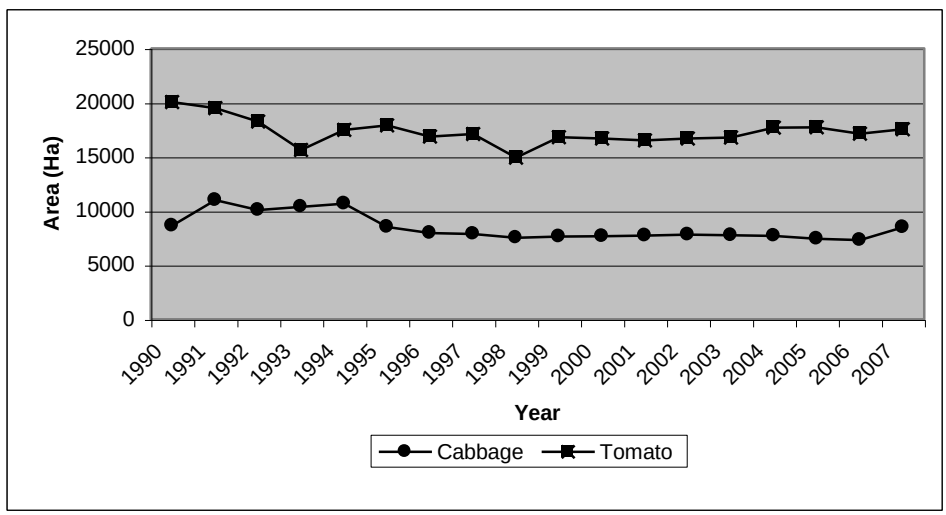
Cabbage. National cabbage production slightly grew at 1.45 percent per year from 117,202 mt in 1990 to 123,443 mt in 2007. Area planted and yield exhibited a much slower growth of less than 1 percent for the period 1990-2007. From 1990 to 1998, cabbage production highly fluctuated mainly due to a decline in area devoted to this crop brought about by bad weather. In a span of 18 years, the lowest cabbage production occurred in 1998 when the worst El Niño phenomenon substantially damaged many vegetable farms in key production areas in Luzon and Mindanao (Fig. 1 and 2). Despite the development of heat resistant varieties and the promotion of Integrated Pest Management (IPM) practices, national cabbage production still decreased by 10.45 percent per year between 1997 and 1998. For the period 1990-2007, the highest yield level of cabbage of 18.88 mt per hectare in Cordillera Autonomous Region (CAR), the top cabbage producing region in the country, was still below the optimum yield of recommended cabbage varieties which ranges from 21-29 mt per hectare. The other dominant cabbage producing regions reported a much lower yield per hectare than CAR.

In 2007, CAR held 81 percent of the total cabbage production in the Philippines, followed by Regions VII, XI , X and I; each with production share of less than 6 percent in the same period (Fig. 3). A slow hike in cabbage production at the national and regional levels from 1999 onwards are due to the slight expansion in area planted and improvement in yield except for Region I where yield has a negative growth of 0.28 percent per year although the area planted indicates a significant increase (Table 1). The top three cabbage producing provinces are Benguet, Mountain Province and Ifugao in CAR; Cebu, Negros Oriental, and Bohol in Region VII; Davao del Sur, Davao City and Compostela Valley in Region XI; Bukidnon, Misamis Oriental and Misamis Occidental in Region X; and Ilocos Sur, Ilocos Norte and La Union in Region I.



Source of data: BAS, 2008

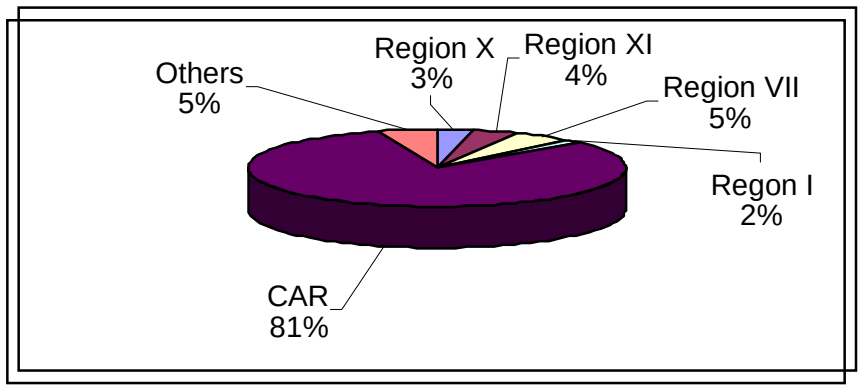
Fig. 1. Production of selected semi-temperate and tropical vegetables at the national level, 1990-2007.



Source of data: BAS, 2008

Fig. 2. Area planted to selected semi-temperate and tropical vegetables at the national level, Philippines, 1990-2007

CAR has an average production of 87,255 mt for the same period (BAS 2008). With the favorable conditions brought about by its location, in terms of climate, soil type, and existing land use and practices, zones devoted to rice, corn, mixed fruit trees, coffee, pasture, grasses and shrubs are recommended to be replaced by or intercropped with vegetables In particular, irrigated and non-irrigated rice fields classified under the Strategic Crop Sub-Development Zone and future expansion areas for the Strategic Agriculture and Fishery Development Zone (SAFDZ) of the Department of Agriculture in CAR are recommended to be planted with semi-temperate vegetables (DA-BSWM 2003).



Source of basic data: BAS, 2008

Fig. 3. Share in cabbage production of top five producing regions, Philippines, 2007.

Table 1. Production and average annual growth rates in production, area planted and yield per hectare of selected semi-temperate and tropical vegetables in five major producing regions, Philippines, 1990-2007.

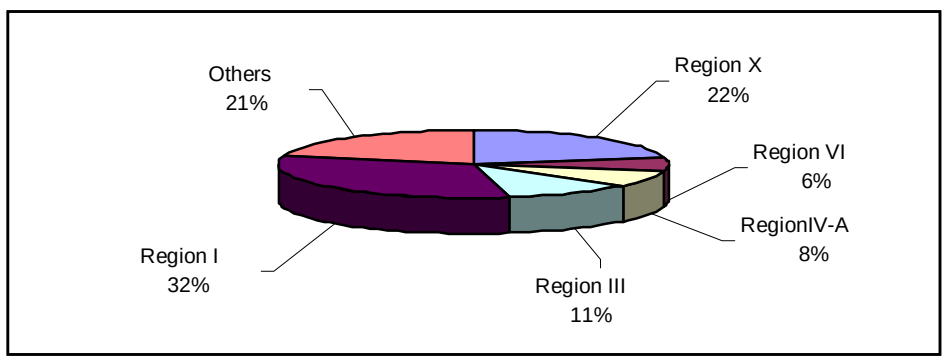
Types of Vegetable/Region	Production (MT) (2007)	Average Annual Growth Rate (%)		
		Production	Area Planted	Yield
Cabbage				
CAR	99,957	2.18	0.80	0.90
Region I	2,752	19.60	19.67	(0.28)
Region VII	6,251	2.67	2.12	0.51
Region X	3,567	3.58	2.44	1.12
Region XI	4,661	3.58	2.54	0.74
Philippines	123,443	1.45	0.36	0.69
Tomato				
Region I	60,827	0.24	(1.99)	2.64
Region III	21,333	0.52	1.04	(0.53)
Region IV-A	15,917	(1.02)	(2.79)	1.56
Region VI	10,669	(2.97)	(1.47)	(1.41)
Region X	41,698	5.74	4.43	1.02
Philippines	188,761	0.53	(0.54)	1.03

Source of basic data: BAS, 2008

Tomato. Domestic production of tomato slightly grew by 0.53 percent annually from 1990 to 2007 (Table 1). Area planted to tomato followed a downward trend in 1990 to 1994 as a result of strong typhoons and other calamities. The Mt. Pinatubo eruption in 1991 decreased production in top tomato producing provinces in Luzon, especially those in Region III, with a three-year decline from 8.33 percent to 9.23 percent during the period 1991-1993 (Fig. 1 and 2). Tomato production also showed a significant fall in 1998 as prolonged drought caused by El Niño severely damaged several tomato producing areas in Mindanao. Nonetheless, the development of improved off-season varieties, adoption of IPM for bacterial wilt and control of fungal diseases and promotion of organic farming have helped producers adjust to weather aberrations in the succeeding years.

The major tomato producing provinces cover Pangasinan and Ilocos Norte in Region I, Nueva Ecija and Tarlac in Region III, Laguna and Quezon in Region IV-A, and Iloilo and Aklan in Region VI. On seasonality of tomato supply, Pangasinan, Ilocos Norte and Nueva Ecija are the major tomato suppliers from December to early March. The bulk of the processing tomato variety in Ilocos Norte is distributed to the Northern Foods Corporation based in the province. The tomato production in Iloilo supplies the requirements of Panay, Negros Islands and Cebu during the same period. The uplands of Nueva Ecija, Nueva Viscaya, Laguna and Quezon extend supplies in the market during the late dry season to early wet season (March-June). The shipment of tomato from Misamis Oriental to Manila starts in May and gradually increases from August until November to take advantage of higher price in major demand centers in Manila (BAR 2002). The latter months are rainy season in Luzon so tomato supply is much lower in Manila markets.

However, cultivation of tomato has shifted from Region I to Region X, as the latter is located outside of the typhoon belt. Between 1990 and 2007, Region X expanded by 10 percent and 7 percent in terms of share in national production and area planted to tomato, respectively while Region I showed a declining production share of 4 percent and 9 percent share in terms of tomato area. In 2007, Regions I and X were followed by Regions III, IV-A and VI (Fig. 4).



Source of basic data: BAS, 2008

Fig. 4. Share in tomato production of top five producing regions, Philippines, 2007.

Supply Response Analysis

This section presents the results of the multiple regression analysis for the direct and indirect methods of supply response analysis using time-series-data covering the period 1991-2006. Both the linear and double-log functional forms were estimated and tested in both methods of supply estimation to determine the best model.

Direct Method

Cabbage. The double-log functional form provided the best supply response model for cabbage at the national and regional levels. The lagged real farm price of the product showed positive and significant regression coefficient at 5 percent probability level, implying that the farm price of cabbage in the previous year has significantly influenced the farmers' planting decision in the current year throughout the country. Its estimated regression coefficient (0.26) indicates that a 1 percent increase in the real price of cabbage in the previous year would result to a 0.26 percent increase in the national cabbage production in the current year, holding other factors constant (Table 2).

However, the effect of lagged real farm price of carrot as the competing crop was significant but positive. This suggests that carrot may not be the competing crop for cabbage throughout the

country as shown by its illogical relationship to cabbage production. This may be due to the varying mix of vegetables as substitutes (e.g., pechay or lettuce) evident in various regions. These vegetables were not incorporated in the model since BAS data on pechay are aggregated regardless of type, whether it is native pechay which is grown in the lowlands or Chinese cabbage commonly called as Chinese *pechay*, which is cultivated in the uplands and cool areas. In the case of lettuce, time-series data for lettuce production are incomplete and unreliable.

The lagged real price of fertilizer, lagged real wage rate and rainfall have shown significant and negative coefficients denoting inverse relationships of these variables with the national cabbage production (Table 2). Fertilizer and labor are important inputs of production so as fertilizer price and wage rate surge, cabbage farmers would be discouraged to improve production of this vegetable crop. On the other hand, too much rainfall particularly during typhoon months could also decrease cabbage production. The R^2 value of 0.95 indicates that 95 percent of the variation in cabbage production in the country is due to changes in all the explanatory variables included in the regression model. The overall estimated national cabbage supply response function is highly significant at one percent probability level based on the F-test.

Results of the multiple regression analysis for the pooled regional data of five major cabbage producing regions (CAR, Region VII, Region X, Region XI and Region I) show that only the real farm price of cabbage, technology and three region dummies (D_1, D_2 and D_4) affected positively and significantly the aggregate or regional cabbage production. With the wide subscription of cellular phone in these regions, perhaps vegetable producers have better access to market information so they depend on the current real farm price instead of the previous real farm price as basis for their production decision-making. Time variable was found to have positive and significant effect on cabbage production which means that in 16 years, technology could have an important impact on the increase in cabbage production in the five regions identified. Among the region dummies, only D_3 (Region XI) was insignificant which means that the difference in cabbage production between Region XI and the reference region (Region I) is negligible. The three dummy regions have demonstrated significantly higher cabbage production than the reference region. The R^2 value of 0.96 was also high similar to that at the national level. The overall regression model for cabbage using pooled regional data was also highly significant at one percent probability level as evident from its very high F-value of 151.01.

Likewise, the real farm price of carrot was also insignificant at 10 percent probability level which means that carrot is not considered as a competing crop for cabbage in these leading five producing regions. The real fertilizer price was also positive and the real wage was negative but both of these input prices are insignificant using pooled regional data.

Tomato. The best supply response model chosen for tomato using national and pooled regional data was also the double-log function. Both regression models were highly significant at one percent probability level based on the F-test. The R^2 value of 0.91 indicates that 91 percent of the total variation in tomato production at the leading producing regions could be explained by the predictor variables included in the model. In spite of high R^2 value, only the nominal price of fertilizer, nominal wage rate and the four dummy regions (Regions I, III, IV-A and X) were found significant at 1 percent probability level. Nominal price of fertilizer, with positive regression coefficient (0.32), implies that given a 1 percent increase in the real price of inorganic fertilizer, tomato production at the national level would still increase by 0.32 percent, other factors remain constant. This situation can be explained in two ways. First, tomato producers in the country would still buy inorganic fertilizer and apply the required amount even though its real price would increase as long as this would enhance tomato production. Second, tomato producers might have used organic fertilizer as a substitute for inorganic fertilizer during the period when the price of the latter surged.

Table 2. Regression results of the most appropriate production response function for selected vegetables at the national and regional levels, Philippines,1991- 2006.

ITEM	Cabbage		Tomato	
	National	Regional	National	Regional
	Double-log Model	Double-log Model	Double-log Model	Double-log Model
Intercept	28.22***	7.11^{ns}	9.04***	8.33***
	(12.43)	(1.51)	(5.22)	(11.26)
Regression Coefficients				
P_{Vt}		0.27**	0.04^{ns}	-0.02^{ns}
		(2.01)	(0.36)	(-0.26)
P_{Ct}		-0.07^{ns}	-0.31^{ns}	-0.01^{ns}
		(-0.63)	(-1.48)	(-0.73)
P_{Ft}		0.01^{ns}	0.26***	0.32***
		(0.02)	(3.41)	(4.26)
P_{Lt}		-0.16^{ns}	0.44^{ns}	-0.29***
		(-0.22)	(1.11)	(-2.76)
P_{Vt-1}	0.26**			
	(2.91)			
P_{Ct-1}	0.24**			
	(2.19)			
P_{Ft-1}	-0.31**			
	(-7.92)			
P_{Lt-1}	-2.73***			
	(-2.61)			
R_t	-0.25*	0.08^{ns}	0.04^{ns}	0.11^{ns}
	(-2.09)	(0.54)	(0.26)	(1.25)
T_t		0.17***	-0.22^{ns}	
		(3.21)	(-1.63)	
$D_1^{a,b}$		3.83***		1.43***
		(9.59)		(23.11)
$D_2^{a,b}$		0.86**		0.41***
		(2.48)		(6.23)
$D_3^{a,b}$		0.16^{ns}		0.25***
		(0.84)		(3.74)
$D_4^{a,b}$		0.68**		0.57***
		(2.81)		(7.51)
R^2	0.95	0.96	0.73	0.91
F-value	34.34***	151.01***	4.04**	75.19***

Figures in parenthesis are t-values.
***,**,* - significant at 1%, 5%, and 10% probability level, respectively.
^{ns} – not significant at 10% probability level.
[a] Dummy regions for cabbage: D_1=CAR, D_2=Region VII, D_3=Region X, and D_4=Region XI. Region I served as the reference region with the lowest production among the five regions.
[b] Dummy regions for tomato: D_1= Region 1, D_2= Region III, D_3=Region IV-A, and D_4=Region X. Region VI served as reference region with the lowest production among the five regions.

