Hybrid tomato seed production practices and economic benefits: A case study in a rainfed area of Khon Kaen Province, Northeast Thailand

Chalee Gedgaew[1], Suchint Simaraks[1] and A. Terry Rambo[1,2*]

ABSTRACT: Northeast Thailand has been one of the most important locations in the world for hybrid tomato seed production. Nowadays, production is confined to only a few villages and a small number of long term growers mostly in rainfed rice areas. This study was designed to examine the management practices employed in the production and to assess the economic benefits received by the long term growers. A rainfed production site of Mueang District, Khon Kaen Province was purposively selected as the study site. In-depth, semi-structured interviews, questionnaires, and group interviews of long term growers were employed to collect data. Hybrid tomato seed production is a very complex operation which requires appropriate knowledge, skills and self-discipline and advanced technologies. However, these long term growers can adapt, accept and conform to the seed companies' requirements in the production process. They can carry out crop management and technical practices in order to produce high quality seed and achieve profitability. On average, long term growers earn a gross income of US$ 30,739.8, 36,426.9 and 34,388.2 per hectare from planting tomatoes in double rows in open-air plots, double rows in netted houses and a single row in netted houses. The net return per labor day for all cultivation patterns is higher than the daily minimum wage for laborers in both farm and non-farm jobs. Therefore, high profitability acts as an incentive for long term growers to continue engaging in the seed production.

Keywords: economic profit, net return per labor day, crop management, technical practices

Introduction

Since the early 1980s, Northeast Thailand (NET) has emerged as one of the most important locations in the world for hybrid tomato seed production (HTSP). Attracted by cheap labor and a suitable growing environment, many international seed companies have established production sites in the NET. Their production model relies on using local Thai companies as their representatives to make contract agreements between individual small farmers and the company (Rosset et al., 1999; Kowithayakorn, 2002). In 1995 Asgrow, the world's largest seed company based in the United States, obtained 90% of its hybrid tomato seeds for global sales from Thailand and most of this was produced in NET (Rosset et al., 1999). However, in the late 1990s, production has shown signs of instability due to uncontrollable costs of production and increased labor costs (Saenjan, 1998), and some companies have moved their production to China and Vietnam where production costs are lower than in NET (Nikornphun, 1999; Rosset et al., 1999).

In the 2013/14 crop year, a preliminary survey showed that HTSP has largely collapsed and is concentrated in only certain villages. On the

[1] Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

[2] The East-West Center, Honolulu, Hawaii 96848-1601, USA.

* Corresponding author: trryrambo@yahoo.com

other hand, trends of Thailand's hybrid tomato seed export volume and value are steadily increasing to 38.1 tons and 638.2 million baht in 2014 (Thai Seed Trade Association, 2015). An exploratory field study on HTSP in NET in the crop year of 2014/15 was conducted. It was found that initially seed production expanded into many villages in both rainfed and irrigated rice areas. However, recently production in irrigated areas has declined while it has gradually expanded in rainfed areas. Production is confined to only a few villages where it is practiced by a small number of long time growers. Hence, production sites will continue to shift from certain areas while remaining stable in others (Gedgaew et al., n.d.b.). The field study identified a number of factors influencing long term production. It was found that the existence of knowledgeable and skillful growers is a vital factor for sustainable long term production and that the ability to earn high incomes was a key factor in the decision of growers to continue producing seed (Gedgaew et al., n.d.a). This finding concerning the importance of high incomes was similar to that found in previous studies in NET (Benziger, 1996), in India (Sudha et al., 2006) and in Bangladesh (Sarkar et al., 2011). It is this linkage between the knowledge and skill of the growers and their ability to carry out the very complex operations involved in HTSP that generates high incomes. Furthermore, in recent year seed companies have improved their production practices and have required the growers to conform to the companies' new designed tasks. However, detailed information about the complex current production system has not been gathered nor have the economic benefits been studied. This information will be useful for the future expansion of HTSP. Hence, this study was undertaken with the following objectives: 1) to identify and examine the complex management practices employed in HTSP by long term growers and 2) to assess the economic benefits to long term growers of HTSP.

