Revenue maximising combination of rice monocrop and cassava-based farm enterprises in the Central Niger Delta: A linear programming solution

E. A. ALLISON-OGURU*, M. S. IGBEN & E. C. CHUKWUIGWE
Department of Agricultural Economics & Extension, Rivers State University of Science and Technology, P M B 5080, Port Harcourt , Nigeria
**Corresponding author*

ABSTRACT

The study focuses on empirical analysis of the optimum combination of rice monocrop and cassava-based cropping systems consistent with revenue maximisation, and the identification of limiting resources in the target cropping systems in the Central Niger Delta of Nigeria. It was based on a cost-route study of 100 small-holder crop farmers throughout an entire farming season spanning 15 months. A linear programming model, with five crop production activities and 10 resources constraints, was employed in analysing the data obtained from the field survey. Results indicate that, of the five crop production activities, only the mixed cropping enterprise, cassava/maize, entered the feasible plan at an hectarage of 2 with a programme value of ₦124,000.00. Crop production activities not included in the feasible plan are cassava, yam, swamp rice, and cocoyam. The shadow price of land indicates that it is the only limiting resource to surveyed crop farmers in the area. It has been argued that rice cassava-based farmers in the area should cultivate about 2 ha of cassava/maize in order to maximise farm revenue. To ensure that cassava-based farmers are encouraged to adopt the optimal farm plan, it has been suggested that government evolves appropriate farm credit policy to enable them have easier access to finance with which to acquire more farm land for cultivation. Land consolidation and reform policies and programmes on the part of government have also been advocated, as well as the evolution of an effective marketing arrangement to forestall anticipated price risks associated with increased production and supply of cassava and maize. Also advocated is the boosting by government of its rural development activities so as to encourage non-farm activities to which the quarterly excess family labour of cassava-based farmers in the area could be profitably re-deployed.

Original scientific paper. Received 22 Mar 07; revised 16 Mar 09.

Introduction

Located in the central part of southern Nigeria, the Niger Delta is Africa's largest delta covering an estimated area of 70,000 km^2, a third of which is made up of wetlands. It is home to Nigeria's oil and gas industry and the economic power house of the country. Revenue from the region's oil and gas accounts for about 95 per cent of Nigeria's export earnings and 80 per cent of total annual national income. In addition to crude oil and gas, the Niger Delta region is also endowed with numerous renewable natural resources. The economy of the area can, thus, be described as natural-resource-based (NEST, 1991; Allison-Oguru, 2006).

Notwithstanding the predominance of the oil and gas industry in the region, primary economic activities like fishing, farming, lumbering, and non-timber forest products exploitation account for the economic livelihood of at least 65 per cent of the indigenes resident in the rural area. The wetlands in the Niger Delta support essentially two kinds of farming: farming on the soils of the flood plain and river banks (locally known as abara or fadama) and non-flood plain or dry land farming. Food crops cultivated on flood plain or river bank farms are early maturing ones such that the crops are harvested before inception of the annual flood sometime in July. Farming on such farmland must necessarily commence in November. The reverse is the case with farming on the non-flood plains. These two farming practices are fairly independent of each other because except for labour and perhaps capital, they do not compete for other farm inputs (Allison-Oguru, 2004).

Major crops cultivated on farms in the area are plantain/banana, cassava, yam, cocoyam, swamp rice, potato, sugar cane, and maize. Others are melon, pepper, okra, pineapple, fluted pumpkin, groundnut, and a variety of fruits, vegetables and cash crops such as oil palm, rubber, cocoa, kolanut, etc. By far the most important farm crops in the area are plantain, cassava, cocoyam, rice, and sugar cane. Mixed cropping, which is the most common cropping system practised in the area, involves planting a major crop say plantain or cassava with one or more supplementary crops like maize, cocoyam, sugar cane, pepper, okra, melon, etc. (Allison-Oguru, 1995; Dickson *et al.*, 2002). The object could be to maximise revenue and, or meet farm household's food consumption needs.

With the current emphasis of the Federal Government of Nigeria on production of cassava and rice as potential export crops, coupled with the need to reposition and strengthen farming and other agricultural activities in the country as a whole and the Niger Delta region in particular, it has become imperative that an optimum cassava-based and rice monocrop farming enterprise be evolved as a guide to farmer decision making in the area. Presently, there is no such information available for farmers in the area. The objective of this study is, therefore, to fill this perceived gap in knowledge by providing empirical information on the optimum combination of rice monocrop and cassava-based cropping enterprise in the Central Niger Delta necessary to maximise farm revenue.