Sources of basic data: BAS and PAG-ASA, 2008

Empirical studies conducted by Nocon et al. (2002) and Aragon (2006) reported that organic vegetable farming in the Philippines is becoming widespread due to the increase in awareness of consumers particularly in urban areas about the health advantages of organically grown vegetables over chemically induced ones and the publicity regarding the negative effects of chemical fertilizers on the health of the general public and the environment**.** The nominal wage rate has a negative coefficient (0.29) denoting its inverse relationship with tomato production. The positive and significant regression coefficients of the region dummy variables indicate that all the four main tomato regions registered higher production through time compared to the reference region (Region VI).

Indirect Method

Cabbage. Among the explanatory variables used in estimating the area response function for cabbage at the national level were: lagged real farm price of cabbage, lagged real farm price of carrot, lagged real price of fertilizer and lagged real wage rate. Based on the economic and statistical criteria, linear form was selected as the best model for the cabbage area response function in the Philippines. Regression results of the appropriate area response function for cabbage show that except for the lagged real farm price of carrot, all the independent variables were significant (Table 3). The lagged real farm price of cabbage was significant at 5 percent probability level in this model. The positive regression coefficient of this variable implies that an increase in the real farm price of cabbage the previous year would result to an expansion in area planted to cabbage in the current year, assuming other factors remain constant. Both the lagged real price of fertilizer and lagged real wage rate were significant and with negative sign of the regression coefficients at 5 and 1 percent probability level, respectively. An increase in the lagged real price of fertilizer by one peso would reduce the area planted to cabbage in the country by 2.89 hectares compared to 103.44 hectares when there is an upward adjustment of real agricultural wage rate the previous year. As CAR and other producing regions are becoming more industrialized, it creates a shortage in farm workers resulting in higher wage rate. In case of inorganic fertilizer, some farmers shift to organic fertilizers as the price of inorganic fertilizer becomes more expensive. According to Diangkinay (2001) and Aragon (2006), there is widespread use of organic fertilizer in CAR.

The most appropriate yield response model for cabbage at the national level was the double-log model. The overall equation was found significant at 1 percent probability level and has a good fit ($R^2 = 0.71$). Among the four predictor variables used, only the real wage rate the previous year was found to have a significant effect on cabbage yield in the country (Table 3). The negative regression coefficient (0.15) of real wage rate implies that a one percent increase in real wage rate the previous year would decrease the yield of cabbage by 0.15 percent, ceteris paribus. This negative sign of the regression coefficient of real wage rate does conform to the production economic theory which states that as the price of input increases, yield decreases because growers tend to reduce the input use in response to the rise in input price.

Using pooled regional data, only D_1 region dummy was found significant in the area response function while the regression coefficients of real wage rate in the current year and D_1 region dummy were significant in the yield response function for cabbage (Table 3). CAR, the leading cabbage producing region which is represented by D_1 region dummy, had positive regression coefficient indicating that consistently it has attained much higher hectarage and yield for cabbage in 16 years compared to Region X, the reference region. The other three region dummies were insignificant, meaning that area planted and yield of cabbage are not significantly different from that of the reference region.

Tomato. The national area response model for tomato using the linear form showed that the nominal price of fertilizer and wage rate the previous year were significant at 1 percent probability

level. Based on the regression coefficients, a peso increase in the nominal price of fertilizer or wage rate the previous year would lead to a 5.02-hectare increase or a 34-hectare decrease in area devoted to tomato, respectively, holding other factors constant (Table 3). The prevalence of organic farming has expanded the land area planted to tomato despite a rise in nominal price of inorganic fertilizer. Growing tomato is labor intensive so as the nominal wage rate the previous year increases, the farmer reduces the hectarage devoted to tomato. The country's yield response function for tomato in double-log form showed much better results compared to the national area response model. This is reflected by the higher R^2 value of the former (0.65) over the latter (0.50). Only the nominal price of fertilizer was found to have significant and positive influence on the yield of tomato at 5 percent probability level (Table 3).

Using pooled data for five main tomato producing regions, the double-log functional form was chosen as the best model for area response and yield response analysis of tomato as indicated by higher R^2 value and the number of significant determinants (Table 3). Four region dummies representing Regions I, III, IV-A and X were highly significant in the area supply response function for tomato. These region dummies showed a positive regression sign indicating that these regions have increased their hectarage faster than Region VI. The nominal price of eggplant the previous year was insignificant implying that eggplant may not be the competing crop for tomato but other types of vegetables knowing that the five regions are producing several tropical vegetables. Nominal prices of inputs (fertilizer and labor) were also not significant. The area response function for tomato had a very good fit as shown by its high R^2 value of 0.93.

The predictor variables included in the yield response model for tomato were: nominal price of fertilizer, nominal wage rate, rainfall, time as a proxy for technology and four region dummies. All these variables were found to significantly affect tomato yield. The regression coefficient of the nominal wage rate (0.54) and rainfall (0.11) both have a negative sign suggesting a situation where an increase in either of the two determinants would lead to a decline in tomato yield per hectare. Nominal price of fertilizer positively affected the tomato yield maybe due to increasing number of tomato farmers who prefer growing tomato organically. Technology had also a positive effect on the yield per hectare of tomato in five major producing regions for the past 16 years.

It is expected that Region X, designated as D_4, would have a much higher yield per hectare for tomato considering that tomato growers in this region are more progressive than their counterparts in Luzon as far as adopting improved production technologies and planting high-yielding varieties of tomatoes are concerned. The presence of a well-organized vegetable producers' association in Region X has also led to the adoption of the clustering approach among its members to sustain the supply of quality vegetables to fast food chains, semi-vegetable processors and supermarkets in Manila and other key cities in the Visayas and Mindanao. Also, other region dummies (Regions I, IV-A and VI) were highly significant at 1 percent probability with positive coefficients. Thus, the four regions have improved their yield faster than Region III. The estimated R^2 for the yield response model for tomato was 0.89, indicating that the estimated regression model has a good fit.

CONCLUSIONS AND RECOMMENDATIONS

Results of the supply trend analysis show that cabbage and tomato posted a slow growth in domestic production mainly due to limited expansion in area planted and minimal improvement in yield for the period 1990-2007. Tomato hectarage even exhibited a downward trend in the 1990s as many farms were badly hit by strong typhoons and prolonged drought. In recent years, rapid urbanization has further reduced the land area for vegetable production. With the growing demand for cabbage and tomato, the government should focus on yield improvement as a policy measure to increase vegetable production rather than on area expansion. This can be done through (1) additional investment in R&D to develop high yielding and pest and disease-resistant varieties; (2) provision of

Table 3. Regression results of the most appropriate area and yield response function for selected vegetables at the national and regional levels, Philippines, 1991-2006.

ITEM	Cabbage				Tomato			
	National		Regional		National		Regional	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield
	Linear Model	Double-log Model	Linear Model	Double-log Model	Linear Model	Double-log Model	Double-log Model	Double-log Model
Intercept	25956*** (6.73)	39.55*** (4.66)	364^{ns} (1.19)	5.18* (1.95)	19686*** (16.72)	2.07** (2.60)	7.00*** (21.31)	4.79*** (5.28)
Regression Coefficients								
P_{Ft}				0.05^{ns} (0.46)		0.12** (2.67)		0.13** (0.71)
P_{Lt}				-0.83** (-2.12)		0.01^{ns} (0.03)		-0.54*** (-2.74)
P_{Vt-1}	117** (2.54)		5^{ns} (0.29)		-17^{ns} (-0.11)		0.03^{ns} (0.53)	
P_{Ct-1}	32^{ns} (0.94)		-3^{ns} (-0.20)		-74^{ns} (-0.32)		0.08^{ns} (0.70)	
P_{Ft-1}	-2.89** (-2.29)	-0.01^{ns} (-0.57)			5.02** (2.86)		0.11^{ns} (1.55)	
P_{Lt-1}	-103.44*** (-5.45)	-0.15*** (-3.50)			-34* (-1.94)		-0.23^{ns} (-2.51)	
R_t		0.00^{ns} (0.53)		0.12^{ns} (1.39)		-0.08^{ns} (-1.18)		-0.11* (-1.83)
T_t		-0.03^{ns} (-0.51)		-0.04^{ns} (-1.39)		-0.01^{ns} (2.28)		0.21** (2.48)
$D_1^{a,b}$			4832*** (16.50)	0.95*** (7.51)			1.51*** (26.33)	0.61*** (11.61)
$D_2^{a,b}$			0.12^{ns} (0.00)	0.08^{ns} (0.67)			1.21*** (20.79)	0.56*** (11.81)
$D_3^{a,b}$			260^{ns} (0.90)	0.09^{ns} (1.16)			0.46*** (8.02)	0.62*** (7.93)
$D_4^{a,b}$			245^{ns} (0.86)	0.01^{ns} (0.06)			0.54*** (8.60)	0.78*** (10.73)
R^2	0.87	0.71	0.88	0.80	0.50	0.65	0.93	0.89
F-value	17.85***	6.59***	85.93***	34.47***	2.73*	5.06**	121.35***	72.34***

Figures in parenthesis are t-values.
***,**,* - significant at 1%, 5%, and 10% probability level, respectively.
^{ns} – not significant at 10% probability level.
For Area Response Function:
^{a} Dummy regions for cabbage: D_1=CAR, D_2=Region I, D_3=Region VII, and D_4=Region XI. Region X served as the reference region with the lowest hectarage among the five regions.
^{b} Dummy regions for tomato: D_1= Region 1, D_2= Region III, D_3=Region IV-A, and D_4=Region X. Region VI served as reference region with the lowest hectarage among the five regions.
For Yield Response Function:
^{a} Dummy regions for cabbage: D_1=CAR, D_2=Region I, D_3=Region VII, and D_4=Region X. Region XI served as the reference region with the lowest yield among the five regions.
^{b} Dummy regions for tomato: D_1= Region 1, D_2= Region IV-A, D_3=Region VI, and D_4=Region X. Region III served as reference region with the lowest yield among the five regions.

Sources of basic data: BAS and PAG-ASA, 2008

training on appropriate production technologies/practices; and (3) promotion of production programming to avoid harvesting vegetables during peak typhoon months.

The paper also analyzed the supply response of cabbage and tomato to different explanatory variables using direct and indirect methods of supply estimation. Based on the number of significant regression coefficients and R^2 values, the direct method using national and pooled regional data provided better results for cabbage while the indirect method gave better outputs for tomato. The factors that significantly affected the supply response of cabbage using direct method of supply estimation based on the national data were lagged own real farm price, lagged real farm price of alternative crop like carrot, lagged real price of fertilizer, lagged real wage rate and rainfall. Except for the positive regression coefficient of the lagged real price of carrot, all the other predictor variables have the expected signs that conform to the economic theory. High fertilizer price and wage rate have negative impact on cabbage production. As the price of inorganic fertilizer became more expensive, some farmers shifted to organic fertilizer. However, it is important that organic fertilizer being used by farmers is properly processed to produce quality and safe vegetables. Seasonal shortage of agricultural labor contributed to a rise in wage rate in CAR and other key production areas. One way to address this problem is by increasing access to credit for vegetable growers so they can engage in small farm mechanization which involves acquisition of small farm implements and tools.

For the pooled regional data, regression analysis show that real farm price, technology and three region dummies have positive and significant influence on the cabbage supply. As mentioned earlier, cabbage producers have relied more on the current real farm price than the previous one in deciding whether to expand or reduce cabbage production. This calls for timely dissemination of reliable price information to help vegetable farmers make decision on where and when to market their produce.

Using indirect method of supply estimation, nominal price of fertilizer and wage rate the previous year have significant and negative effect on the national area response model for tomato while in the yield response model, only the nominal price of fertilizer was found to have significant but positive influence on tomato yield. Using pooled data, all the predictor variables (nominal price of fertilizer, nominal wage rate, rainfall, time as a proxy to technology and four dummy regions) included in the yield response model significantly affected the tomato yield. The nominal price of fertilizer was also found to positively affect the tomato yield. This indicates that organic growing of tomato is becoming popular in major producing regions due to health and environmental concerns. Applying organic fertilizer instead of inorganic fertilizer also reduces production cost of tomato farmers.

Among the regions analyzed, Region X could sustain the supply of quality vegetables to processors and institutional buyers in Manila and other demand centers in the Visayas and Mindanao because of the presence of well-organized vegetable cluster consisting of 5 to 8 grower-members. The clustering or group marketing approach should be promoted among vegetable farmers in major production areas in Luzon and the Visayas in order to tap better alternative markets. This can encourage farmers to increase production of vegetables with the availability of ready markets that can pay higher prices. Farmer-members of the cabbage and tomato clusters in Region X have penetrated high-end markets in Manila for Class A vegetables and sell also other vegetable grades to supermarkets and other market outlets in the Visayas and deficit areas in Mindanao. Individually, they cannot sell their vegetables in these markets because of the quantity and quality requirements; but the formation of well-organized and committed groups of farmers or clusters could meet these requirements.

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EFFECT OF CADMIUM ON GROWTH OF FOUR NEW PHYSIC NUT (*Jatropha curcas* Linn.) VARIETIES

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(Received: August 18, 2008; Accepted: November 17, 2008)

ABSTRACT

A trial was conducted from February 2007 - February 2008 to study the effect of cadmium (Cd), at levels of 0, 100, 200 and 300 mg/kg in soil by weight, on four new varieties of physic nut (*Jatropha curcas* Linn), namely Takfa, Doi Saket, Lao, and Rayong. Plant growth, yield and Cd residue in the plants, as well as chemical characteristics, nutrients and Cd residue in the soil were monitored. Differences in growth potential, yield obtained, and Cd residue in the plant parts (P>0.05) were not observed among the 4 varieties. However, the Cd soil residue, at 100 - 300 mg/kg, caused a decrease in growth potential in all varieties, which was significantly different from untreated controls (P<0.05). In addition to stunted growth, the plants did not produce any yield. Cd levels in all plant parts were higher than the standard in all varieties (0.100 – 2.00 mg/kg) for all treatments. Decreased nutrient utilization was observed in the treated plants. These physic nut varieties, therefore, cannot be grown as a renewable energy source in areas where Cd residue is present in soils at a level of 100 mg/kg and above.

Key words: growth, heavy metal, nutrient, residue, yield

INTRODUCTION

Nowadays, the problem of heavy metal residues such as cadmium (Cd) in the environment is more severe than ever. The primary sources of heavy metal contamination are industrial activities such as energy and fuel production and mining and smelting of metalliferous ores (Mangkoedihardjo and Surahmaida, 2008). There was a dramatic acceleration of heavy metal contamination in soil as a result of industrial revolution (Nriagu, 1979). An example of an area where Cd residue is found in the environment and in products like rice, aquatic animals and drinking water is the Huay Maetao watershed, Tak province, Thailand due to mineral extraction (Wongphanich, 2005). Cd was found in the soil at 61 - 207 mg/kg and in 95% of sampled paddy rice, at levels 25 times higher than the standard value set by the Pollution Control Department (2006) at 0.100 - 2.00 mg/kg. The high level of Cd residue in the soil has affected the occupation, marketing, and way of life of farmers living in the area as their produce is unfit for consumption. Meanwhile, another significant problem in Thailand is a lack of energy, with oil energy imports amounting to more than 2.86 thousand million dollars each year (Suppadit, 2003). Searching for plants that can be used as renewable energy or biodiesel, to be grown in areas unsuitable for crop production, could be an alternative to solve this problem.

Physic nut (*Jatropha curcas* Linn) is an alternative cash crop that can generate income for the grower. It can be grown rapidly and produces yields 8 months after seeding. The grower need not use much technology to grow it and it cannot be consumed directly through the food chain (Lueang - a - papong, 2005). Also, it can be used in oil production since its oil content is 34 percent and the extraction process is not complicated (Chinawong, 2005). The obtained oil can be used directly in an engine without mixing with fuel oil or going through a biodiesel production process (Thummaprasit, 2005). This results in reduced processing costs and, like diesel, it is a highly efficient fuel (Puapan, 2005). In addition, physic nut can remove Cd from soil as a phytoremediation method. Cd in soil at about 50 mg/kg did not produce adverse effects on physic nut (Chehregani and Behrouz 2007;

Mangkoedihardjo and Surahmaida 2008). Based on these reasons, this study was undertaken with the objective of utilizing physic nut by growing it in an area where there is a high level of Cd residue like the area in Tak province mentioned above.

MATERIALS AND METHODS

Trials were conducted at Klang District, Rayong Province, Thailand from February 2007 to February 2008. The trials were done in an open area that measured 20 m wide x 20 m long (400 m^2). Corrugated iron and blue netting were used as border around the trial area. The concrete basins in which the physic nut was planted were 100 cm in diameter (7,857 cm^2) x 30 cm high.