Materials and methods

Study site

The study site was purposively selected in a rainfed rice area of Lat Na Phiang village, Sawathee Sub-district and Wang To village, Ban Kho Sub-district, Mueang District, Khon Kaen Province. These two villages have a similar ecology and are adjacent to each other. Both have been producing hybrid tomato seed for a long time (Kerdsuk et al., 1996; Gedgaew et al., n.d.b.).

Methodology

Secondary data on the study site was obtained from the authorities of two sub-district municipalities. In-depth, semi-structured interviews were conducted with 15 villagers (key informants) who have been living in these villages for a long time and are knowledgeable about the village's context and the history of HTSP. These key informants estimated the number of total hybrid tomato seed growers in this production site to be about 200. These growers are located in the in the lower part of the undulating land and in non-flood plain land. The snowball sampling technique was use to identify long term growers with more than 10 years experience for in-depth

interview. In-depth interviews were carried out with 39 farmers. Of this number 22 were growing tomatoes in the lower part of the undulating land and 17 were growing in non-flood plain land. These growers were also interviewed by a short questionnaire to obtain information about their household resources, cropping systems and HTSP, i.e., production processes, techniques, costs and returns. A group interview of the growers was also conducted.

Data analysis

Economics concepts and measurement criteria were used for data analysis. These included: 1) Opportunity cost which refers to the cost of using any kind of inputs or what the growers must give up to use the inputs (Salvatore, 2007; Thomas and Maurice, 2008). In this study the opportunity cost of a) the growers' labor was set as Thailand's national daily minimum wage of US$ 8.8 (Herbert Smith Freehills-Employment notes, 2016) and b) the interest rate of invested money was set as 0.5% which is the average interest rate for savings (Bank for Agriculture and Agricultural Cooperatives, 2016); 2) Explicit cost refers to cash payments of the growers for hired, rented or purchased inputs required; 3) Implicit cost refers to the value of the growers' inputs used in their production activities; 4) Fixed cost is the summation of the amount paid for fixed inputs; 5) Variable cost is the sum of the amount spent for each of the variable inputs used that increases as HTSP increases; 6) Total cost is the sum of fixed and variable costs; 7) Gross income is the hybrid tomato seed yield multiplied by its price; 8) Net income is the difference between gross income and total cost; 9) Net cash income is the difference between total cash income and total cash expenses (Kay, 1981); and 10) Net return per labor day is net income plus variable income divided by total labor days (FAO, 2016).

Results and discussion

Profile of the long term hybrid tomato seed growers

The farming system of the long term growers in this site is based on rice. Wet season rice is planted in the lower part of the undulating land and in non-flood plains land in the rainy season. Seeds and fresh vegetables for sale, such as tomatoes, bitter gourds, luffa gourds, yard long beans, chilies and cucumbers, are then planted after harvesting the wet season rice. Cassava, sugarcane and rubber are the main crops in the uplands. Most of the growers (82.1%) cultivated hybrid tomato seeds in double rows in beds in open-air plots. The majority of the growers (64.1%) cultivated tomato plants in 2 plots, each plot with a different variety. The mean total land area used for HTSP per grower was 0.16 hectare, which is same as reported by Martwanna and Lertrat (2007). The majority of the growers entered into contracts with 1 - 2 seed companies each production season. They diversified varieties and contracts in order to spread the risk which affected their incomes. In general HTSP provided an average annual gross income per grower of US$ 4,814.

Cultivation patterns in hybrid tomato seed plots

Nowadays, seed companies have developed their own planting techniques in order to meet their standards for seed quality. Three different plot cultivation patterns for female varieties planting are required by the seed companies: 1) planting in double rows in beds in open-air plots, 2) planting in double rows in beds in netted houses and 3) planting in single rows in beds in netted houses. All male plant varieties were planted in double rows in beds close to the female varieties beds either in open-air plots or in netted houses.