Materials and methods

Conceptual framework

In recent times, farm business management experts have made very frequent use of linear programming (LP) models in analysing farm planning and related problems both at the micro and macro-economic levels in Africa and Asia (Sankhayam & Cheema, 1991). Though the theory of mathematical programming from which LP evolved had been known for a long time, its application to agricultural production economics is relatively recent, dating back only to the middle of the 20th century (Aromolaran, 1993). Since then, LP models have been employed in the diagnosis, analysis, and solution of various farm business problems. In Nigeria, the pioneering works of Abalu (1975), Osuji (1978), Onyenwakwu (1980), and Adesimi (1991) are cases in point.

In its simplest form LP is a mathematical technique by which the allocation of limited resources to maximise a desired quantifiable objective can be determined under the assumptions that there is no risk involved and that all the relations between relevant variables are linear and continuous (Charry *et al.*, 1992). Thus, LP is no more than a form of budgeting which, by making use of mathematics, ensures that the optimum budget is found.

Structurally, an LP model has three essential components: an objective function, competitive enterprises with possible alternative methods of producing each; and constraints to attainment of the set objective (Heady & Candler, 1958; Thiam & Ong, 1979; Olayemi & Onyenwakwu, 1999). The objective function of an LP model can take one of several forms. It can be the maximisation of the revenue or gross margin from one or a combination of farm enterprises and minimisation of productions costs, etc. The three components of a typical LP model are illustrated mathematically as follows:

$$\text{Max. } Z = P'X \quad \text{.......(1)}$$

$$\text{subject to } AX \leq B \quad \text{.......(2)}$$

$$\text{and } X \geq 0 \quad \text{.......(3)}$$

where Z = Estimated net annual income or gross margin,

P' = Vector of price coefficients or gross margins,

AX = Vector of activity levels,

B = Vector of available resources.

In linear programming, a process denotes the method of transforming farm inputs into outputs and is indicated by input-output coefficients. Input-output coefficients refer to the quantities of resources required to produce a unit of an activity or output. Different processes are associated with different methods of product transformation, e.g. cultivation of cassava on mounds and cultivation on flat ground are two different processes in cassava cultivation. Activity refers to any enterprise being undertaken. However, the same enterprise or farm product produced by different method or process constitutes different activities for the purpose of LP modelling. In general, there are real, intermediate, disposal and artificial activities in a typical LP model.

One of the advantages of LP is that the dual solution to the primal provides a direct measure of the shadow prices or marginal value productivities (MVP) of the resources. In general, only limiting resources or excluded activities have shadow prices greater than zero. Shadow prices in a maximisation problem are income penalties which show by how much the value of an objective function or programme will increase by increasing the level of resource by one unit (Osuji, 1978; Noori-Naini, 1978).

All of this is not to suggest that linear programming does not have limitations. Some of the limitations, as pointed out by Beneke & Winterboer (1973), Jensen (1977), and Charry *et al.* (1991), are theoretical. For example, the linearity assumption of the basic LP model implies that no risk is present or that farmers are risk-neutral. No account is taken of uncertainty about the actual values of the unit return coefficients (C'), nor of the input-output coefficients (a_{ij}) and the resources available (b_j) which determine the output levels. This deterministic nature of the basic LP model constitutes a fundamental limitation in its application for policy formulation.

Notwithstanding the limitations of the static LP model, it stands out as the most widely used mathematical programming technique for analysis of resource allocation efficiency. Many studies in Africa (Clayton, 1961; Heyer, 1971; Shapiro, 1973; Abalu, 1975) have successfully used the technique to solve a variety of farm management problems.

Sources and types of data

The data used for the study were obtained from small-holder rice monocrop and cassava-based crop farmers drawn from three of the eight local government areas (LGAs) in Bayelsa State, Nigeria. The data comprised farm land availability and endowment, farm labour availability and endowment, farm capital availability and the input-output coefficients of the various resources endowment and the crop production activities involved.