Physic nut plants were collected from local agriculture agency and bred by Chiang Mai Field Crops Research Center in January 2003. The variety and the quantity of the Cd were assessed in a 4 x 4 factorial arrangement with 4 replications in a completely randomized design (Johnson and Bhattacharyya, 2001), with the first factor being the varieties of Takfa (Var. Tak.), Doi Saket (Var. Doi.), Lao (Var. Lao.), and Rayong (Var. Ray.) and the second factor being the Cd levels contaminating the soil at 0 (Cd0), 100 (Cd100), 200 (Cd200), and 300 (Cd300) mg/kg. The data were subjected to an analysis of variance and the comparisons among means were made using Least Significant Difference (LSD) test of the Statistical Analysis System (SAS version 61.2) (SAS Institute, 1996).

Soil from the Krabi soil group, Wangchan district, Rayong province was used and prepared with a total weight of 150 kg/basin. The initial Cd analysis showed 4.11 mg/kg soil. The treatments were: Cd0, control (without Cd chloride - 2.5 - hydrate; $CdCl_2$ - 2.5 - H_2O); Cd100, $CdCl_2$ - 2.5 - H_2O mixed with soil at a rate of 0.203 g : 1 kg (30.4 g/basin), (w/w); Cd200, $CdCl_2$ - 2.5 - H_2O mixed with soil at a rate of 0.406 g : 1 kg (60.9 g/basin), (w/w); Cd300, $CdCl_2$ - 2.5 - H_2O mixed with soil at a rate of 0.609 g : 1 kg (91.4 g/basin), (w/w).

Physic nut seeds of each variety were planted in individual plastic pots. Three month old seedlings were transplanted into the trial concrete basin, with 1 plant/basin. These were watered every week and weeded by hand. An aqueous solution of tobacco leaves was used for insect control. Soil temperature, moisture and pH were measured every week; plant height and canopy every 2 months and number of leaves and branches at 6 months after transplanting. The yield components in terms of number of fruits per plant, fresh and dry fruit weight per plant, fresh and dry fruit weight per fruit, number of seeds per fruit and weight of 100 dry seeds were measured at 8 months after transplanting. The oil at harvest was obtained using a screw press. The Cd residue in component plant tissues was measured using by atomic - direct aspiration with an Atomic Absorption Spectrophotometer (AAS; Analytik Jena - NVAA 300). Cd and nutrients in the soil, nitrogen (N), phosphorus (P), potassium (K), iron (Fe), boron (B), zinc (Zn), sodium (Na), calcium (Ca) and magnesium (Mg) were measured by inductively coupled plasma atomic emission with an Inductively Coupled Plasma Emission Spectrophotometer (ICPES; ACTIVA - M). Soil chemical characteristics, in terms of pH (pH meter; HATCH - Senion 156), moisture (Tensiometer; KRUSS - BP100) and organic matter (OM) (Walkley - Black method), were analyzed based on the Land Development Department's 2004 manual.

RESULTS AND DISCUSSION

All trials were conducted without interruption, wind and rain problems, or disease and insect problems during the eight months in the field. The observed temperature and moisture in each treatment was suitable for the uninterrupted growth of physic nut. Soil temperature and moisture were 23.2 - 27.4° C and 1.00 - 8.97, respectively. For the preparation of the trial soils at the 4 Cd levels, the results of Cd accumulated in the trial soils after processing were 4.11 mg/kg (Cd0), 104 mg/kg (Cd100), 204 mg/kg (Cd200), and 304 mg/kg (Cd300). The chemical characteristics and nutrients in the soil at the beginning of the trial were pH 7.65, 0.300% OM, 0.0400% N, 1.00 mg/kg P, 40.0 mg/kg K, 8.65 mg/kg Fe, 1.00 mg/kg B, 0.440 mg/kg Zn, 380 mg/kg Na, 280 mg/kg Ca, and 55.0 mg/kg Mg.

Growth Potential and Yield

Plant height at the initial stage of the experiment were not statistically different among the 4 varieties (P>0.05) (Fig. 1). Measurements taken at 2, 4, 6 and 8 months after transplanting showed

there were still no statistically significant differences in plant height among the 4 varieties (P>0.05). However, there was a statistically significant decrease in the growth potential of the 4 varieties when there was an increase in the level of Cd residue in the soil (P<0.05). All varieties of physic nut at a Cd residue level of 100 - 300 mg/kg showed clear differences in growth potential of physic nut compared to that with a level of 0 mg/kg (P<0.05). This was because the increasing amount of Cd was toxic to the plant, making it stunted and causing it to grow slowly with falling leaves. This is because Cd affects the metabolism process, photosynthesis and respiration of the plant (Mahler et al., 1981; Suppadit et al., 2005). Francis (1994) reported that Cd at a level of 1.00 - 10.0 mg/kg could affect the growth potential of a lettuce. This conformed to a study by Sangjun (2000) which found that paragrass could grow normally when the level of Cd residue was not more than 100 mg/kg. Similarly, Sanoh (2005) found that the growth potential of vetiver grass, sunflower, and rice was decreased due to an increased level of Cd, causing these plants to be stunted in growth.

With regard to the size of the physic nut canopy at the initial stage of the experiment at levels of Cd residue in the soil of 0, 100, 200 and 300 mg/kg, there was no statistically significant difference among the 4 varieties (P>0.05) (Fig. 2). Two months after the beginning of the experiment, all varieties and levels of Cd residue showed slow canopy growth and statistically significant difference among treatments (P<0.05). After 4, 6 and 8 months, the size of the canopy was still not different among the varieties (P>0.05). However, for the treatments that had levels of Cd residue of 100 - 300 mg/kg, the size of the canopy was decreased due to an increase in the level of Cd and there was a statistically significant difference between these treatments and those that had 0 mg/kg of soil Cd (P<0.05), which was due to the toxic effect of Cd (Mahler et al., 1981; Suppadit et al., 2005).

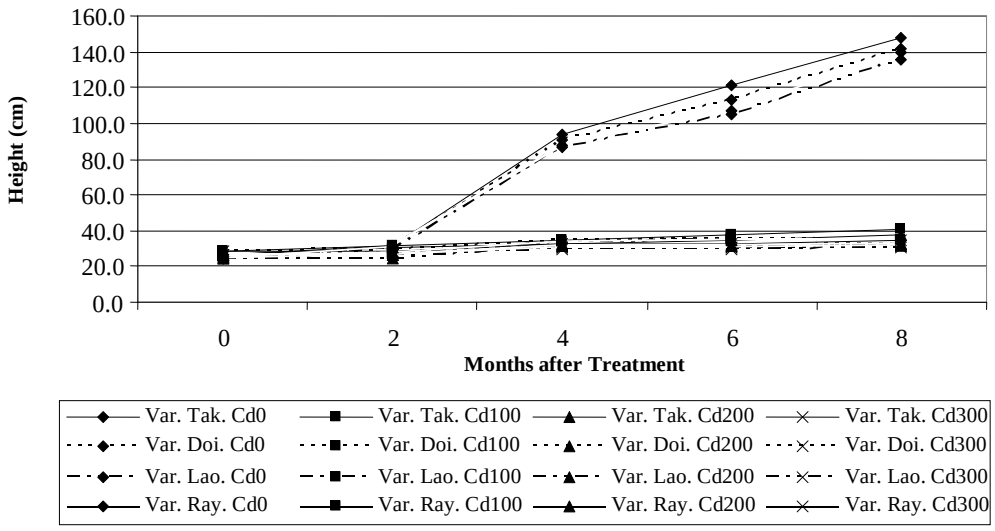

Fig. 1. Plant height of four physic nut varieties planted in soil treated with Cd at various levels. Vertical lines represent LSD for probability at 0.05.

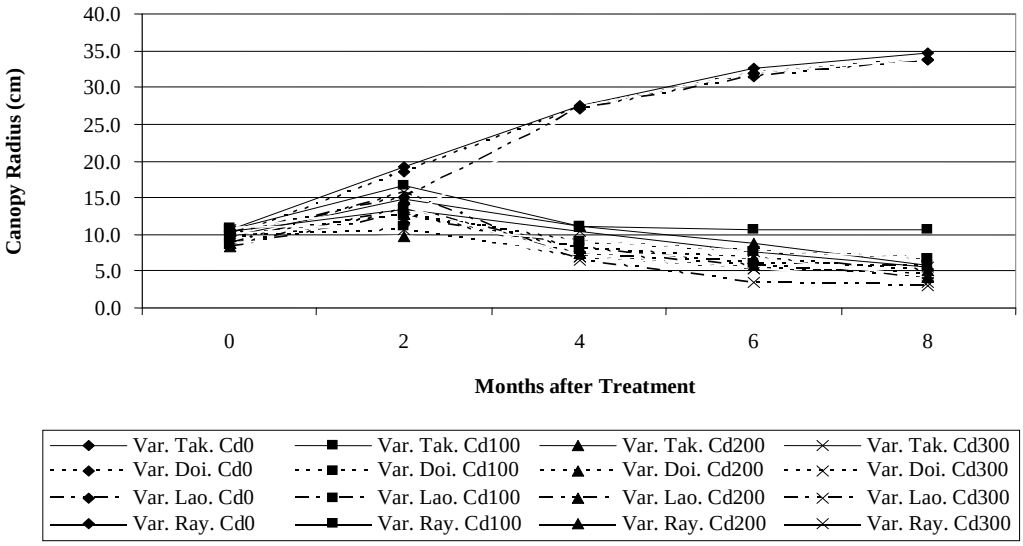

Fig. 2. Plant canopy (radius) of four physic nut varieties planted in soil treated with Cd at various levels. Vertical lines represent LSD for probability at 0.05.

There was no statistically significant difference in the number of leaves of physic nut at the initial stage of the experiment at all levels of Cd residue (P>0.05) (Fig. 3). Six months after the beginning of the experiment, there was no difference in the number of leaves among the 4 varieties (P>0.05). At different levels of Cd residue, however, it was found that there was a statistically significant difference (P<0.05). This was because an increase in the level of Cd residue resulted in a decreased of number of leaves. All 4 varieties of physic nut grown at the Cd residue level of 0 mg/kg had the highest number of leaves. Cd residue in the soil at a level of 100 - 300 mg/kg resulted in a decreased number of leaves (P<0.05) (Mahler et al., 1981; Suppadit et al., 2005).

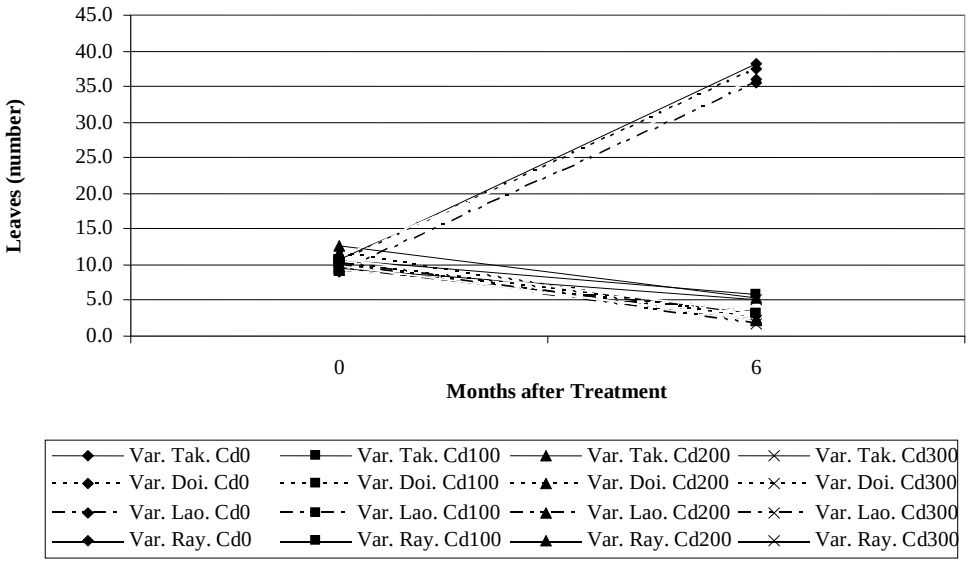

Fig. 3. Number of leaves of four physic nut varieties planted in soil treated with Cd at various levels. Vertical lines represent LSD for probability at 0.05.

At the initial stage of the experiment, there were no statistically significant differences in the number of branches among the different levels of Cd residue in the soil (P>0.05) (Fig. 4). Six months after the beginning of the experiment, at the Cd residue level of 100 - 300 mg/kg, the number of branches in all of the 4 varieties of physic nut did not increase. However, the untreated controls of the 4 varieties of physic nuts had a greater number of branches. This shows that the Cd levels tested were toxic to the plant (Mahler et al., 1981; Suppadit et al., 2005).

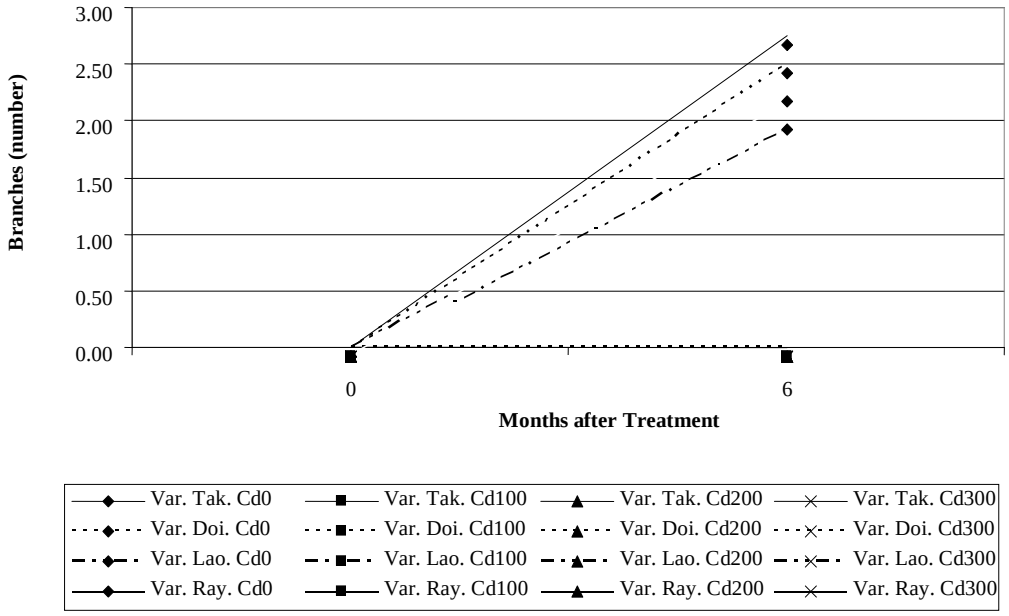

Fig. 4. Number of branches of four physic nut varieties planted in soil treated with Cd at various levels. Vertical lines represent LSD for probability at 0.05.

Yield components were assessed in terms of number of fruits per plant, fresh fruit weight per plant, dry fruit weight per plant, fresh fruit weight per fruit, dry fruit weight per fruit, number of seeds per fruit, dry weight of 100 seeds, and percentage of oil per seed weight (Table 1). At the end of the eight month experiment, all 4 varieties of physic nut grown at the Cd residue levels of 100 - 300 mg/kg did not give any yield whereas the plants grown in soil without Cd gave some yield which did not have any significant differences among the 4 varieties (P>0.05). The plants, grown in soil with Cd, did not produce any yield because the Cd residue in the soil caused the physic nut plant to be stunted (Sangjun, 2000; Suppadit et al., 2005).