HTSP management practices by the long term growers

The hybrid tomato seed growers engage in the following practices:

1. Crop management practices

1.1 Planting season. The planting season is from October to early April.

1.2 Land use plan. Some hybrid tomato seed growers who desire to plant in early October must grow short-duration rice or stop growing rice on a particular plot that will be used for growing tomatoes.

1.3 Soil and plot location. The growers usually select plots with well-drained soil. All plots must be in the low land near water sources. Most of the plots are selected immediately after harvesting the wet season rice because these plots are relatively free from pests and diseases. If however the hybrid tomatoes suffered from wilt disease or root-knot nematodes, then the plots need to be changed or rotated. Nowadays, some growers cannot change the plots due to limited land availability. However grafted seedling technology can reduce disease problems.

1.4 Planting plan, tomato seed varieties and company contracts. Most growers prefer to sign two contracts or grow two tomato seed varieties (two plots) with the same or different companies in a single production season because of the high instability of seed yields which in turn depends on the tomato variety.

1.5 Plot management. The timing of planting the female seedlings in each plot varies by 15 - 20 days. The growers always spread the planting of female variety seedlings of each variety over a 5 - 7 day period. These practices spread out the demand for labor.

1.6 Labor management. Growers use only their household labor for all operations except for emasculation and pollination which are labor intensive and require a team of skillful pollinators. Most growers prefer to hire relatives to help them on an exchange paid labor basis. In addition, some growers make contracts with the laborers both in their own village and nearby villages by giving them advance payments.

2. Technical practices

2.1 Seedling cultivation. Some companies provide foundation seeds of male and female (parental varieties) to the growers in September or October. These seeds are cultivated for about 25 days after which the seedlings can be transplanted into the plots. However, some female varieties need grafting for wilt disease tolerance. In general, female scions are grafted on rootstocks of eggplants or other high tolerance tomato varieties. It takes 22 - 25 days before the rootstock and scion seedlings

can be grafted. After grafting the seedlings are placed in an enclosed plastic container for 5 - 10 days and then in the open-air for 5 - 10 days to be ready for transplanting into the plots.

2.2 Land and plot preparation. The first tillage is done by two wheeled hand tractors or four wheeled tractors after which the exposed soil is allowed to dry in the sun for about 5 - 7 days. Bed harrowing and raising are done with two wheeled hand tractors. The beds are about 25 to 30 cm in height, 80 cm to in width for single row planting and 100 cm for double row planting. The spacing between beds is 50 cm. Each bed is covered by plastic sheets. Then the netted house is constructed after the bed is raised and covered with plastic sheets.

2.3 Planting. In double row beds both in open-air plots and in netted houses, male and female variety plants are spaced within 40 - 50 cm of each other and the rows are spaced 40 - 60 cm apart. In single row beds in netted houses, female plants are planted with a row spacing of about 40 - 50 cm. However male plants are planted in double rows per bed. In staggered planting, growers normally plant the male variety 3 - 10 days earlier than the female variety. However some growers plant the male variety twice with each planting 3 - 5 days apart in order to have sufficient pollen for when the female is ready. Female seedlings are commonly planted 5 - 7 days apart in order to spread out the growers' workload.

2.4 Staking and pruning. Only female plants are normally staked and pruned in order to facilitate hand emasculation and pollination and to protect the fruit from touching the soil and thus avoid rotting. Growers have to prune the plants in order to retain only 4 branches per plant.

2.5 Maintenance of purity of the parental varieties. Field inspection for purity of the parental varieties is always done by the growers and the company staff at the beginning of the season. Removal of off-type which contaminates and lessens purity is carried out jointly by the growers and the company staff.

2.6 Irrigation. Almost all growers irrigate their plots by furrow irrigation every 5 - 7 days. A few growers use a drip irrigation system in order to save water and reduce labor time.