Method of data collection

A three-stage sampling technique was used in collecting the data for the study. The first stage involved the purposive selection of three of the eight LGAs in the study area, based on preponderance of rice monocrop and cassava-based crop production activities. The second stage involved random selection of 14 farming communities from a list of such communities in the LGAs. Lastly, in each farming community so selected, five farm households were randomly selected and studied. This gives a sample size of 210 farm households during the first phase of the study, which was focused primarily on reconnaissance survey of farm and farm household in the area.

The cost-route data collection procedure was used in the second phase of the study which involved an in-depth study of 100 out of the 210 farm households surveyed in the earlier phase. The principal feature of the cost-route survey method is the frequent interviewing of sample farm households throughout the cropping season. For the purpose of the study, the interviews were conducted on weekly basis throughout the cropping season. The basis of selection of the 100 farm households included in the in-depth study was farmers' willingness to participate in the study. With the aid of trained enumerators drawn from the Agricultural Projects and Extension Services of Shell Petroleum Development Company of Nigeria Limited (SPDC), and the Bayelsa State Ministry of Agriculture and Natural Resources, data on weekly crop farming activities were collected from the 100 farm households surveyed for a period of 15 months using pre-designed questionnaire.

Method of data analysis

The data for the study were analysed using a linear programming model adapted from Noori-Nami (1978) and Adesimi (1991).

The LP model specified for the study is given as follows:

$$\text{Max. Z} = \sum_{i=1}^{m} C\,Xi \tag{4}$$

subject to:

$$\text{Max. Z} = \sum_{i=1}^{n} a_{ik}\,X_i \leq b_k \tag{5}$$

and

$$X_i \geq 0 \tag{6}$$

where Z = Sum of the net annual returns of the activities in the crop year surveyed.

C_i = Net annual return per hectare of the i^{th} activity in the crop year surveyed.

X_i = Hectarage devoted to the i^{th} activity in the crop year surveyed.

n = Total number of activities in which crop appears.

m = Total number of activities.

a_{ik} = Per hectare requirement of the k^{th} resource by the i^{th} activity in the crop year surveyed.

b_k = Level of the k^{th} resource available in the crop year surveyed.

The LP model specified in equations (4) through (6) has five crop production activities and 10 resource constraints. The crop production activities are cassava sole, yam sole, swamp rice sole, cocoyam sole; and cassava and maize mixture. The 10 resources constraints are farm land (LD), 1st quarter family labour (FLAB 1), 2nd quarter family labour (FLAB 2), 3rd quarter family labour (FLAB 3), 4th quarter family labour (FLAB 4), 1st quarter hired labour (HLAB 1), 2nd quarter hired labour (HLAB 2), 3rd quarter hired labour (HLAB 3), 4th quarter hired labour (HLAB 4), and capital (CAP).

Results and discussion

Matrix of input-output coefficients

The matrix of input-output coefficients which specifies the various inputs employed by the farmers in farm production, and the net farm income per unit of crop production activity included in the LP model are shown in Table 1. Note that in this model, all plantain-based enterprises have been excluded, thus, leaving only five crop production activities, namely cassava sole, yam sole, swamp rice, cocoyam sole, and cassava and maize mixture (Allison-Oguru, 2004).

Mechanics of programming

The LP model specified theoretically in equations (4) through (6) is presented empirically using the information furnished in Table 1 as follows:

Maximise $Z = 63X_1 + 41X_2 + 45X_3 + 25X_4 + 62X_5$ .... (7)

Subject to the following input constraints

(a) $X_1 + X_2 + X_3 + X_4 + X_5 \leq 2.00$ Ha ... (8)

(b) $30.8X_1 + 47.5X_2 + 27.66X_3 + 40.46X_4 + 25.65X_5 \leq 63.04$ mandays .... (9)

(c) $52.44X_1 + 35.98X_2 + 28.33X_3 + 59.00X_4 + 28.72X_5 \leq 78.55$ mandays .... (10)

(d) $22{,}75X_1 + 29.32X_2 + 25.96X_3 + 69.7X_4 + 23.77X_5 \leq 52.29$ mandays .... (11)

(e) $14.88X_1 + 68.24X_2 + 45.3X_3 + 67.00X_4 + 15.27X_5 \leq 62.40$ mandays .... (12)

(f) $7.72X_1 + 9.72X_2 + 5.67X_3 + 8.28X_4 + 5.25X_5 \leq 15.76$ mandays .... (13)