Cadmium Residue

There was no difference in Cd residue in the stem, root and leaves (P>0.05), among the 4 varieties of physic nut (Table 1). This means that the 4 varieties of physic nut were able to absorb Cd from the soil at almost the same rate. However, all of the 4 varieties of physic nut had a significantly higher level of Cd residue in the various plant tissues when there was a high level of Cd in the soil (P<0.05). Also, the level of Cd in the tissues of plants grown in 100 - 300 mg/kg were higher than the set standard levels of 0.100 - 2.00 mg/kg (Pollution Control Department, 2006). Physic nut grown in soil with 100 mg/kg Cd and above gave no yield. Thus, Cd in the fruits could be analyzed only with physic nut grown in the area where Cd residue was in the soil at a level of 0 mg/kg and there was no difference in Cd residue among the 4 varieties (P>0.05). The accumulation of Cd in the plants came from the soil by the phytoextraction process through convection and diffusion (Crowley et al., 1991). Cd ions dissolved in water move from soil solids at the rhizosphere to the root. The water is absorbed by the root to replace the water which is used in respiration (Romheld and Marschner, 1986). Cd accumulated in the roots more than in the stems and leaves as roots have more opportunities to come into contact with the Cd and had longer Cd accumulation time than the stem and the leaves (Panichasakpatana, 1996; Suppadit et.al., 2008). The results are in agreement with the study of Giesy et al. (1981) that found the highest levels of Cd in root tissues, followed by stems and then leaves of mangrove plant.

At the start of the experiment, the soil was determined to contain 4.11 mg/kg Cd which served as the baseline level. There was no Cd residue left in the soil to which Cd was not added, at 6 months after the experiment. There was no difference in the amount of Cd residue left in the soil after the experiment among the 4 varieties of physic nut (P>0.05) (Table 2). This implies that Cd was absorbed at almost the same rate by each of the varieties. However, the rate of Cd residue increased in accordance with the higher rates of contamination. The soil that was contaminated with Cd at a level of 300 mg/kg had the highest level of remaining Cd residue. Cd in alkaline soil moves slowly

(Panichasakpatana, 1996) and little is lost due to leaching caused by watering or rain. Thus, a large amount of Cd residue was found in the soil after the experiment.

Chemical Characteristics and Nutrients

There was an increase in the amount of organic matter in the soil that had an initial Cd contamination level of 0 mg/kg (Table 2). However, the soil that had higher levels of Cd contamination was found to have decreased amounts of OM. For the soil with Cd contamination levels of 100 - 300 mg/kg, the physic nut had a low rate of growth potential. At the same time, it might have lost OM due to watering and rain.

After the experiment, all four varieties of physic nut and all levels of Cd contamination increased in acidity (Table 2). The soil with an initial Cd contamination level of 0 mg/kg showed the greatest decrease in pH, a statistically significant difference from the treatments with initial Cd contamination levels of 100 - 300 mg/kg ($P<0.05$). This might be because the plants grew well in the soil that had a Cd contamination level of 0 mg/kg and produced a great deal of humus in the soil, which resulted in organic degradation activities that created soil acidity due to organic acids (fulvic acid and humic acid) and carbonic acid (Osotsapar, 2002). The physic nut plants did not grow well in the soil that had Cd contamination levels of 100 - 300 mg/kg, so there was little humus added to the soil and soil acidity increased only slightly.

All 4 varieties and all levels of Cd contamination showed a decrease in soil nutrients - N, P, K, Fe, B, Zn, Na, Ca and Mg - when compared to their levels in the soil before the experiment (Table 2). This might be due to the fact that these were absorbed by the plants in addition to leaching by watering and rain (Suppadit, 2005). There were no statistically significant differences in the levels of remaining nutrients among the 4 varieties of physic nut ($P>0.05$). However, there was an increase in the level of remaining nutrients that corresponded to an increased level of Cd contamination. The soil with the highest Cd contamination level of 300 mg/kg was found to have the highest level of remaining nutrients. This was because all of the four varieties were stunted and could not absorb a large amount of nutrients. For soil without Cd, physic nut could grow well and absorb a large amount of nutrients. Thus, the amount of remaining nutrients was small.

CONCLUSIONS

At a Cd contamination level of 100 - 300 mg/kg, all 4 varieties of physic nut exhibited decreased growth potential and did not give any yield. For Cd residue in various physic nut tissues, the residue in plants grown in soil with Cd contamination of 100 mg/kg and above was considered to be higher than standard at 0.100 - 2.00 mg/kg. After the experiment, the soil with an initial Cd residue level of 0 mg/kg showed the greatest increase in soil acidity due to greater plant growth, which resulted in more organic matter returning to the soil, the digestion of which increased soil acidity. The level of remaining nutrients was lowest in the soil that did not have any Cd. Physic nut was stunted at high levels of Cd and cannot be grown in areas where Cd contamination occurs at levels of 100 mg/kg and above.

ACKNOWLEDGEMENTS

The authors would like to thank the Thailand Research Fund for financial support and would also like to express their deepest appreciation to the Chiang Mai Field Crops Research Center, the Thailand Institute of Scientific and Technological Research, and Kasetsart University for their permission to use some of their laboratory facilities.

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J. ISSAAS Vol. 14, No 2:96-105(2008)

MATHEMATICAL MODEL FOR FATE OF ATRAZINE IN WATER AND SEDIMENT IN THE KHLONG I TAO WATERSHED, THAILAND

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(Received: November 5, 2007; Accepted: November 3, 2008)

ABSTRACT

The fate of atrazine in water and sediment of the Khlong I Tao sub-watershed, was studied from July 2004 to March 2005. About 75% of the area had been applied with Atrazine 90% WG at a rate of 2.25-3.75 kg/ha (360 – 600 g/rai) once a year to eliminate pre-emergence weeds. Stream water and sediment samples were collected 14 times at the outlet of the sub-watershed area for atrazine analysis. The atrazine concentrations in the water and sediment were found to be in the range of 0.03 to 4.4 ppb and 1 to 179 ppb, respectively. About 29% of the water samples exceeded the 2 ppb maximum allowable concentration in drinking water as defined by WHO (2003). Residue and rainfall data were used to develop a mathematical model for atrazine reflecting herbicide runoff in the watershed area. Elements of the model include the atrazine content accumulated in the watershed area before a specific rainfall day (ΔATZ_{i-1}), the number of days after atrazine application (D) and daily rainfall (R). Regarding the model developed, the atrazine content (%) which was carried out of the watershed area per atrazine content which was accumulated in the watershed area (ATZR) can result to the mathematical model in terms of regression model: Atrazine = 63.322 + 2.402E-05D – 4.462E-05R – 2.745E-05ΔATZ_{i-1} ; R^2 = 0.964 based on storm events which occurred during the period of investigation. Using the ATZR model, the atrazine application rate for maize cultivation within the Khlong I Tao sub-watershed that can reduce atrazine concentrations in the stream water to near the drinking water standards at 43 days after application has been determined to be 2.305 kg a.i./ha.

Key words: Herbicide transport, runoff, water pollution

INTRODUCTION

Atrazine (2-chloro 4-ethylamino 6-isopropylamino 1-3-5-triazine) has been one of the most intensively used for pre- and post-emergence herbicide to control weeds in maize cultivation in Thailand. It is relatively low in cost, affects a broad spectrum of weeds and lasts all season. Inspite of its numerous benefits to agricultural production, several studies have demonstrated that row crop production leads to frequent residue detections. Atrazine also has had some adverse impacts and has been linked to hormonal disruption and increased risk of cancer relating to protection of human health (Thurman et al.1992, Lerch et al 1998, Blanchard and Lerch 2000). Atrazine residues were found in water samples, taken from the Mae Klong river, ranging from 0.01 to 6.63 ppb (Jumratsakun et.al 1999). Atrazine from the farm fields and the watersheds have been found to be the non-point sources of contamination for water, sediment and cultivated soil in lower central and northeastern Thailand. Residues range from 0.5 to 4.0 ppb in 71.2 % of groundwater samples (Sagunteing et al 2002). The highest atrazine concentration exceeds the 3 ppb drinking water standards and health advisories of U.S. EPA (2003) while WHO(2003) has a maximum allowable concentration of 2 ppb for atrazine in drinking water. It is considered that atrazine contamination of surface water by runoff is a matter of

great concern. Tillage, herbicide formulation, the rate of herbicide applied, soil type and incidence of rainfall after herbicide application are major factors related to herbicide loss (Barnes et al, 1992).

The Khlong I Tao sub-watershed, located in Wang Nam Khieo district, Nakhorn Ratchasima province in northeastern Thailand is one of three sub-watersheds of the Upper Lam Phra ploeng watershed which is an escarpment of the Korat Plateau in the central highland region. It covers an area of 7.38 sq.km, consisting of 4 villages in two sub-districts: 2 villages in Wang Mmee sub-district (Ban Bhu chao-Khun, and Ban San Kamphaeng) and 2 villages in Wang Namkhieo sub-district (Ban Klong Sai and Ban Sai Thong). Maize is the main crop and most of the farmers apply atrazine as a pre-emergence herbicide before maize is sown. Since topographic conditions in the agricultural area are mostly hill-slope with no irrigation system, the potential for soil erosion and water pollution increases due to the adsorption into the soil. In this case, it causes accumulation and suspension of sediment in the water resulting in the dispersion of herbicide in the environment (Kreuger, 1998).

Mathematical models are widely used to study of fate of pesticides from agricultural areas in the environment ecosystems, including environment risk assessment. It is essential to model scenarios which can closely predict pesticide fate in order to calculate the impact of long term application. Therefore, a mathematical model of atrazine application in stream water and sediment in Khlong I Tao sub-watershed would be useful for developing procedures to reduce atrazine in the environment.

MATERIALS AND METHODS

Land use and cropping pattern

Land use at Khlong I Tao sub-watershed was investigated by 1:15,000 aerial photographs from the Soldier Map Department (1992) and 1:250,000 land use map from the Land Development Department (2000) and site survey. Patterns of cropping systems were studied by interviewing 30 farmers who planted maize in order to survey the kinds of crops, cropping system, pest and its control methods and pesticide use (type, application rate, application period and frequency of usage). Hydrologic data of Khlong I Tao sub-watershed were also collected.

Sampling of water, sediment and soil

Fourteen stream water and sediment samples were collected at the weir in the outlet of Khlong I Tao sub-watershed (Fig. 1) during July 2004 to March 2005. Data collection was divided into 3 periods: once before planting of maize (July 2004), 11 times during the maize growing period (August to October 2004), and twice after harvest (December 2004 and March 2005).

During the planting period, water samples were collected at the weir whenever the surface runoff water occurred. In addition, suspended solids in runoff events from the Khlong I Tao sub-watershed were also measured at the same location. Three replicates of soil samples were collected 3 times at the depth of 0-15 cm and 15-30 cm from five cultivated areas in 2 periods: before planting of maize (July 2004), during planting of maize (August and September 2004). Each soil sample was air-dried, sieved at 2 mm before extraction for atrazine analysis.

Extraction and atrazine analysis

Stream water, sediment and soil samples were extracted using a modified method of Alfred and Afghan (1982) and analyzed using a gas liquid chromatograph (GLC) equipped with an ECD detector (Agilent, model HP 6890) for atrazine determination.

Fate of atrazine in stream water and sediment in Khlong I Tao sub-watershed

The fate of atrazine from the Khlong I Tao sub-watershed was traced from the first storm water runoff after atrazine application over the watershed in August 2004 until harvest in October 1, 2004.

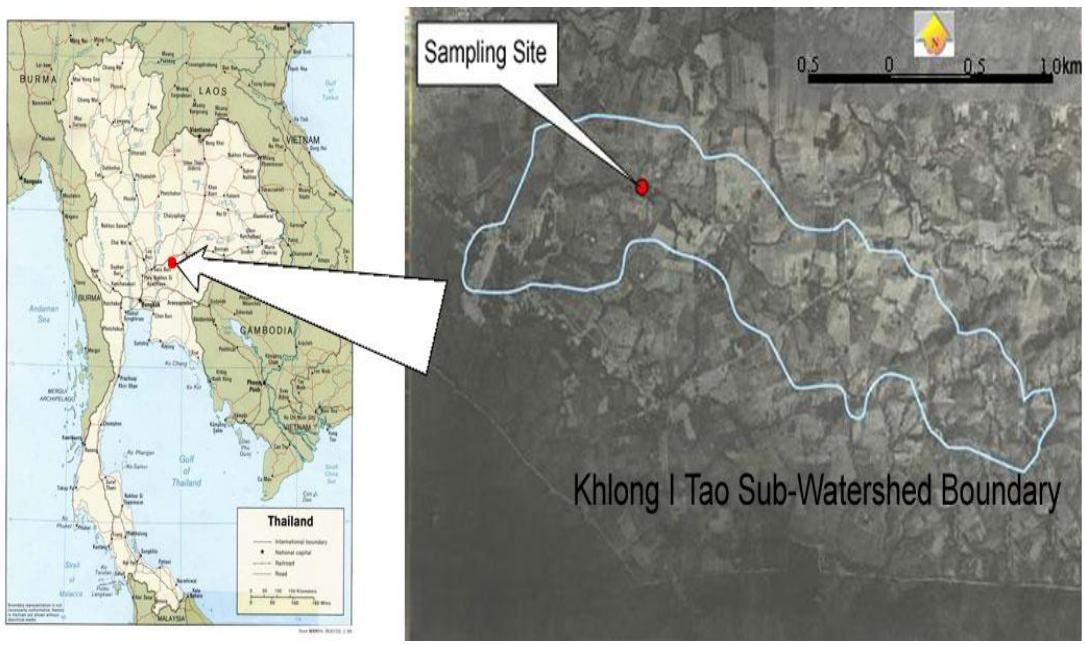

Fig. 1. Sampling site and rainfall recording at the outlet of Khlong I Tao sub-watershed in Thailand.

Mathematical model formula

A model formula based on the assumption that atrazine concentration in water and sediment varied with daily rainfall amount, and accumulated atrazine. The amount of atrazine leaving, through their movement in each storm runoff from the the Khlong I Tao sub-watershed, was calculated in terms of the ratio of the atrazine concentration as a percent (ATZR). This parameter (ATZR) was established to be a dependent variable which is the function of 3 independent variables, i.e. (1) daily rainfall (mm;R), (2) atrazine content accumulated in the sediment following application over the watershed before a specific rainfall day (mg/ha; ΔATZ_{i-1}) and (3) the number of days following the first atrazine application (D). Linear regression analysis was employed to derive the model.

Model verification

Model verification was conducted using coefficient of model-fit efficiency (Fleming,1975). With this model, atrazine application at the dose below impact to human health and environment can be estimated based on the following criteria:

1) The maximum allowable concentration for atrazine in drinking water established by WHO (2003) does not exceed 2 ppb.

2) The maximum allowable concentration for atrazine in soil established by the Authority for Enforcement of National Environment Committee, 25th Edition (2004) follows the

Environmental Protection Act, 1992 entitled "The standard of soil quality used for living and agriculture" is not in excess of 22,000 ppb (Pollution Control Department, 2005).

RESULTS AND DISCUSSION

Land use and cropping pattern

The Khlong I Tao sub-watershed in Thailand covers an area of 738 ha of which about 92% is farmland, 5% is residential area and the rest is forest land. The cultivated areas were identified as field crops (82.50%) and orchards (9.77%). Maize, the main field crop, is grown on 554 ha and in 75% of the area as a rainfed monocrop. Soil preparation is done from May to June, seeds are planted in July and harvest is in November. Most of the farmers apply atrazine only once as a pre-emergence herbicide, 90% applied as wettable granules (90% WG) at the rate of 2,25 -3.75 kg/ha (360-600 g/rai) and 10% applied as wettable powders (85% WP).

Atrazine concentrations in water and sediment in Khlong I Tao sub-watershed

Atrazine concentrations in stream water and sediment at the outlet of Khlong I Tao sub-watershed, measured 14 times from July 2004 to March 2005, were in the range of non-detectable to 4.45 ppb and non-detectable to 179 ppb, respectively. During the planting period (August - October, 2004), atrazine concentrations and amounts in water and sediment, measured 11 times, were in the range of 0.04 to 4.45 ppb and 1 to 179 ppb, respectively (Table 1).

Table 1. Atrazine concentration and amount in water at the outlet of Khlong I Tao sub-watershed collected during the planting period (August – October, 2004) .

Days after atrazine application (day)	**Rainfall (mm)**	**Runoff (m^3)**	**Atrazine in water**	
			Concentration (ppb)	**Total amount (mg)**
(1)	(2)	(3)	(4)	(5)
43	15.2	22,887	4.45	101,731.8
47	21.6	34,290	2.59	88,810.1
57	35.3	62,217	0.34	20,842.7
74	25.1	40,968	0.34	13,878.0
76	13.2	19,538	3.05	59,664.3
77	10.6	6,553	3.14	20,551.8
79	4.4	8,051	0.08	613.8
81	32.6	46,133	0.13	5,997.2
85	18.9	21,779	0.16	3,511.8
86	30.8	33,793	0.08	2,745.6
88	29.0	79,266	0.04	3,269.7

Note : (3) runoff (m^3) = discharge (m^3/s) x 24(hr) x 60(min) x 60(sec)
(4) analyzed from water samples (ppb)
(5) = (3) x (4)
***** WHO (2003) standards for drinking water quality = 2.0 ppb

Four out of 11 water samples, contained atrazine concentrations exceeding the 2.0 ppb maximum allowable level for drinking water (WHO 2003). On the other hand, atrazine concentrations in all sediment samples remained below the standard of 22,000 ppb set by Pollution Control Department (2005) (Table 2).