2.7 Fertilizer application. Manure and organic and chemical fertilizers are applied to the plots before the beds are raised. Male plants are fertilized three times - 3 days, 6 days and 20 days after transplanting. For female plants, growers dilute chemical fertilizer in water before watering the plants directly 10 days after transplanting. About 20 days after transplanting or before pollination, hand-pulled plows are used to open tracks in the furrows and apply the chemical fertilizers or manure before covering with soil. After pollination some growers broadcast chemical fertilizer in furrow irrigation or dilute chemical fertilizer in water and pump the fertilizer solution through drip irrigation every week until harvesting.

2.8 Chemical spraying is normally done every 5 - 7 days depending on the presence of diseases and pests.

2.9 Emasculation of the female line flowers starts 25 - 30 days after transplanting. Flowers of the first panicle are removed. Second panicles onward are emasculated 2 - 3 days before anthesis while their petal color is greenish

white. Emasculation is done by using forceps to remove the stamen from the flower buds.

2.10 Pollen collection. Male flower buds with complete yellow petals are picked the day before pollination. The anthers are separated and dried on a tray in the shade. In the evening, the anthers are collected in envelopes and put in a box for with calcium oxide for one night. The pollen is then extracted in the early morning the next day by shaking the contents in a closed container with a fine mesh screen.

2.11 Pollination. The emasculated flowers are pollinated on the day of flowering by using a pollination ring worn on the pollinator's finger. The female stigmas are dipped into the pollen tube. Then 2 - 3 sepals are removed from the flowers in order to identify the pollinated flowers as well as the hybridized fruit at the time of harvest. Three to four flowers are pollinated in a cluster and 3 - 4 clusters on a branch. Pollination in each plot is done every day for about 21 - 30 days.

2.12 Post-pollination management. After the final round of pollination, the female plants are immediately top-dressed and pruned to remove the new tips and flowers so as to reduce competition for nutrients, to prevent self-pollination and to avoid seed contamination.

2.13 Harvesting. Tomatoes ripen 30 - 40 days after pollination. Before harvesting the clipped sepal must be carefully checked in order to identify the hybrid fruits. Growers collect the ripened fruits in plastic sacks or crates and place them in a cool dry place for one night only.

2.14 Seed extraction. A mechanical wet seed extractor is used for crushing and separating the seeds and gel from the pulp. The seeds are put into a clean fine-mesh bag. Then the seed bag is placed into a plastic container which is filled with clean water and a pectinase enzyme for one night of fermentation. In the early morning, between 3.00 to 7.00 a.m., the washing process is repeated 2 - 3 times until the seeds are clean. All wet seeds are collected at a central place in the village before 8.00 a.m. and then are transported to the companies' processing house.

2.15 Seed drying. Some companies prefer to buy dry seeds. The growers must dry the washed seeds on a flat tray made of nylon net mesh and dry them in sunlight for 3 - 4 days. Growers then submit all the dried seed on that day to the company at the appointed place in the village.

2.16 Seeds standards. Tomato seed standards differ among companies but the growers indicated that these standards include a genetic purity rate of between 98% and 100%, a germination rate of 90% and 98% and moisture content rate less than 6%.

All of the long term growers in this study site are able to practice a very complex system of production in terms of crop management and technical practices to satisfy the companies' requirements.

Labor use in HTSP

Table 1 presents data on the use of labor for the various activities of HTSP for different cultivation patterns. Average labor use per hectare of all cultivation patterns is higher than in India (Sudha et al., 2006) and in Bangladesh (Sarkar et al., 2011) which averaged 613.0 and

580.0 labor days per hectare, respectively. The higher labor per hectare found in this study is because of additional labor needed for staking and pruning, emasculation and pollination and post-pollination cultural management. The proportion of household labor use in the study is 78 - 93% of the total labor use which was much higher than in India which was about 15.0% (Sudha et al., 2006).