(g) $13.11X_1 + 7.89X_2 + 7.08X_3 + 14.75X_4 + 7.18X_5 \leq 17.24$ mandays .... (14)

(h) $4.66X_1 + 7.33X_2 + 5.69X_3 + 1.53X_4 + 4.86X_5 \leq 10.71$ mandays .... (15)

(i) $3.27X_1 + 13.97X_2 + 9.27X_3 + 16.75X_4 + 3.81X_5 \leq 17.48$ mandays .... (16)

(j) $16X_1 + 17X_2 + 13X_3 + 23X_4 + 19X_5 \leq 17.6$ naira .... (17)

Programming results and optimum farm plan

The result of the LP model indicates that, of the five basic crop production activities specified, only one: cassava/maize enters the feasible solution (Table 2). The hectarage allocated to this cropping enterprise was two with a programme value of ₦124,000.00. If profit maximisation is the underlying motive of farm enterprise or the behavioural principle guiding resource use and allocation decisions, then farmers in the area who are into rice monocrop and cassava-based cropping enterprises, should allocate their 2 ha of land to the cultivation of cassava/maize.

TABLE 1

Linear Programming Input-Output Coefficients Matrix of the Crop Enterprises Surveyed

Activity→ Constraints↓	*C* X_1	*Y* X_2	*SR* X_3	*Cy* X_4	*CM* X_5	X_6	X_7	X_8	X_9	X_{10}	*Value of constraints*
NFI	60	41	45	27	65						≥ 46.6
LD	1	1	1	1	1						≤ 2.00
FLAB 1	30.8	47.5	27.66	40.46	25.65	-1					≤ 63.04
FLAB 2	52.44	35.98	28.33	59	28.72		-1				≤ 78.55
FLAB 3	22.75	29.32	25.96	69.7	23.77			-1			≤ 52.29
FLAB 4	14.88	68.24	45.3	67	15.27				-1		≤ 6.92
HLAB 1	7.72	9.72	5.67	8.28	5.25	1					≤ 15.76
HLAB 2	13.11	7.89	7.08	14.75	7.18		1				≤ 17.24
HLAB 3	4.66	7.33	5.69	1.53	4.86			1			≤ 10.71
HLAB 4	3.27	13.97	9.27	16.75	3.81				1		≤ 17.48
CAP	16	17	13	23	19					-1	≤ 17.6

Source: Computer printout of LP model

Given the current crops production function and the input and output prices prevailing in the market, it is advisable that crop farmers in the area do away, for now, with the monocropping enterprises not included in the model's optimum farm plan shown in Table 2. These crop enterprises are cassava, yam, swamp rice, and cocoyam. This is because forcing any of these sole crop enterprises into the programme would lead to reduction rather than increase in programme value. This implies reduction in the net farm income that the average farmer practising rice monocrop and cassava-based cropping system could earn annually.

The marginal opportunity cost of capital (MOC) reported in Table 3 measures by how much the programme value will be reduced if any of the non-basic farm production activities mentioned is forced into it. For example, if cassava sole (C) is forced into the optimal farm plan, net farm return will decrease by ₦20,000.00. The corresponding figures for the other crop enterprises are ₦21,000.00, ₦17,000.00, and ₦37,000.00, respectively, for yam monocrop (Y), swamp rice monocrop (R), and cocoyam monocrop (Cy). The most detrimental of all excluded activities is, therefore, cocoyam monocrop (Cy) while the least detrimental is swamp rice monocrop (R).

Out of the 10 resources specified in the LP model, only three were fully utilized at the satisfying solution. These resources are farm land, capital, and hired labour for quarter two. The shadow price for the fully utilized resources were ₦62,000.00 for land, and zero for both capital and hired labour for quarter two. These results indicate that net farm income in the study area could be increased by ₦62,000.00 per additional hectarage of farm land allocated for cassava/maize cropping enterprise. It can, therefore, be argued that whereas farm land is a limiting resource in the area, capital and hired labour are relatively non-limiting.