The highest concentration was observed in the runoff water of the first storm during the early part of the rainy season, shortly after atrazine application during the initial period of maize cultivation. Since most of the cropland were on slopes, consequently, the soil surface was substantially eroded, carrying out atrazine into stream waters and sediment. The atrazine concentrations in the water and sediment were found inversely proportional to the amount of rainfall and tended to be lower as post-application day progressed (Table 1 and 2).

Table 2. Atrazine concentration and amount in sediment at the outlet of Khlong I Tao sub-watershed collected during planting period (August – October, 2004).

Days after atrazine application (day)	**Rainfall (mm)**	**Runoff (m^3)**	**Sediment (g/m^3)**	**Total Sediment (kg)**	**Atrazine in sediment**	
					Concentration (ppb)	**Total amount (mg)**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
43	15.2	22,887	370	8,468.12	141	1,192
47	21.6	34,290	330	11,315.58	179	2,023
57	35.3	62,217	240	14,932.14	003	37
74	25.1	40,968	1210	49,571.63	002	101
76	13.2	19,538	500	9,769.03	005	48
77	10.6	6,553	260	1,703.78	001	1
79	4.4	8,051	1860	14,974.86	003	37
81	32.6	46,133	1289	59,465.44	002	110
85	18.9	21,779	240	5,226.96	001	5
86	30.8	33,793	260	8,786.18	003	25
88	29.0	79,266	310	24,572.46	001	14

Note : (5)= (3) x (4)
(6)= analyzed from sediment samples (ppb)
(7)= (5) x (6)
Pollution Control Department in Thailand (2005): 22,000 ppb in soil standard

Atrazine in soil samples was not detectable at a depth of 0-15 cm, but it ranged from non-detectable to 0.05 ppm at a depth of 15-30 cm before the application. After application, atrazine concentrations in soil increased, but decreased slowly with time until harvest.

Atrazine amount in water and sediment in Khlong I Tao sub-watershed.

The fate of atrazine, out of Khlong I Tao sub-watershed, started at the first storm runoff shortly after atrazine spraying over the sub-watershed on August 17, 2004 and ending October 1, 2005. The atrazine quantities found moving together with stream water and sediment were 321.617 g and 3.597 g, respectively (Table 3).

Table 3. Cumulative atrazine transported to the Khlong I Tao sub-watershed.

Days after Atrazine application (day)	**Cumulative atrazine transported to Khlong I Tao sub- watershed (mg)**		
	Within runoff water	**Within sediment**	**Total**
(1)	(2)	(3)	(4) = (2) + (3)
43	101,731	1,192	102,924
47	190,541	3,216	193,758
57	211,384	3,253	214,638
74	225,262	3,355	228,618
76	284,927	3,403	288,330
77	305,478	3,405	308,884
79	306,092	3,442	309,535
81	312,090	3,552	315,642
85	315,602	3,557	319,159
86	318,347	3,583	321,930
88	321,617	3,597	325,215

Note : (2) cumulative atrazine from Table 2, col.5
(3) cumulative atrazine from Table 3, col.7
(2) + (3) = (4) total atrazine in water and sediment

From the test results, it can be concluded that atrazine in the runoff corresponds mainly to rainfall, which carry out atrazine from the sub-watershed, either dissolved in runoff water or attached to eroded soil particles. The cumulative atrazine moving out of Khlong I Tao watershed will increase when the post-spraying date are longer (Table 3).

The percentage of atrazine amount carried out from the Klong I-Tao sub-watershed area divided by atrazine amount accumulated in the sub-watershed before specific rainfall days after the first storm runoff occurred following the atrazine application was calculated as shown in Table 4.

Table 4. Percentage of atrazine carried out from Khlong I Tao sub-watershed per atrazine accumulated within Khlong I Tao sub-watershed area (ATZR).

Days after Atrazine Application D (days) (1)	**Daily Rainfall** R (**mm**.) (2)	**Atrazine leaving the sub-watershed ATZi** (mg/ha) (3)	**Atrazine accumulated within sub-watershed** ΔATZ_{i-1} (mg/ha) (4)	ATZR (%) (5)
43	15.2	185	2306250	0.008
47	21.6	349	2306064	0.015
57	35.3	387	2305900	0.016
74	25.1	412	2305862	0.017
76	13.2	520	2305837	0.022
77	10.6	557	2305729	0.024
79	4.4	558	2305692	0.024
81	32.6	569	2305691	0.024
85	18.9	575	2305680	0.025
86	30.8	580	2305674	0.025
88	29	586.75	2305669.18	0.0254

Note : (3)/(4) x 100 = (5) atrazine (%)

Derived mathematical model

The model for the amount of atrazine carried out from the Khlong I Tao sub-watershed area per atrazine accumulated within Khlong I Tao sub-watershed area was derived as the following regression model:

$$ATZR = 63.322 + 2.402E\text{-}05D - 4.462E\text{-}05R - 2.745E\text{-}05\Delta ATZ_{i-1} \quad ; R^2 = 0.964 \text{--}(1)$$

where: ATZR = Percentage of atrazine carried out from the Khlong I Tao sub-watershed area divided by atrazine accumulated in the sub-watershed.

D = Numbers of days following the first application of atrazine (days).

ΔATZ_{i-1} = Atrazine accumulated in the Khlong I Tao sub-watershed area before a specific rainfall date (mg/ha)

R = Daily rainfall (mm)

Considering Equation 1, it was found that the later the application date of atrazine the greater the proportion of herbicide carried out by storm runoff from the area. That is, the most recently sprayed atrazine was mostly likely to end up in the stream water and sediment. This proportion of lost atrazine was reduced when the herbicide was applied early in the season before the heaviest rainfall.

Environmental degradation of atrazine in the system could be considered by coefficient of ΔATZ_{i-1} (-2.745E-05) implying the degradation of atrazine in soil system

Application of model for obtaining suitable rate of atrazine application

To determine the suitable atrazine application rate, the verified model was applied assigning the maximum allowable concentration for atrazine in drinking water of 2 ppb (WHO, 2003) and in soil of 22,000 ppb (Pollution Control Department, 2005). Base on the storm runoff event occurred during the period of investigation given the first day of storm water runoff dated 43 days following atrazine application over the Khlong I Tao sub-watershed with 15.2 mm of rainfall, the maximum application rate of atrazine that could be applied based on equation, should not be greater than 2,305 g a.i/ha (369 g a.i./rai). Surface runoff first occurred at day 43 following atrazine spraying over the Khlong I Tao sub-watershed. Therefore, in order to reduce atrazine concentration in runoff to near the drinking water standard, the percentage model of the atrazine carried from the Klong I Tao sub-watershed area per atrazine amount accumulated in the sub-watershed (ATZR) , was used to predict the appropriate atrazine application rate. Table 5 and Table 6 illustrate the calculation used in the application of the model.

From the equation: $ATZR\ (\%) = 63.322 + 2.402E\text{-}05D - 4.462E\text{-}05R - 2.745E\text{-}05\Delta ATZ_{i-1}$

where: ATZR (%) = [ATZ loss in water and sediment / (ATZ in maize + ATZ in soil] x 100
= [value in Table 5 / value in Table 6] x 100
ATZR (%) = (336.2 / (52.6 + 2750010)) x 100
= 0.0122 %
D = 43 days
R = 15.2mm.

Substituting the values in the equation above gives, the application rate as

$$0.0122 = 63.322 + (2.402E\text{-}05 \times 43) - (4.462E\text{-}05 \times 15.2) - 2.745E\text{-}05\Delta ATZ_{i-1}$$

ΔATZ_{i-1} = 2,305,368 mg/ha
= 2,305 g/ha

Therefore, the maximum application rate of atrazine should be not greater than 2,305 g a.i/ha (369 g a.i./rai).

Table 5. Estimated atrazine residues in water and sediment at maximum allowable concentration at 43 days after atrazine application.

Outlet	**Water and sediment at day 43**	**Standard atrazine concentration (ppb)**	**Atrazine amount**	
			(mg)	**(mg/ha)**
(1)	(2)	(3)	(4)	(5)
Water	22,887 m^3	2	46	0.08
Sediment	8,468.12 kg.	22,000	186,298	336.1
Total	-	-	186,344	336.2

note : (4) = (2) x (3)

Table 6. Estimated atrazine in maize and cultivation soil at 43 days after atrazine application.

Atrazine accumulation source	Quantity	Atrazine concentration	Atrazine amount	
			(mg)	mg/ha)
(1)	(2)	(3)	(4)	(5)
Maize	29,445,700 plants	0.99*	29,151	52.6
	(8,500 plants/rai)	µg/plant		
Soil	69,284,000 kg**.	22,000 ppb	1,524,248,000	2,750,010

note: (4) = (2) x (3)

* estimated atrazine in maize = (application rate - amount of atrazine in soil – atrazine in water and sediment)/ No. of plants

**estimated soil amount = watershed area x soil depth x soil bulk density

Presently, the farmers in the Khlong I Tao watershed use Atrazine 90% WG at the rate of 2,250-3,750 g/ha (2,025 – 3.375 g a.i./ha) once a year in order to eliminate the pre-emergence weeds. If the atrazine is sprayed at a higher rate or maize is planted in wider area, this can affect the environment. Since there is no irrigation in the Khlong I Tao watershed, maize can be planted only once a year, and the long fallow period encourages weed infestation. As a result, the atrazine is applied at high rates to control the weeds, and the dispersal of atrazine from the Khlong I Tao watershed can be much higher than the standard.

CONCLUSION

The fate and behavior of atrazine in stream water and sediment in the Khlong I Tao sub-watershed during maize planting showed atrazine concentrations in runoff ? water exceeding the 2 ppb maximum allowable concentration for drinking water in about 29% of the water samples. Farmers must therefore be aware of the risk of consuming water during this period. Rainfall following atrazine application was a very important factor in the potential movement of atrazine from the sub-watershed. Reducing these amounts will require increased adoption of farming practices which use less herbicide or eliminate the potential for runoff, especially during the rainy season.

A mathematical regression model has been developed to estimate the optimal atrazine application rate for maize cultivation within Klong I Tao sub-watershed at a level that reduces atrazine concentrations in runoff to near the drinking water standard. The calculated application rate was 2.3 kg a.i./ha by mathematical model which is below the commercial recommended rate (2.6 kg a.i./ha). However,. this equation should be improved using cumulative rainfall rather than daily rainfall amount.

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J. ISSAAS Vol. 14, No 2:106-114(2008)

RESTRICTED FEEDING AS A RESOURCE MANAGEMENT STRATEGY FOR BROILERS

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(Received: November 22, 2007; Accepted: December 12, 2008)

ABSTRACT

A synthesis or meta-analysis of various studies on restricted feeding is presented to evaluate the effects of feed restriction on feed efficiency, livability and dressing recovery; and establish the biological feasibility and economic appeal of feed restriction in broilers. The two laboratory experiments were done at the University Animal Farm (UAF) of the University of the Philippines Los Banos. Data were analyzed statistically using the analysis of variance in Completely Randomized Design (CRD). Marginal product analysis was used and input-output ratio was computed to find the economically optimum level of restriction. Feed restriction does not necessarily result in lower intake since birds restricted to 20% level gave the highest consumption. The biological optimum level is also the economic optimum which is sensitive to price. Thus, if the price of feeds increases relative to price of broilers, it is advisable to practice feed restriction.

Key words: Dressing recovery, feed efficiency, feed restriction, livability, marginal productivity

INTRODUCTION

The Philippine broiler industry started in the 1960's with the introduction of modern breeds of chicken and contract growing arrangement. Broiler farms are smaller in size and contract arrangements are mostly focused on the marketing of finished broilers. During this time contracts were rather small wherein flock size consisted of a few hundred heads. In the 1970's, contract growing increased in popularity and in size; contract size ranged from 5000-10,000 birds. Independent raisers also increased the flock size to 10,000 broilers. Under the contract arrangement, farmers and integrated companies become business partners; farmers provided housing, labor and management while the integrated companies provide chicks, feeds and medicines (Coligado, 1990).

The growth in both independent and contract growing jointly contributed to the increase in the supply of chicken (Table 1). At present, the minimum flock size for contract growing schemes' ranges from 20,000 birds/farm to as large as 200,000 birds/farm. Improved technology and stronger market orientation brought about a steady increase in chicken supply over the years. Consumers have benefited from the increase in supply due to the introduction of modern breeds of chicken and the contract growing scheme. Chicken meat has become cheaper and more affordable for Filipino households.

The real prices of broilers at the farm gate (live) and market retail price (dressed) showed mild fluctuations but it remained relatively constant over time (Table 2). Real prices in Tables 2 and 3 were computed by multiplying the reported actual values by the 1994 deflation rate to standardize the values for meaningful comparison. Gonzales (1993) stated that meat consumption (demand) is determined by income, meat prices and taste and preferences of the population. Because chicken meat

is generally considered a cheaper source of animal protein, its per capita consumption exhibited a generally increasing trend. From 1971 to 2004, it increased from 2.7 kg/year to 8.2 kg/year (BAS, 2001). However, consumption of poultry meat is still relatively low in the Philippines. This implies that increased production at lower cost gives a bright prospect for the industry not only because more people can afford to eat more chicken but also opportunities in the export market can also be explored.

Table 1. Philippine chicken inventory (in 000' head), 1990-2005**.**

Year	Layer& Upgrade (Native)	Broiler	Total
1990	54,738	26,565	81,303
1995	68,331	27,885	96,216
2000	88,636	29,024	117,660
2005	95,620	40,380	136, 000

*Source: Bureau Agricultural Statistics, Dept. of Agriculture, Philippines. 2006

Table 2. Real prices of broilers (in constant 1994 prices)

Year	Real Prices, Pesos/kg	
	Farm gate, Live	Retail, Dressed
1994	56	71
1995	43	66
1996	40	59
1997	39	56
1998	40	57
1999	36	57
2000	39	54
2001	40	55
2002	36	50
2003	36	52
2004	40	57

Source: Bureau of Animal Industry Department of Agriculture, Philippines, 2005

The poultry industry is heavily dependent on imported feed ingredients which are relatively expensive because of the tariffs imposed on them (Gonzales, 1993). The real prices of broiler feeds showed an increasing trend (Table 3). Feeds comprise about 62-80% of the total cost of production In 2001, Mascariñas reported that feeds account for 62% of the total cost of production for broilers which are produced by contract growers (Table 4). In the case of independent raisers it could reach as high as 70-80% depending on the system of management.

The two most important challenges facing the broiler producers are reliance on imported inputs (e.g. feedstuffs, vaccines and breeding stock) and the threat of imports (Mateo, 2001; Department of Agriculture, 2001). With the high cost of production local broiler producers are often

unable to compete with imported chicken and be able to sell in the world market. One way to reduce production cost is to reduce feed cost. Results of this study indicate the potential of restricted feeding as a management strategy geared towards minimizing feed cost. It owes its beginning from an observation made 10 years ago. The researcher was motivated to have a closer look at the situation of some small farmers who were forced to starve their broilers for a day or two whenever they run short of cash to buy feeds. The same situation was observed at the University Animal Poultry Farm and the phenomenon observed was explained by an article on compensatory growth (Zubair et. al.,1996).

Table 3. Real prices of broiler feeds (in constant 1994 prices).