Table 1 Labor use (labor days per hectare) for HTSP by different cultivation patterns, in 2014/15

Activity	Double rows in open-air plot	Double rows in netted house	Single row in netted house
1. Receiving the seedling and transport	1.9	1.9	0.6
2. Land and plot preparing	30.0	44.4	40.6
3. Netted house construction	0	37.5	37.5
4. Planting	13.8	15.6	14.4
5. Staking and pruning	392.5	312.5	156.3
6. Irrigation	46.9	37.5	28.1
7. Fertilizing	78.8	75.0	37.5
8. Spraying	35.6	37.5	28.1
9. Emasculation and pollination	941.3	937.5	593.8
10. Post-pollination cultural management	353.1	281.3	140.6
11. Harvesting	156.9	125.0	125.0
12. Seed extraction	117.5	93.8	125.0
13. Seed drying	31.3	50.0	0
Total	2,199.6	2,049.5	1,327.5

Costs and returns of HTSP

The average total cost per hectare for double rows in beds in open-air plots was US$25,434.9, for double row in beds in netted houses was $28,725.9 and for single rows in beds in netted houses was 16,818.1 (**Table 2**). Planting in single rows in beds in netted houses cost the least because the number of tomato plants per plot is one half of other cultivation patterns. Variable costs were the largest production cost. Out of the total production cost, 63.0% - 76.0% was non-cash expenses especially household labor which constituted 53.0% - 70.0% of the cost. Most growers primarily use household labor to carry out the production work because they desired to reap a higher cash income from the production.

The average yield of double rows in beds in open-air plots, double row in beds in netted houses and a single row in beds in netted houses was 137.6, 138.4 and 135.6 kg per hectare, respectively (**Table 3**). These yields were higher than in India and in Bangladesh which were 49.3 and 96.0 kg per hectare, respectively (Sudha et al., 2006; Sakar et al., 2011) but lower than the average yield in Taiwan which was 140.0-200.0 kg per hectare (Tay, 2002). Earnings on labor inputs were also high with the average net return per labor day higher than the daily minimum wage of US$ 8.8. In addition, gross income was higher than for commonly cultivated cash crops by smallholders in rainfed areas of NET. As one tomato seed grower remarked, *"I got less than US$ 2,920.0 from growing 1.1 hectares of sugarcane but I got US$ 5,840.0 to 8,760.0 from growing tomato seeds on only 0.16 hectare"*.

Table 2 Cost structure of HTSP per hectare (US$)[1/], in 2014/15

Item	Double rows in open-air plot			Double rows in netted house			Single row in netted house		
	Cash	Non-cash	Total	Cash	Non-cash	Total	Cash	Non-cash	Total
A. Variable costs	**6,016.3**	**17,886.6**	**23,902.9**	**10,424.5**	**15,107.0**	**25,531.5**	**6,304.7**	**9,061.6**	**15,366.3**
1. Labor	1,391.9	17,871.5	19,263.4	2,860.7	15,081.1	17,941.8	2,579.9	9,045.9	11,625.8
2. Plough (by four wheeled tractor)	137.4	0	137.4	109.5	0	109.5	63.9	0	63.9
3. Inputs credit from the seed company	3,323.7	0	3,323.7	6,068.6	0	6,068.6	2,642.2	0	2,642.2
4. Fuel costs	567.9	0	567.9	558.4	0	558.4	401.4	0	401.4
5. Food and beverage costs	229.0	0	229.0	474.4	0	474.4	428.8	0	428.8
6. Materials cost	366.4	0	366.4	352.9	0	352.9	188.5	0	188.5
7. Interest on money-capital	0	15.1	15.1	0	25.9	25.9	0	15.7	15.7
B. Fixed costs	**0**	**1,532.0**	**1,532.0**	**0**	**3,194.4**	**3,194.4**	**0**	**1,451.8**	**1,451.8**
1. Depreciation	0	802.9	802.9	0	2,464.5	2,464.5	0	1,050.4	1,050.4
1.1 Two wheeled hand tractor	0	610.5	610.5	0	486.5	486.5	0	243.2	243.2
1.2 Netted house	0	0	0	0	1,824.7	1,824.7	0	730.6	730.6
1.3 Gas water pump	0	91.6	91.6	0	73.0	73.0	0	36.5	36.5
1.4 Engine sprayer	0	70.1	70.1	0	55.8	55.8	0	27.9	27.9
1.5 Hand tools and equipment	0	30.7	30.7	0	24.5	24.5	0	12.2	12.2
2. Land rent	0	729.1	729.1	0	729.9	729.9	0	401.4	401.4
C. Total cost (A + B)	**6,016.3**	**19,418.6**	**25,434.9**	**10,424.5**	**18,301.4**	**28,725.9**	**6,304.7**	**10,513.4**	**16,818.1**