About 11.74 mandays of family labour for quarter one, 23.99 mandays for quarter two; 4.75 mandays for quarter three; and 39.38 mandays for quarter four were left unused. Similarly, 5.26 mandays of hired labour for quarter one; 0.99 mandays for quarter 3; and 9.86 mandays for quarter four were left unused. These results suggest that there are not enough of the other complementary resources on the farm to be combined with these unused resources in order to increase net farm income. The results also suggest that the labour requirements for cassava/maize cropping enterprise in the study area are less than what the farmers can muster. In order to fully utilise these idle farm labour resources, therefore, farmers would need to increase their current hectarage or

TABLE 2

Basic Optimal Resources Use and Allocation Pattern of the Crop Enterprises Surveyed

Basic activity		*Fully utilised resources*		*Unused resources*	
Crop mixture	*Hectarage*	*Resource*	*Shadow price (₦)*	*Resource*	*Surplus*
Cassava monocrop	0.00	Land	62,000	FLAB 1	21.72
Yam monocrop	0.00			FLAB 2	3.24
Swamp rice monocrop	0.00	Capital	0.00	FLAB 3	16.26
Cocoyam monocrop	0.00		0	FLAB 4	6.26
Cassava/Maize	2	HLAB 2	0.00	HLAB 1	5.26
				HLAB 3	0.99
				HLAB 4	9.86
Programme value ₦124,000.00					

Source: Computer printout of LP model No. 3 in Allison-Oguru (2004)

TABLE 3

Marginal Opportunity Cost (MOC) of the Non-Basic Activities in the LP Model

Non-basic activity	*Marginal opportunity cost (MOC) (₦)*
Cassava monocrop (C)	₦20,000.00
Yam monocrop (Y)	21,000.00
Swamp rice monocrop (R)	17,000.00
Cocoyam monocrop (Cy)	37,000.00

Source: Computer printout of linear programming model No. 3 in Allison-Oguru (2004)

redeploy the excess labour to other farm or non-farm employment such as fishing, gathering of non-timber forest products (NTFP), lumbering, and trading.

In order to increase farm hectarage in the area, government needs to embark on a farm credit policy that makes it easier for farmers to access the needed finance to acquire more farm land and other complementary farm inputs. In the long-run, it might also be necessary for government to evolve policies and programmes of land consolidation and reform, and to encourage group or collective farming. Government policies that encourage rural development activities in the area could also provide the needed environment for non-farm activities to thrive, thereby, providing avenues for the re-deployment of some of the observed excess quarterly farm labour.

Theoretically, it can be argued that should cassava-based crop farmers in the area adopt the optimal farm plan, it would lead to increased production and supply of cassava and maize. Given the poor marketing system for farm produce in the area, such anticipated increase in production and supply could lead to marketing and price risks. This scenario is probable theoretically but, in practice, it is not automatic, given the resource-poor status of crop farmers in the area and the time lag required for them to mobilise the resources required to adopt the recommended farm plan. However, cassava and maize are high value crops in great demand locally and internationally. Government through its agencies should, therefore, put in place an effective marketing arrangement for cassava and maize, in order to forestall any anticipated price risk, thereby, encouraging cassava-based crop farmers in the area to adopt the optimal farm plan.

Conclusion

The study has confirmed that mixed cropping in the Central Niger Delta of Nigeria is generally more income generating than sole or monocropping. For example, out of the five crop production activities included in the LP model, the only one that enters the feasible solution is a mixed cropping enterprise: cassava/maize. Given the crops production function in the area, the prevailing prices of farm inputs and outputs, and the experience of crop farmers, the cultivation of 2 ha of cassava/maize is seen as the revenue maximisation combination of cassava-based cropping systems in the area.

The study has further shown that farm land relative to capital and labour is the most limiting resource to cassava/maize crop farming in the study area, *ceteris paribus*. This is evidenced in the positive value of the shadow price of land as a farm resource. It can, therefore, be argued that cassava-based crop farmers in the Central Niger Delta of Nigeria who wish to maximise revenue should cultivate 2 ha of cassava/maize. In anticipation that the adoption of this cropping pattern could lead to increase in production and supply of cassava and maize, thus, generating marketing and price risks, it is suggested that government undertakes proactive measures to ensure that adequate marketing arrangements for cassava and maize are put in place to forestall such anticipated price risks.

It is further suggested that government gives a boost to its rural development activities in the area so as to encourage non-farm activities to which cassava-based crop farmers could redeploy all or part of their excess quarterly farm labour. A government's farm credit policy that makes it easier for cassava-based farmers in the area to access finance, with which to acquire farm land, promises to be part of the solution to increasing hectarage of cassava/maize cultivated. In the long-run, it is argued that government evolves policies and programmes of land consolidation and reforms aimed at encouraging group and collective farming.