Year	Real Prices, Pesos/bag		
	Booster (25kg/bag)	Broiler Starter (50kg/bag)	Broiler Finisher (50kg/bag)
1994			
1995	253[e]	389	363
1996	257[e]	395	410
1997	277[e]	426	395
1998	285[e]	439	414
1999	252[e]	388	367
2000	253	389	366
2001	271	400	385
2002	271	396	381
2003	272	395	379
2004	292	430	408

Source: Bureau of Animal Industry, Department of Agriculture, Philippines, 2005
[e]Estimate

Table 4. Input share in producing broilers for contract growers, 2001**.**

INPUTS	% COST
Day-old Chicks	23
Feeds	62
Grower's fee	13
Vaccines/medicines	1
Operating Expense	1
TOTAL	**100**

Source: Mascariñas, 2001

Compensatory Growth and Restricted Feeding Principle

Compensatory growth is defined as the abnormally rapid growth relative to age within a breed of the animal (Bohman, 1955, Wilson and Osbourn, 1960; O' Donnovan, 1984). Summers

(2000) described compensatory growth as the rapid weight gain that usually follows a period of reduced nutrient intake of an animal, especially when it is placed back on a high quality diet.

In animal production, the most classical studies in compensatory growth have involved sheep and cattle (O' Donovan, 1984). Previous studies have shown that compensatory growth has occurred in most farm animals and even in broiler chicken, which has a very short grow-out cycle. This catch-up growth follows a period of feed nutrient restriction which is imposed through either physical feed restriction or feeding of diets which are very low in nutrient density. To be of economic interest, such animals must achieve normal weight-for-age prior to market and/or show improved efficiency of growth and/or exhibit superior carcass characteristics (Doyle and Leeson, 1996). In a review of works in poultry by various authors (Plavnik and Hurwitz, 1985; Plavnik et al.,1986; McMurtry et al., 1988) Robinson et al., (1990) found out that severe feed restriction for a few days in the early life of broilers can take advantage of the compensatory growth phenomenon resulting to reduced total feed intake and lower body fat without compromising the final weight.

Current Feeding Practice

The current feeding practice for broilers is usually full feeding (*ad libitum*) from start to market. Broilers must be encouraged to eat as much as possible, since the more they eat, the faster they grow and the earlier they will be marketed. Feed is always made available to the birds at all times. Moreover, to ensure rapid growth and high feed conversion efficiency and economical gains for the broiler producers, poultry nutritionist formulated different feed rations based on the nutrient requirements of the broilers at specific stage of growth.

Potential of Restricted Feeding as a Resource Management Strategy

Restricted feeding is a common feeding strategy for growing egg type pullets and breeder chickens. Restricting the feed intake, in this case, results to the delay in the onset of sexual maturity. In broilers, however, feed restriction is not commonly practised by broiler raisers since their objective is to grow the birds at the shortest time for market. However, various studies were conducted on restricted feeding to investigate the possibility of utilizing compensatory growth phenomenon to improve feed conversion efficiency. As pointed out by Zubair and Leeson (1994), the improvement in feed efficiency noted with compensatory growth was due to the smaller body mass of the bird up to the point of growth compensation where there is lower nutrient required for maintenance.

The study sought to present a synthesis or meta analysis of various studies conducted by the author on restricted feeding. It will be showcased as a resource management strategy which directly enhances efficiency of broiler production which leads to improved profitability. Specifically, it sought 1) to evaluate the effects of feed restriction on feed efficiency, livability and dressing recovery; and 2) to establish the biological feasibility and economic appeal of feed restriction in broilers.

MATERIALS AND METHODS

Study site

Six independent laboratory experiments on restricted feeding (volume restriction) were conducted at the animal farm of the University of the Philippines at Los Baños from 1998-2004. The experiments tested the effect of different levels of feed restriction at different ages/sexes of broilers on different production parameters such as body weight, feed conversion efficiency, mortality and dressing recovery. In general, findings of these studies support the findings found in the literature.

Restricted feeding was also experimented on-farm through an arrangement with a privately operated farm. The result was generally positive but was not free of complications.

Management and Care of the experimental Broilers

In all these experiments physical feed/volume restriction was used wherein daily weighing of feed during the restriction period was done. Feed offered to the restricted fed broilers were based on the total feed intake of the control on the previous day. The same procedure was done for the rest of the restriction period. All the experimental broilers were fed with commercially formulated feed rations (one brand) consisting of broiler booster (21-23% CP; 2800-3000 kcal/kg ME), starter (19-20% CP;2700-2900 kcal/kg ME) and finisher (18-19%CP;2700-2900kcal/kg ME) and subjected to the same management practices except for the restriction level. These were vaccinated against New Castle Disease B1B1 and La Sota strain and given anti-stress medication in the drinking water two days before and after vaccination and weighing.

Data Analysis

Data used in this presentation were drawn from two laboratory experiments done at the University Animal Farm (UAF) at UPLB (Table 5). Data were analyzed statistically using the analysis of variance in Completely Randomized Design (CRD). Differences on means were tested for significance using Least Square Difference (LSD)

Table 5. Source and description of data sets.

Experiment number	**1**	**2**
No. of replications	4	3
No. of treatments	10	10
Restriction period	4th wk	3rd wk
Levels of restriction (%)	0	0
	20	20
	30	30
	40	40
	50	50
Sex		
Male	50%	straight
Female	50%	run chicks
Strain		
Arbor acre	100%	50%
Anak (Manila bird)		50%
No. of observations	40	40
Flock size	200	240
Season	Feb.-Mar 02	Apr.-May 99
Feeds(booster, starter, finisher)	Commercial	Commercial

To evaluate the economic gains from restricted feeding, final body weight and total feed consumption of broilers were assessed vis–a-vis their respective prices using marginal analysis. Marginal product (MP) is the incremental change in output (body weight gain) per incremental change in input (feed). It is computed by dividing the change in body weight gain by the change in feed consumption. To find the economically optimum level of restriction, the marginal productivities were compared with the input- output ratio. The decision rule is that MP should be positive and should be as close as possible if not equal to the price ratio.

RESULTS AND DISCUSSION

Feed Conversion Efficiency, Livability and Dressing Recovery

Feed conversion efficiency is another very important parameter in measuring broilers performance. The current strains of broilers available in the market are good feed converters and fast growers. The higher the convertion of feed to meat, the higher is the profit. Majority of the broilers subjected to feed restriction showed an improvement in feed conversion efficiency (FCE) either during feed restriction or during the re-feeding period. When feed restriction is implemented at an early age (day 6th - 14th), the restricted birds become better feed converter than the full fed birds at the time of the restriction period and a week after the restriction (re-feeding) as observed and reported by Bustria, (2000). On the other hand, when restriction is done later or after the second week of age, the broilers exhibited poor FCE at the time of the restriction period, but were better feed converters than the full fed broilers during the re-feeding period. No interaction was observed with FCE between sexes (Table 6). However, regardless of sex, FCE of broilers fed different levels of restriction showed significant differences. The full fed broilers showed significantly better FCE over the restricted birds (40% and 50% level of restriction) which is attributed to the period (4th week of age) when restriction was implemented.

Table 6. Average feed conversion efficiency, livability, and dressing recovery of broilers subjected to different levels of feed restriction. [1]

PARAMETER	Level of feed restriction					
	0%	20%	30%	40%	50%	Ave.
Feed Conversion Efficiency						
Sex:						
Male	1.56	1.65	1.64	1.66	1.85	1.70
Female	1.64	1.64	1.66	1.74	1.81	1.67
Ave. (CV=3.279)	1.60^{c}	1.64^{c}	1.65^{bc}	1.70^{b}	1.83^{a}	
Strain:						
A	1.68	1.61	1.75	1.68	1.85	1.70
B	1.55	1.69	1.69	1.75	1.75	1.68
Ave. (CV=5.529)	1.60^{b}	1.65^{b}	1.73^{ab}	1.72^{ab}	1.77^{a}	
Livability (%)						
Sex:						
Male	100	100	100	95	100	99.0
Female	100	100	95	95	100	98.0
Strain:						
A	92	100	92	96	96	95.3
B	96	96	96	96	100	96.8
Dressing Recovery (%)						
Sex:						
Male	67.20	69.00	68.25	70.89	65.64	67.57^{b}
Female	70.56	71.31	68.26	68.42	69.20	69.39^{a}
Ave. (CV=1.653)	68.72^{ab}	70.05^{a}	68.06^{b}	68.39^{ab}	67.29^{b}	
Strain:						
A						
B	72.62	74.21	71.61	70.74	72.58	72.25
Ave. (CV=1.755)	72.08	72.58	70.75	71.27	72.02	71.74
	72.42^{ab}	73.27^{a}	71.23^{b}	70.90^{b}	72.25^{ab}	

[1] Means within column and within row with different superscript s are significant at ($P<0.05$)

The livability or percent recovery of broilers is a major determinant of income in production. The number of marketable broilers is determined by the number of broilers that were able to grow and attain market weight. During the growing period, birds that show poor performance i.e., stunted growth, injured and with abnormalities are culled which affect the percent recovery of birds for market. A good livability performance was observed in all the studies conducted on laboratory scale. Mortalities of the birds were caused by physical injuries. The same results were observed by all the other researchers (Flores, 1998; Gomez, 2001; Agaloos, 2001 and Lee and Leeson, 2001).

Significant differences were observed on the dressing recovery parameter between sex but not between strain. The dressing recovery of full fed and restricted re-fed broilers did not significantly differ. This implies that restricted feeding does not adversely affect carcass quality. Summers (2000), stated that very little or no difference was noted in carcass characteristics for the compensatory versus birds grown on normal feeding program. This observation supports the findings of several authors (Leeson et al., 1991; Zubair and Leeson, 1994a and Palo et al.,1995) who were not able to demonstrate any effect of feed restriction on dressing percentage as cited by Ramos (2003). Dagaas (1989) reported that there was no significant difference in dressing recovery of broilers regardless of strain when slaughtered at the same age.

Resource use efficiency and profitability analysis of feed restriction

The volume of feed consumption at different levels of restriction are arranged in ascending order (Table 7). However, it did not show consistency with respect to level of feed restriction since 0% restriction did not give the highest volume of feed consumption. With regard to body weight gain, higher feed consumption did not likewise result in highest body weight. Therefore, ranking in terms of input use 50% level is the best (3104.98g), in terms of body weight, 30% level gave the highest (1802.68g) hence, the biological optimum.

To get the economically optimum level (maximum profit), MP must be as close as possible if not equal to the price ratio and that is at 30% (0.40) level. This implies that restricting the feed up to 30% will give the maximum return so it is the best. Since the second nearest value is 1.03 which is at 40%, it also shows that broilers can be restricted up to 40% level. Nevertheless, 20% level of feed restriction is not advisable. It is better to implement full feeding than subject broilers to 20% restriction level. Moreover if the price of feed is increasing, restriction can be applied at 30% level or up to 40% level. On the other hand, if the price of broiler is increasing it is advisable to practice full feeding.

Table 7. Marginal productivity and input–output ratio.

Level of Feed Restriction	Feed consumption	Body weight gain (g)	Marginal Product, MP= ΔBWG/ ΔFC	Input-Output Ratio* Feed price / Broiler price
50%	3104.98	1672.22		
40%	3191.13	1760.84	1.03	0.22
30%	3295.92	1802.68	0.40	0.22
0%	3301.88	1788.62	-2.35	0.22
20%	3302.62	1769.85	-25.36	0.22

* Based on 2004 prices: live broilers at the farm gate and weighted feed price.

CONCLUSION

In this study, feed restriction does not necessarily result in lower feed intake since birds restricted to 20% level gave the highest consumption. Moreover, the biological optimum level is also the economic optimum. Economic optimum is sensitive to price therefore, if the price of feed increases relative to price of broilers, it is advisable to practice restriction.

ACKNOWLEDGEMENT

This paper was part of the Development Fund Diamond Jubilee Professorial Chair Lecture awarded by the University of the Philippines Los Baños. Thanks are expressed to the following: San Miguel Foods Inc., Bounty Agro Ventures, Ms. Zenaida M. Huelgas, Nenita de Castro, Cisima P. Lavega, Nellie M Lalican and Veneranda A. Magpantay.

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J. ISSAAS Vol. 14, No. 2:20-36 (2008)

ECONOMIC ANALYSIS OF MANGO PRODUCTION UNDER SHARE CONTRACT IN GUIMARAS, PHILIPPINES

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(Received: April 6, 2008; Accepted: November 5, 2008)

ABSTRACT

The discovery of chemical flower inducers in the 1970s revolutionized mango production in the Philippines. Since then, commercial mango orchards planted with grafted trees started to proliferate, effective yet expensive pesticides were formulated, and labor became more specialized and intensive. However, the original backyard production adapted to this technological change. The rise in production costs, the capital-deficient tree-owners, and the advanced technical know-how on production being limited only to certain groups had presented an economic incentive for the people to go into sharing practices of inputs and outputs. In Guimaras, a major mango production area, a unique sharing arrangement involving three parties has become a common practice. Based on a questionnaire survey of mango producers, this paper aims to clarify the input and output sharing arrangements in Guimaras, Philippines.

Key words: Productivity, production function, income distribution

INTRODUCTION

Share tenancy has long been practiced in the Philippines not only in agriculture but in other sectors as well (Hayami and Otsuka, 1993). The prevalence of share tenancy can be explained by evidence confirming the alignment of the Philippine experience with Cheung's model in which share tenancy is as equally efficient as fixed-rent tenancy and owner cultivation (Cheung, 1969; Mangahas, 1975). Although studies on share tenancy in agriculture have mostly been confined to rice production (Fujimoto, 1996), a few studies revealed that contracts possessing attributes of share tenancy were also practiced and are not uncommon in mango production. Owners of mango trees with financial constraints, limited time or inadequate knowledge of mango cultural practices (FRLD, 1994; Brown, 1992) enter into share contracts with contractors who perform certain production and post-production activities under certain arrangements. Because small-scale production is unprofitable, contractors make their investments worthwhile by managing several trees of different owners (Bondad, 1989).

Guimaras is a province-island in Western Visayas that is very famous for its superior quality mangoes. A comprehensive study on mango marketing revealed that the common sharing ratio in the island between tree owners and contractors was 1:2 (FRLD, 1994). In these contracts, the contractors incurred all the cost from production to post production activities while the tree owner incurred land rent and cost of fertilization that included fertilizer cost and labor, a non-deductible operating cost. In the same study, cost and returns on these contracts were calculated based on grafted trees that could be found mostly in big-scale commercial orchards and plantations rather than in small-scale backyard farms which constituted 84% of the farms in Guimaras (Catelo, 1997).

In the case of small-scale mango production, which is operated in backyard, share tenancy predominates and involves three parties, the tree owner, spraymen team and financier. However, no studies have been conducted yet on the practice and economic implications of the contractual arrangements in backyard mango production in Guimaras. This paper is probably the first economic analysis of the three-party share tenancy.

To investigate the three-party share contracts in backyard production, a questionnaire survey of sharing contracts was conducted in Barangay Concordia of the Municipality of Nueva Valencia in Guimaras in 2002. A list of mango farmers was acquired from the village head. Using a three-set questionnaire corresponding to the three parties in share contracts, the respondents were interviewed according to their participation in mango production.

Following our earlier paper on yield and quality in mango production (San Juan and Fujimoto, 2005), this paper analyzes the structure and distribution of cost and income in mango production under share contract. It generally aims to clarify the sharing arrangements in input and output commonly practiced in backyard production. Specifically, this paper aims (1) to examine the cost components and discuss the input sharing arrangement, and (2) to examine net income of the sharing parties from mango production.

Although data were collected from a total of 70 production contracts, only 48 contracts were used in the analysis. Because of significant differences in the yields of seeded and grafted trees, contracts that exclusively induced seeded trees were singled out for simplification purposes. Only successful production contracts, which actually produced saleable harvest, were included in the analysis. Four contracts that did not have cost-sharing features were also excluded from the analysis. It should be noted that age and yield of the individual trees in a contract could not be ascertained, and thus, the average age and yield per contract were used. Physical quantities of the material inputs were also not available so that they were analyzed in their monetary value.

MANGO PRODUCTION AND EMERGENCE OF SHARE CONTRACTS

The Philippines is one of the top mango producers in the world (UAP 2000). In 2004, almost a million metric tons of mangoes were produced by about 7 million bearing trees planted on 158,948 hectares of land (BAS, 2005). In response to the increasing demand in both local and international markets, the volume of production grew at 3.8% annually in 2000-2003 and the volume of export grew at 4.0% during the same period (NSCB, 2004a). However, mango was actually a neglected crop in the Philippines until the 1970s. Because of its seasonal, irregular and poor fruiting habit, it was mainly grown for shade, shelter and ornamental purposes rather than for fruit production. These mango trees were originally trees grown from seeds and found in almost every backyard in the country. These were mostly left un-irrigated and unfertilized because they were believed to thrive even without care and maintenance. However, in the early 1970s, the mango industry of the Philippines was revolutionized by the discovery of potassium nitrate (KNO_3) as an effective flower inducing agent correcting mango's fruit bearing habit. This was compounded by the progress in pest control with the formulation of effective and less toxic pesticides that protect flowers and fruits sprayed with KNO_3. These two events practically assured a lucrative profit for the growers and paved the way for the commercial production of mango in the Philippines (Bondad, 1989).