Note: [1/] At 2015 exchange rate of 34.2524 Baht to one U.S. dollar

Table 3 Returns of HTSP per hectare by cultivation pattern, in 2014/15

Item	Double rows in open-air plot	Double rows in netted house	Single row in netted house
1. Average yield (kg)	137.6	138.4	135.6
2. Average price (US$ per kg)	223.4	263.2	253.6
3. Gross income (US$) (1 × 2)	30,739.8	36,426.9	34,388.2
4. Total cost (US$)	25,434.9	28,725.9	16,818.1
5. Cash payments (US$)	6,016.3	10,424.5	6,304.7
6. Net income (US$) (3 - 4)	5,304.9	7,701.0	17,570.1
7. Net cash income (US$) (3 - 5)	24,723.5	26,002.4	28,083.5
8. Net return per labor day (US$)	11.2	12.5	22.0

Although HTSP generates high profits, only farmers with the knowledge, skills and self-discipline needed to methodically carry out to the complex management practices required to produce high quality seed are able to engage in this activity on a long term basis. Interestingly, the growers themselves do not recognize the importance of these individual capabilities but

rather focus almost entirely on the satisfactory income they earn. The importance of the growers' individual capabilities is, however, fully recognized by the company staff.

In the growers' perception receiving the high net cash income is a key incentive to seed production because it resulted in receiving a large lump sum payment. This enabled them to invest in other agricultural activities, in house construction, in higher education for their children and in loan repayment. Hence, high income from tomato seed production is an important factor for influencing the growers to continue tomato seed production.

Conclusions

HTSP under the contract farming system is much more complex and labor intensive than is the case for other common cash crops by small holder farmers in NET. Even though they have low levels of formal education, smallholders in this region are capable of dealing with the complex management and technical practices required to produce high quality hybrid tomato seed. By relying on their knowledge and skill at performing the dexterous manual labor needed for HTSP, they are able to earn high profits from small areas of land. Income from HTSP is much higher compared to other commonly cultivated crops and is more economically worthwhile than working as wage laborers in both farm and non-farm jobs. It is this high profitability that acts as an incentive for long term growers to continue engaging in production of this very demanding crop.

Long term contract growers can adapt, accept and conform to the seed companies' requirements in the production process employing advanced technologies, crop management practices and technical practices. They can apply their own experience and become knowledgeable and skillful growers who can sustain long term HTSP and maintain mutually beneficial relationships with seed companies. It is the highly developed capability of these long term growers that acts as a magnet attracting many seed companies, local and international, to locate their production activities in NET even though labor costs are lower in neighboring countries. It is in order to retain these long term growers needed to produce high quality products that the companies must offer much more favorable terms than are usually found in other forms of contract farming. However, the growers do not recognize their own expert capacity and only take it for granted.

Although economically beneficial for the growers, the future of HTSP in NET is uncertain. Many current growers are primarily using household labor, especially a spouse, to carry on the complex and tedious work of HTSP. Few younger people in general seem to want to take up farming and would prefer to migrate to the cities in search of non-farm jobs. Thus the question of the long term sustainability of HTSP under contract farming in NET remains to be answered.