REFERENCES

Abalu, G. O. F. (1975) Optimal investment decisions in crop production: A linear programming approach. *J. agric. Econ.* **26**, 383-389.

Adesimi, A. A. (1991) Farm enterprise combination and resource use among small-holder farmers in Ijebu, Nigeria: In *Issues in African Rural Development*. (Cheryl R. Doss and Carol Olson, ed.). Winrock International Institute for Agricultural Development.

Allison-Oguru, E. A. (1995) Report on overview and evaluation of existing data on agronomy/ agroeconomics in the Niger Delta. *Report submitted to Euroconsult, Managing Consultants, Niger Delta Environmental Survey (NDES) Phase I.*

Allison-Oguru, E. A. (2004) *Economics of resource allocation by small-holder farmers in Bayelsa State of Nigeria.* (PhD Thesis.) Rivers State University of Science and Technology, Port Harcourt, Nigeria.

Allison-Oguru, E. A. (2006) Socio-economic characteristics of the Niger Delta. In *The Renewable Natural Resources of the Niger Delta: Options for its Sustainable Management.* (A.U. Ezealor and O.A. Akinsola, ed.), pp.15-31. Nigerian Conservation Foundation, Lagos, Nigeria.

Aromolaran, A. B. (1993) *Multiple Objectives and Resource Allocation Behaviour of Small Farmers in Ifedapo Area of Oyo State, Nigeria*. (PhD Thesis.) University of Ibadan, Ibadan, Nigeria.

Beneke, R. R. & **R. Winterboer** (1973) *Linear Programming Applications to Agriculture.* Iowa State University Press, Ames, Iowa.

Charry, A., A. G. Daramola & **J. L. Dillon** (1992) Applications of mathematical programming in farming systems research and extension: A methodological outline. *Agric. Syst. Afr.* **2(**1), 31-37.

Clayton, E. S. (1961) Economic and technical optima in peasant agriculture. *J. agric. Econ.* **14**, 337-346.

Dickson, A. A., Allison-Oguru, **E. A.** & **Isirimah, N.O.** (2002). Fertility capability classification-based land evaluation in relation to socio-economic conditions of small holder farmers in Bayelsa State of Nigeria". *Indian J. agric. Res.* **36** (1), 10-15.

Heady, E. O. & **Candler** (1958) *Linear programming Methods*. Iowa State University Press, Ames, Iowa.

Heyer, J. (1971) A Linear Programming Analysis of Constraints on Peasant Farms in Kenya. *Fd Res. Inst. Stud.* **10**, 55-67.

Jensen, R. (1977) *Farm Management and Production Economics.* In *A Survey of Agricultural Literature*, vol. 1. (Lee R. Martin, ed.) Minnesota University Press, St. Paul.

Nigerian Environmental Study Action Team (NEST) (1991) *Report of the environmental study action team.* NEST, *Lagos*, Nigeria.

Noori-Naini, M. S. (1978) *An Economic Analysis of Resource Allocation Issues in traditional Agriculture: A Case Study of the Neighbour District of Iran, 1969-1970*. (PhD Thesis.) Cornell University, Ithaca, New York.

Olayemi, J. K. & **Onyenwakwu, C. E.** (1999) *Quantitative Methods for Business Decisions*. Department of Agricultural Economics, University of Ibadan, Nigeria.

Oyenwakwu, C. E. (1980) *A Linear Programming Analysis of Inter-Regional Competition in Nigerian Agriculture.* (PhD Thesis.) University of Ibadan, Ibadan, Nigeria.

Osuji, L. O. (1978) *Resource Productivity in traditional Agriculture: A Case Study of Selected Villages in Imo State of Nigeria*. (PhD Thesis.) University of Ibadan, Ibadan, Nigeria.

Sankhayam, P. L. & **Cheema, H. S.** (1991) Using linear programming models for generating optimum farm plans - An expository". *Indian J. agric. Econ.* **46**(4), 601-612.

Shapiro, K. H. (1973) Efficiency and Modernization in African Agriculture: A Case Study of Geita District of Tanzania. (PhD Thesis.) Stanford University, Standard.

Thian, B. & **Ong, S.** (ed.) (1979) *Readings in Asian Farm Management*. Singapore University Press, Singapore.