Mango production by contract also became widely practiced in the 1970s. Because small-scale production was deemed unprofitable, contractors managed mango trees of several tree owners for business to be viable. Two conditions that led production contracts to be widely

practiced in the Philippines were the combination of high production costs and poor financial resources of backyard tree owners (Bondad, 1989). It was also likely that tree owners were not updated with the technical know-how (Brown, 1992). On the other hand, contractors were regularly informed by agents of agricultural chemical company about the latest and more effective way of producing mangoes. These contractual arrangements in mango production can be viewed as share tenancy contracts where the tree owner is equated to the landlord and the contractor the tenant. For economies of scale to work, the contractor enters into more than one contract with several tree-owners even in geographically separated areas. Although sharing was commonly carried out between two parties in rice production, in the case of mango farming in the study area, contractors actually consisted of two economic subjects, spraymen team and financiers. Thus, the prevailing share tenancy contracts in mango production involved three parties, each of whom was related to production factors of land (tree), labor and capital.

The Study Area

One of the provinces in the Philippines famous for its mangoes is Guimaras, an island in Western Visayas (Fig. 1). It is classified under climate type I characterized by two pronounced seasons: dry and wet. The dry months are from November to early May and the wet months from June to October. In Guimaras, the bulk of harvest starts from the month of January when prices are relatively high until May when mangoes flood the markets and prices go down (Catelo, 1997). In 2003, the island produced 11,264 metric tons of mangoes, or 1.1% of the total production in the Philippines (NSCB, 2004b).

Fig. 1. Map of the study area

There are two kinds of mango tree in Guimaras: grafted and seeded tree. The former bears fruits earlier than the latter and is thus suitable for commercial orchards. On the island, grafted trees constituted about 80% of mango trees at fruit bearing age. The remaining 20% were seeded trees, which were generally bigger in size and had a higher yield than grafted trees. Seeded trees could be found mostly in backyard farms with an average size of 0.32 hectare. According to the mango census in 1995, more than 80% of these backyard farms were planted with one to five trees only (Catelo, 1997).

Contracts

The total number of tenancy contracts analyzed in this study amounted to 48 contracts, involving 235 seeded trees or an average of 4.9 trees per contract. The distribution of contracts by season, age of trees, size and type of contract is presented in Table 1.

Table 1. Profile of contracts studied

Category	No. of Contracts		Total No. of Trees		Ave. Size of Contract		Ave. Age of Trees (yrs.)	
	n	%	n	%				
Season								
On	38	79.2	177	75.3	4.7	a	75.6	a
Off	10	20.8	58	24.7	5.8	a	84.6	a
Age of trees (yrs.)								
Young (20-99)	24	50.0	102	43.4	4.3	a	52.0	a
Old (100-120)	24	50.0	133	56.6	5.5	a	102.9	b
Size of contract								
Small (1-5 trees)	34	70.8	109	46.4	3.2	a	73.4	a
Big (6-15 trees)	14	29.2	126	53.6	9.0	b	87.4	a
Type of Contract								
A	40	83.3	190	80.9	4.8	a	72.9	a
B	8	16.7	45	19.1	5.6	a	100.0	b
Overall	48	100.0	235	100.0	4.9		77.4	

Source: Survey 2002

Note: Different letters, a and b, indicate significant difference at the 5% probability level.

Almost 80% of these contracts were concluded for on-season months, and 20% for off-season production. Among the on-season contracts, about 15% were commenced in January in time for harvesting in May when the Mango Festival is held yearly. On the other hand, most (80%) of the off-season contracts were commenced in November and harvested in March. Rainfall usually gives detrimental effects to mango production, which is also associated with higher occurrence of pest and diseases, thus risks are higher during the wet months.

The trees induced to flower ranged in age from 20 to 120 years old, with an average of 77 years. In order to determine the differences in cost, yield, quality and income in terms of age of tree, this study classified the contracts into two categories: young trees for those younger than 100 years, and old trees for those 100 years old and older. Half of these contracts involved young trees and the other half are centennial trees.

In terms of size, contracts involved a range of 1 to 15 trees with an average of 5 trees per contract. Contracts were divided into two categories according to the size of contract: 1 to 5 trees for small contracts, and 6 to 15 for big contracts. About 71% of the contracts were small in size which was consistent with the findings of the mango census in 1995.

In this study, the classification of contracts was also made by output-sharing arrangements. Interview with respondents confirmed that the ratio received by the tree owner and contractors has been changing. According to older mango farmers, the tree owner and laborers each received half of the output when smudging was used to induce flowering in mango trees. However with the discovery of chemical flower inducers and subsequently the use of other agro-chemicals which augmented the capital requirements of mango production, the ratio received by the tree owner started to decrease. The arrangements existing in the area are evidence of this change.

There are two types of output-sharing arrangement that have become widely practiced in the study area: type A and type B. Under type A contract, locally called *terciahan* and predominated in the study area, the contractor received two-thirds of sales. Under type B contract, the contractor received three-quarters of sales. There was a significant difference in the average age of trees between the two types of contracts. Because older trees were bigger in size and thus predicted to entail higher production cost, contractors needed to receive a higher percentage of the sales under type B contract. It is also speculated that the older and bigger trees required the contractors to have a higher skill in spraying, to which a larger proportion of the sales is paid.

Input and Output Sharing

When a tree owner (TO) could not afford to finance the spraying of his own trees, he entered into sharing arrangements with a contractor who financed the spraying operations. Contractor is the collective name for the tandem of spraymen team (SP) and financier (FN). However, in the study area, spraymen team and financier were considered two distinct groups. On the average, there was only one spraymen team of 3.25 members and one financer group of 1.27 men for one tree-owner. The actual number of workers and creditors appeared to be much larger than three. Sharing was carried out among the three parties.

A contract lasted for about 120 days (Table 2). It started from flower induction and ended in harvesting. There were four major stages in mango production: (1) flower induction, (2) foliar fertilizer and pesticide application, (3) fruit bagging, and (4) harvesting. In the share contracts, each of the three parties had a specified input to provide. The tree owner provided the tree and paid land tax. The spraymen team provided labor inputs and bore either rental charge or depreciation of machines used in spraying activities. The financier provided all material inputs needed for chemical induction to fertilizer and pesticides application.

Under type A contract, the parties received equal shares of the Net Income for Sharing (NIS) while under type B contract, the tree owner received a quarter of the NIS and the remaining three-quarters were halved between the spraymen team and the financier.

Table 2. Inputs in mango production

Category	Stages of Production			
	Flower Induction	**Chemical Application**	**Fruit Bagging**	**Harvesting**
Days After Flower Induction (DAFI)	0-5	until 50-60	50-60	110-120
Materials	Flower inducer	Foliar fertilizer Pesticides Fuel	Newspaper Stapler and staple wire	
Labor Source	Spraymen Team		Hired Labor	
Equipment	Power or manual sprayer and hose		Rope and bamboo for climbing	
Bearer of Cost	Spraymen team bears all labor inputs and equipment cost, financier bears all material input costs		Shared equally	
Type of Cost	Cost under contract		Cost above contract	

Source: Survey 2002

PRODUCTION INPUTS AND COST-SHARING

This section focuses on the cost of mango production under share contracts. Based on both on-season and off-season production data, the average mango production cost per tree is presented in Table 3. Cost items were generally divided into two: cost under contract and cost above contract. The former was further classified into respective bearers of cost.

In mango share contracts, the first material cost incurred was flower inducers. The first spraying was marked the day from which counting of days until harvest was done. The second application of flower inducers of lower concentration was carried out about 4-5 days after flower induction (DAFI). The purpose of this second spraying was to induce some spots which were missed in the first application. An average of PhP223 per tree was spent on flower inducers, constituting 6.7% of the total cost.

The next step was the application of foliar and chemical fertilizers during flowering and fruiting stages. Although basal application of fertilizer was not a common practice in share contracts in the study area, foliar fertilizer was applied to provide nutrients to the leaves to prepare for fruit development. An average of PhP143 was spent per tree on foliar fertilizer, which constituted 4.3% of the total cost. To reduce labor cost, foliar fertilizer was usually mixed with pesticides.

Pesticides were applied to control two types of diseases (anthracnose and scab) and six insect pests (mango hopper, tip borer, mealy bug, mango seed borer, helopeltis bug and fruit fly) commonly attacking mangoes at their different growth stages from flower induction to full development. The financier paid an average of PhP789 per tree for pesticides, constituting 23.7% of the total cost. Aside from these chemicals, the financier also paid for the fuel cost of power sprayers, with an average of PhP16 per tree. In total, the financier spent PhP1,172 per tree as specified under contract, which constituted 35% of the total cost.

All the labor required from flower induction until the application of foliar fertilizer and pesticides were provided by the spraymen team. Unfortunately, labor inputs for foliar and pesticide application could not be ascertained. Therefore, the lower range of the frequency of spraying of pesticides in the province, 5 times per season, was assumed for determining the cost of labor. In total, the spraymen team spent 7.15 man-days per tree in one season, which was equivalent to PhP1,072 per tree, constituting 32% of the total cost.

Because the spraying of chemicals necessitated the use of machines, their depreciation cost if owned and rental fee if borrowed were also calculated. The cost of the machine, manual or power sprayer, was borne by the spraymen team. The rental fee was either fixed or a percentage of the share of the spraymen team in the income. The depreciation cost of manual and power sprayers differed, but rental fee did not differ according to type of sprayer. Collectively, the cost for the equipment is PhP100 per tree constituting 3% of the total cost.

The tree owner was comparable to an absentee landlord, who made no contribution to input. Since he did not have any explicit cost under contract, land tax was calculated for four months. It cost him PhP20 per tree on the average.

These costs under contract constituted 71% of the total cost, with tree owner having the least share, and the spraymen team and the financier bearing equal shares in the expenditure. It should be emphasized that these costs under contract were incurred during the first half of the contract period, which was actually the most critical and risky period in mango production. Should the production fail, they could not be recovered pointing to the fact that costs under contract represented the values of the risk each party faced under the share tenancy arrangements.

Table 3. Average cost per tree in mango production in Guimaras (PhP)

Cost	Ave.	S.D.	%
Cost Under Contract	2,363.6	1,201.4	71.1
TO			
Land Tax	20.0	0.0	0.6
SP	*1,171.8*		*35.2*
Equipment [1]	100.0	84.9	3.0
Unpaid SP Labor	1,071.8	882.9	32.2
FN	*1,171.8*		*35.2*
Flower Inducer	223.3	131.6	6.7
Foliar Fertilizer	143.2	91.8	4.3
Pesticides	789.4	568.7	23.7
Fuel and oil	15.9	17.4	0.5
Cost Above Contract	960.8	499.2	28.9
Bagging Materials	286.5	254.5	8.6
Hired Labor	674.3	338.3	20.3
Total Cost	3,324.4	1,445.3	100.0

Source: Survey, 2002

Note: [1] Equipment cost includes rental fee and depreciation cost if equipment is owned.

The remaining 29% of the total cost or specifically the cost above contract was spent during the second half of the contract period, which started with fruit bagging and ended in harvesting activities. The practice of bagging the fruits originated from Cebu in order to protect the fruits from insects bites that damage the mango peel. Bagging of fruits was carried out at 50 to 60 DAFI with such materials as newspapers and staplers, totaling to PhP286 per tree. Harvesting was carried out between 110 to 120 DAFI. No material input was needed in this final activity.

All labor requirements in the second half of the contract period were classified as hired labor. Anybody could perform these activities, including the tree owner, spraymen team, financier who were paid as hired laborers. On the average, hired labor cost was PhP674 per tree, including the food provided for the workers. The financier initially paid for all material and labor inputs needed in bagging and harvesting activities, amounting to PhP961 per tree. These "costs above contract" were similar to what Mangahas (1975) referred to "deductible operating cost." They were paid back to the financier without interest after harvest was sold. In other words, these costs were borne equally by the three parties as they were deducted from gross sales before the NIS was divided among the parties.

Thus, the average total production cost of mango was PhP3,324 per tree. In order to analyze how mango production cost varied by season, age of trees, size of contract and type of contract, the average costs were calculated for these categories (Table 4). The following points deserve mentioning. First, there was no statistically significant difference in the average production cost per tree between the two seasons. One may have expected a higher expenditure during the off-season production in order to obtain a higher production for a premium price. However, the sharing parties, specifically the financier, appeared to take the risk-averting attitude during the off-season.

Second, in terms of the age of trees, the average total cost was statistically higher for contracts involving younger trees. In mango production, as the tree grows older, yield becomes naturally higher. The higher cost for younger trees, specifically the cost of flower inducer, means the higher investment, indicating the intention of contractors to increase production of younger trees through artificial means. The higher cost of bagging materials for younger trees can be interpreted as salvaging the quality of the produce, because the quantity of harvest was expected to be relatively lower than older trees.

Third, the average production cost was significantly higher for small contracts than big contracts. Significantly higher costs could be noted for flower inducer and pesticide, pointing to the more intensive nature of small contracts. This was probably caused by the contractor's attitude to higher investment for realizing a higher production, if contract size was small.

Fourth, the cost structure also differed significantly between the contracts of varying sharing ratios. It is seen that the average production cost was significantly lower under type B contract, reflecting lower expenses on flower inducer and foliar fertilizer. This can be interpreted to indicate a more efficient use of the inputs under type B contract, pointing to the possibility that these contractors had longer experiences and higher skills, therefore were given the privilege of entering into type B contract.

Table 4. Average cost per tree in mango production in Guimaras by category (PhP)

Cost	Season				Age of Trees				Size of Contract				Contract Type			
	On		Off		Young		Old		Small		Big		A		B	
Cost Under Contract																
Land Tax	20.0	a	20.0	a	20.0	a	20.0	a	20.0	a	20.0	a	20.0	a	20.0	a
Equipment [1]	104.3	a	84.0	a	93.5	a	106.5	a	117.9	a	56.6	b	108.7	a	56.5	a
Unpaid SP Labor	1,171.9	a	691.0	a	1,195.1	a	948.4	a	1,327.9	a	449.6	a	1,139.5	a	732.8	a
Flower Inducer	228.0	a	205.8	a	263.1	a	183.6	b	248.3	a	162.8	b	242.4	a	128.2	b
Foliar Fertilizer	144.6	a	138.1	a	149.3	a	137.1	a	156.0	a	112.2	a	153.7	a	90.7	b
Pesticides	812.7	a	700.9	a	858.4	a	720.4	a	891.6	a	541.3	b	836.3	a	554.8	a
Fuel	12.8	a	27.7	b	11.6	a	20.2	b	13.2	a	22.3	a	15.6	a	17.3	a
Sub-total	2,494.2	a	1,867.5	a	2,590.9	a	2,136.3	a	2,775.0	a	1,364.7	b	2,516.2	a	1,600.4	a
Cost Above Contract																
Bagging Materials	277.9	a	319.2	a	359.0	a	214.0	b	311.5	a	225.9	a	309.9	a	169.6	a
Hired Labor	699.8	a	577.4	a	755.5	a	593.1	b	744.3	a	504.4	b	701.9	a	536.3	a
Sub-total	977.7	a	896.6	a	1,114.5	a	807.2	b	1,055.8	a	730.3	b	1,011.8	a	705.9	b
Total Cost	**3,471.9**	**a**	**2,764.1**	**a**	**3,705.4**	**a**	**2,943.4**	**b**	**3,830.8**	**a**	**2,095.0**	**b**	**3,528.0**	**a**	**2,306.3**	**b**

Source: Survey, 2002

Notes: 1) [1] Equipment cost includes rental fee if rented and depreciation cost if equipment is owned.

2) Different letters, a and b, indicate significant difference at the 5% probability level.

MANGO PRODUCTION ANALYSIS

Our earlier paper dealt with the determination of yield and quality of mango production, based on a mixture of seeded and grafted trees (San Juan and Fujimoto 2005). In this paper, we limit our analysis to production of seeded trees.