Acknowledgements

This paper is based on the first author's dissertation research in the Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kaen University. The research was supported by a grant (BRG5680008) from the Thailand Research Fund (TRF) Basic Research

Program to Prof. Dr. A. Terry Rambo, but the views expressed in this paper are not necessarily shared by TRF.

References

Bank for Agriculture and Agricultural Cooperatives. 2016. Historical deposit interest rates (percentage per year). Available: https://goo.gl/Y2eyxv. Accessed Aug. 20, 2016.

Benziger, V. 1996. Small fields, big money: Two successful programs in helping small farmers make the transition to high value-added crops. World Development. 24(11): 1681-1693.

FAO (Food and Agriculture Organization). 2016. Technical paper 5: concepts and methods for economic evaluation of Alley farming. Available: https://goo.gl/ETaY1r. Accessed Nov. 18, 2016.

Gedgaew, C., S. Simaraks, and Rambo, A.T. (n.d.). Factors influencing long term hybrid tomato seed production under contract farming in Northeast Thailand. Journal of the Agriculture, Food, and Human Values Society (Under review).

Gedgaew, C., S. Simaraks, and Rambo, A.T. (n.d.). Trends in hybrid tomato seed production under contract farming in Northeast Thailand. Southeast Asian Studies, Kyoto University (Under review).

Herbert Smith Freehills-Employment notes. 2016. Thailand: minimum wage rate set to change for 2016. Available: https://goo.gl/krXfAf. Accessed Sep. 27, 2016.

Kay, R.D. 1981. Farm Management. McGraw-Hill, Inc., New York.

Kerdsuk, W., S. Chartbunchachai, S. Usanawarong, J. Reungchayachatuporn, C. Yenchai, S. Boonsanure, P. Saenchaisuriya, and P. Ketsomboon. 1996. Self-Care Behavior of the Northeast Farmers Involved in The Dry Season Seed Production: Case Study in 2 villages. The Research and Development Institute, Khon Kaen University (in Thai).

Kowithayakorn, L. 2002. Vegetable seed production. Faculty of Agriculture, Khon Kaen University (in Thai).

Martwanna, N., and K. Lertrat. 2007. Contract Farming: Seed Production of Seed Companies in Thailand. Thailand Research Fund report, Bangkok (in Thai).

Nikornphun, M. 1999. Hybrid vegetable seed production. Odion Store, Bangkok (in Thai).

Rosset, P., R. Rice, and M. Watts. 1999. Thailand and the world tomato: globalization, new agricultural countries (NACs) and the agrarian question. IJSAF. 8: 71-94.

Saenjan, V. 1998. Future prospect of small and medium size agribusiness in Thailand. Proceedings of the Second International Seminar on Agribusiness and Its Impact on Agricultural Production in Southeast Asia (DABIA II). 15-20 October 1997. Faculty of Agriculture, Khon Kaen University.

Salvatore, D. 2007. Managerial Economics: Principles and Worldwide Applications. 6th Edition. Oxford University Press, Inc., New York.

Sarkar, M.A.R., M.H.A. Rashid, and M.R. Sarker. 2011. Contract farming in tomato seed production in Rangpur District of Bangladesh: A financial analysis. Progressive Agriculture. 22: 169-179.

Sudha, M., T.M. Gajanana, and D.S. Murthy. 2006. Economic impact of commercial hybrid seed production in vegetables on farm income, employment and farm welfare-A case of tomato and okra in Karnataka. Agricultural Economics Research Review. 19: 251-268.

Tay, D. 2002. Vegetable hybrid seed production. Proceedings International Seed Seminar: Trade, Production and Technology. 15-16 October 2002. Santiago, Chile.

Thomas, C.R., and S.C. Maurice. 2008. Managerial Economics. 9th Edition. McGraw-Hill, Irwin, New York.