Yield and Quality

Table 5 shows that the average yield was 348.0 kilogram per tree, produced by an average cost of PhP3,324 per tree. The average cost of production was PhP12 per kilogram. The average yield per tree was significantly higher in small contracts (397 kg) than those of big contracts (230 kg). The intensive nature of small contracts seems to have resulted in a higher yield. However, there was no significant difference in yield between the contracts of different seasons, ages of trees and types of contract. It is also interesting to note that there was no significant difference in the average cost per kilogram. Any differences in inputs by season, age of trees, size of contract, and type of contract seemed to have been absorbed in production levels, resulting in the same production cost per kilogram.

Table 5. Yield, cost efficiency and quality of mango production in Guimaras

Category	n	Yield (kg/tree)		Cost (PhP/kg)		Quality of Harvest[1]			
						% of Class A		% of Class B	
Season									
On	38	367.7	a	11.9	a	38.8	a	56.8	a
Off	10	273.4	a	13.8	a	55.7	b	36.5	b
Age of trees									
Young	24	305.0	a	13.4	a	43.8	a	52.6	a
Old	24	391.1	a	11.2	a	41.6	a	51.7	a
Size of contract									
Small	34	396.7	a	12.5	a	44.7	a	50.7	a
Big	14	229.9	b	11.9	a	38.2	a	55.2	a
Type of Contract									
A	40	361.0	a	12.6	a	42.7	a	53.7	a
B	8	283.3	a	11.0	a	42.4	a	44.4	a
Overall	48	348.0		12.3		42.6		52.1	

Source: Survey 2002

Notes: 1) [1]Sorted harvest only (n=35)

2) Different letters, a and b, indicate significant difference at the 5% probability level.

However, important differences could be observed in the quality of the produce by season. In Guimaras, harvest was sold either unsorted or sorted. Out of the 48 contracts, only 35 or about 73% sold their harvest sorted. For sorted harvest, there were generally two classifications, "good" and "buging." The former referred to mangoes of 230 grams or heavier with no mechanical injuries, while the latter below 230 grams and/or with visible damage. During the time of the survey, the direct exportation to the US had already started, so that mangoes for exportation were classified as "Exportable," with a higher price than "Good." However, since only one of the 48 contracts had its harvest included in the exportation, both Good and Exportable mangoes were classified as Class A in this study. Class B is the Buging class. It is clearly seen that there were more Class B than Class A

mangoes in the study area, but in the case of off-season production, the majority of the fruits were classified as Class A. This is a rather surprising finding in that the quality of mango was generally expected to lower in the off-season production, carried out during the wet months with higher occurrence of pest and diseases. The higher proportion of Class A mangoes in the off-season seemed to imply that the small quantity of fruits which survived the wet months ended up with a higher quality.

Production Function Analysis

To determine the mechanism of mango production, production function was estimated using the Cobb-Douglas form. The variables used are as follows. The dependent variable, Y, is the gross production of mango per contract expressed in kilograms. A total of 8 independent variables were alternatively used in the three models. The variable X_1 is the average age of trees per contract, expressed in years. It is expected to have a positive sign because production seemed to be higher for older trees leading to higher gross income. The variables X_2, X_3, X_4 and X_5 refer to the value of flower inducers, foliar fertilizer, pesticides and bagging materials per contract in peso, respectively. The first three variables are classified as costs under contract, which are expected to have a positive sign because their increased application is believed to be directly proportional to yield and therefore income. The bagging material cost is indicative of a successful spraying operation and is expected to have a positive sign. The variable X_6 is a dummy variable for season: 1 for on-season production and 0 for off-season production. The variable X_7 refers to the size of contract in terms of the number of trees. It is expected to have a positive sign as total production should be higher for bigger contracts. The last variable X_8 is a dummy variable for the type of contract: 1 for type A and 0 for type B.

The coefficients of determination (R^2) indicate that models fit moderately well to the data, explaining 58% to 61% of the total variations in mango production (Table 6). The F-value is statistically significant and the DW-value indicated the absence of auto-correlation. The sum of the regression coefficients in Model I indicated a constant return to the scale.

The following points deserve mentioning. First, the age of tree is a significant determinant of production for Models II and III. It has a positive sign and means that for every 10% increase in the age of trees, there will be a subsequent increase of approximately 3% in total mango production. Second, foliar fertilizer cost is significant but has a negative sign, indicating the excessive use of foliar fertilizer. This was probably due to the local practice of mixing it with pesticides, whenever pest control was carried out. Third, pesticide and bagging material costs were both significant and positive determinants of income. A 10% increase in pesticide and bagging cost would result in about 9% and 4% increase in production, respectively. These findings confirm the importance of pesticides and bagging materials, which were actually the most expensive material inputs in mango production. Pesticide was applied to ensure the quantity and bagging carried out to ensure the quality of the harvest.

Labor inputs are excluded in the analysis because their inclusion in the equation yielded a very low R^2. Moreover, because it is assumed that the amount of labor input used is highly dependent on the amount of material inputs employed in mango production, inclusion of labor in the analysis proved unnecessary.

Table 6. Estimates of Cobb-Douglas production function for mango in Guimaras

Item		Model I		Model II		Model III	
Constant		1.025		-3.130		-0.308	
		(0.890)		(-0.287)		(0.273)	
X_1	Age of trees (yrs.)	0.193		0.299	**	0.311	**
		(1.241)		(1.944)		(1.950)	
X_2	Flower inducer cost (PhP)	-0.102		-0.046		-0.017	
		(-0.496)		(-0.241)		(-0.083)	
X_3	Foliar fertilizer cost (PhP)	-0.601	***	-0.590	***	-0.601	***
		(-2.938)		(-2.843)		(-2.857)	
X_4	Pesticide cost (PhP)	0.909	***	0.825	***	0.899	***
		(3.613)		(3.276)		(3.423)	
X_5	Bagging materials cost (PhP)	0.301	***	0.407	***	0.386	***
		(2.608)		(3.723)		(3.534)	
X_6	Season (1=on, 0=off)			0.266			
				(1.414)			
X_7	Number of trees	0.303	*				
		(1.823)					
X_8	Type of contract (1=Type A, 0=Type B)					0.234	
						(1.035)	
Sum of Regression Coefficients		1.003		0.895		0.978	
R^2		0.605		0.593		0.584	
F-value		10.471	***	9.954	***	9.592	***
Durbin-Watson value		2.002		2.265		2.139	
N		48		48		48	

Notes: 1) Figures in parentheses are the t values.

2) ***, ** and * denote significance at the 1%, 5% and 10% probability levels, respectively.

SALES AND INCOME DISTRIBUTION

Income from mango sales depended on three factors, quantity of harvest, quality of harvest and prevailing prices. Since the first two factors were discussed in the previous section, the last factor is discussed in this section. The price of mango was high until about February when supply was low, after which mangoes started to flood the markets, making the peak season from March to May, with much lower prices.

Mango prices at which the produce was sold by the contracts under study are shown in Table 7. In the study area, the price of unsorted mango ranged from PhP14 to PhP22 per kilogram, with an average of PhP17 per kilogram. The average price of unsorted mangoes did not differ significantly between the contracts under different categories. In contrast, the price of sorted mangoes largely fluctuated from PhP17 to PhP38 per kilogram for Class A mangoes, and from PhP9 to PhP22 per kilogram for Class B. The average price of mango was significantly higher for the

off-season than the on-season, implying the existence of the premium for those contracts that risked spraying during the wet months when rainfall interfered with production.

Table 7. Price of mango per kilogram in Guimaras

Category	Unsorted Harvest					Sorted Harvest								
							Class A				Class B			
	n	Price (PhP)				n	Price (PhP)				Price (PhP)			
		L.	H.	Ave.			L.	H.	Ave.		L.	H.	Ave.	
Season														
On	11	14	22	16.5	a	27	17	38	19.9	a	9	22	11.1	a
Off	2	18	18	18.0	a	8	20	30	25.5	b	10	22	14.3	b
Age of trees														
Young	8	15	18	16.0	a	16	18	30	21.7	a	9	22	12.6	a
Old	5	14	22	17.8	a	19	17	38	20.8	a	9	16	11.3	a
Size of contract														
Small	10	15	18	16.3	a	24	17	38	20.6	a	9	16	11.2	a
Big	3	14	22	18.0	a	11	18	30	22.6	a	10	22	13.4	a
Type of contract														
A	11	15	22	16.8	a	29	17	38	20.8	a	9	22	11.7	a
B	2	14	18	16.0	a	6	18	30	23.2	a	10	16	12.7	a
Overall	13	14	22	16.7		35	17	38	21.2		9	22	11.9	

Source: Survey 2002

Notes: 1) One contract in the On Season had exportable mangoes priced at PhP38 per kg

2) L. and H. mean lowest and highest price, respectively.

3) Different letters, a and b, indicate significant difference at the 5% probability level.

The gross sales, profit and BC ratio of the 48 contracts were also studied (Table 8). Profit was obtained by subtracting total production cost from gross sale. The average gross sale and profit were PhP5,542 and PhP2,217 per tree, respectively. The contracts of small size had a significantly larger gross sale on a per tree basis. A tree in the small contracts earned almost twice as much as that in the bigger ones, reflecting its higher yield.

On the other hand, the significantly higher profit per tree from the older trees reflected the lower average cost for these centennial trees. In terms of the type of contract, there was no significant difference in the gross sale and profit between type A and B contracts. This indicates that type B contracts are more cost-efficient considering that type B contracts entailed significantly lower cost than type A contracts. Also as is confirmed by the high benefit-cost ratio (1.7), mango production can be said to be a profitable venture in the area at the time of the study. This BC ratio means that for every PhP100 invested in mango production, there would be a profit of PhP70 after four months of production activities.

Table 8. Gross sale and profit per tree from mango production in Guimaras

Category	n	Gross Sale (PhP)		Profit (PhP)		B/C Ratio	
Season							
On	38	5,671.7	a	2,199.8	a	1.7	a
Off	10	5,046.9	a	2,282.8	a	2.0	a
Age of trees							
Young	24	4,858.4	a	1,153.0	a	1.5	a
Old	24	6,224.6	a	3,281.2	b	2.0	a
Size of contract							
Small	34	6,301.7	a	2,471.1	a	1.7	a
Big	14	3,695.3	b	1,600.3	a	1.9	a
Type of Contract							
Type A	40	5,745.3	a	2,217.3	a	1.7	a
Type B	8	4,522.6	a	2,216.4	a	1.8	a
Overall	48	5,541.5		2,217.1		1.7	

Source: Survey 2002

Note: Different letters, a and b, indicate significant difference at the 5% probability level.

Share Tenancy Arrangements

One of the features of share contract in mango production in Guimaras was the sharing of not only output but also inputs among the parties involved. Therefore, a fundamental question arises as to how much net income does each party receives from the joint production activity. Table 9 presents the distribution of costs and income among the three parties under share contract. Because types A and B contracts are combined in this analysis, the sharing rate is not exactly equal to the three parties. However, our aggregated data heavily reflected the impact of a large number of type A contracts in that the distribution of income, gross and net, was very close to one third each for the three parties. There are several points to be noted.

Table 9. Income distribution in mango production in Guimaras (PhP/tree)

Item	TO	SP	FN	Total
Cost Under Contract (A)	20.0	1,171.8	1,171.8	2,363.6
	(0.3)	(49.9)	(49.9)	(100.0)
Cost Above Contract (B)	320.3	320.3	320.3	960.9
	(33.3)	(33.3)	(33.3)	(100.0)
Total Cost (C=A+B)	340.3	1,492.1	1,492.1	3,324.5
	(9.9)	(45.1)	(45.1)	(100.0)
Gross Income (D)	1,784.4	1,878.6	1,878.6	5,541.5
	(32.2)	(33.9)	(33.9)	(100.0)
Net Income for Sharing (E=D-B)	1,473.9	1,553.4	1,553.4	4,580.7
	(32.2)	(33.9)	(33.9)	(100.0)
Profit (E-A)	1,453.9	381.6	381.6	2,217.1
	(65.8)	(17.1)	(17.1)	(100.0)
B/C Ratio	5.6	1.3	1.3	1.7

Source: Survey 2002

First, the distribution of cost among the three parties was skewed towards the contractors, i.e., spraymen team and financier who respectively bore equal percentages of the total cost. The aggregated share of spraymen team and financier became 90% of the average total cost per tree, indicating that it was the contractors who realized the economic potential of mango trees planted and left unattended at many backyards on the island. The small share of the tree owner in bearing the cost may be attributed to the single cost item assigned to him which is land tax calculated for four months.

Second, although each party received almost equal amount of gross income and NIS, actual profit received varied greatly between the tree owner and contractors, because of the existence of costs under contract. While the tree owner received more than a third of the total profit, the spraymen team and the financier received only 17% each.

Third, despite the smaller amount of profit earned by spraymen team and financier, their BC ratios were high enough to keep them engaged in mango production activities. The BC ratio of 1.3 indicated that they made a profit of as much as PhP30 for every PhP100 invested, which was equivalent to 30% interest for their investment in a period of four months.

Fourth, the consistently equal shares of spraymen team and financier in the distribution of cost, income, profit and BC ratio suggest equal importance of labor and capital in mango production, as well as the rational performance of mango production market in the area. Their contribution to cost was directly proportional to the gross and net income they received under share contracts.

Because of the increasing importance of the contributions of spraymen team and financier in mango production, it is predicted that their share in the output will further increase as evidenced by the practice of Type B contract in the study area. With the further improvement of the skills of the spraymen team entailing higher equivalent wages, and with the capacity of the financier to take risks when input prices are increasing commanding higher interest rates, the share of the contractors in the output is predicted to increase in the future. Although the prevalent contract type was A in the study area, type B will become rampantly employed before it is replaced by another type of contract that gives the contractors who have become more cost-efficient an even bigger share in the output.

CONCLUSION

Share tenancy contract in agriculture usually involves two parties: landlord and tenant. However, in mango farming in Guimaras, Philippines, there existed unique share contracts, involving three parties, namely tree-owner (TO) who provided the tree, the spraymen team (SP) that provided most of the labor requirements, and financier (FN) who provided the capital required for mango production. Based on a detailed survey of 70 share contracts in Guimaras, this paper attempted to analyze the nature of mango farming with respect to yield, cost and income, under share contracts.

The predominant form of share contract was equal sharing among the three parties. However, equal sharing referred to output, and there were sophisticated cost-sharing arrangements in the study area. Two types of cost were observed: costs under contract and costs above contract. For the analysis of mango production under share tenancy, the observed share contracts were classified into the following categories: season, age of trees, size and type of contracts. Average yield per tree was 348 kg for all categories of contracts, but found to be significantly higher for contracts of small size, reflecting the intensive nature of production activities. Average production cost was PhP3,324 per tree for all categories of contract, but it was significantly higher for contracts involving younger trees, small contracts with 1-5 trees and type A contracts. However, average

production cost per kilogram did not differ significantly among various categories of contracts.

Production function analysis revealed the importance of age of trees, fertilization, pest control and bagging in mango production. Older trees were naturally larger, leading to higher production. Pest control was reflected in the cost of pesticide and was a positive determinant of production, while bagging was also a positive determinant in that the higher the cost of bagging materials, the higher the production. However, the regression coefficient of foliar fertilizer had a negative sign, implying the excessive application of this chemical.

Gross income from mango amounted to PhP5,542 per tree, which was significantly higher for small contracts, while average profit amounted to PhP2,217 per tree. The BC ratio was 1.7, indicating the lucrative nature of mango production in the study area. A detailed analysis of the distribution of cost and income among the three contracting parties revealed the unique feature of mango farming in the area. The share of spraymen team and financier in cost and income was consistently equal, indicating the equal importance of both labor and capital in mango production. The extremely high share of the total cost borne by spraymen team and financier suggested that it was the contractors, not tree owners, who actually played the major role in bringing about the production potential of seeded mango trees planted and left unattended in backyards. Under the existence of high production risks and the prevailing poor knowledge and capital endowment among the tree owners, the three-party share contract system in the area functioned as the medium for realizing a commodity production.

To further understand the existence of share cropping in mango production in the Philippines, it is necessary to clarify the uncertainties and risks involved in mango production. This will be the topic of the succeeding papers of the authors.

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The International Society for Southeast Asian Agricultural Sciences