The Economics of Living with Citrus Diseases: Huanglongbing (Greening) in Thailand

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ABSTRACT. The economic losses due to Huanglongbing (greening disease) in Thailand are extreme despite the fact that methods are available for control of the disease. This paper discusses the economic and financial impact of greening disease in Thailand and losses incurred by farmers. It also outlines a program for prolonging the life of their citrus trees, thus greatly increasing their financial returns.

The devastation of citrus in Thailand caused by Huanglongbing (HLB) (greening disease) was described by Roistacher (14) as follows: "*In my lifetime of involvement with citrus virus and virus-like diseases, never have I witnessed such severe destruction of citrus as seen in this consultancy visit through Thailand. This destruction of citrus by the greening disease has been ongoing in Thailand for over 30 years and has been well documented by others. I believe there is a tendency to accept and accommodate to the disease and to live with it. I observed that after a period of destruction by the greening disease, the trees become unproductive and unprofitable after 5 to 8 years*".

The seriousness of this disease and its destruction of citrus in Thailand was mentioned and reviewed by all consultants who visited that country and observed the disease (1, 8, 9, 12, 14, 15, 16, 17, 18).

This paper reports on the financial impact to farmers and their countries by HLB and suggests ways in which these losses can be minimized through programs of certification and education; and by the application of methods for disease control which are now standard practices in other citrus-growing countries throughout the world.

HUANGLONGBING DISEASE IN THAILAND

Citrus is one of the leading fruit crops in Thailand, second only to mango in fruit production. Its tonnage exceeds that of durian and ramboutan and is greater than the combined tonnage of jackfruit, tamarinds, banana, mangosteen, langstats and longan. Yet, primarily due to the greening disease, the average yield of 13 T/ha for citrus in Thailand is low when compared to yields of 50-90 T/ha in other countries (8).

Schwarz et al. (17) reported that HLB first appeared in Thailand in the 1960's and the length of time between the onset of the disease and debilitation of the entire tree was about 2 yr. They reported that: "*Trees are not usually killed, but decline to a point where growers uproot them when costs of production exceed returns*". They further reported that of the two methods of transmission of the disease (by vector and by propagation) "*the vegetative propagation of infected source trees is important in spreading the causal organism from one locality to another when infected nursery stock is moved from an infected area to one that is free of the disease*".

The practice of marcotting or air layering continues to this day in Thailand. Su and Tolley (18) evaluated the current status of citrus production in Thailand and reported that: "*Thailand is the only large citrus producing country in the world using marcotting or air layering to propagate citrus trees. The present technique for all practical purposes guarantees production of nursery trees already infected with greening.*

This technique must be discarded entirely for citrus propagation". They indicated that there is a continuing deterioration of the Thai citrus industry, primarily due to HLB and that the average life span of a citrus tree in the field was only 8 yr. They suggested that there was a lack of trained personnel to handle the difficult problems associated with the disease and indicated that there was an urgent need to develop a clean stock program and establish a citrus certification program for Thailand.

Grenzebach (8) studied the economics of producing citrus in Thailand and calculated the financial returns from an average citrus farm. His analysis showed a 12-yr cycle of production with most citrus declining to a point of non-profitability after 8 yr as shown in Fig. 1. Roistacher (14) observed trees near death from HLB in many citrus groves in the Phrae and Nan areas which were only 5 yr of age or less. The disease destroys about 10 to 15% of the tangerine trees each year in Thailand and is exceptionally destructive in the northern region were many areas have gone out of production. Considering the significant financial losses suffered by the growers and the country from this devastating disease, relatively little has been done to educate on the causes of decline or to develop a strategy for its prevention and control.

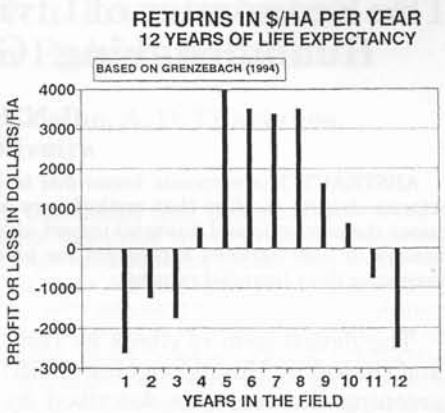

Fig. 1. The expected gross margin of profit for tangerines with a 12-yr life expectancy in Thailand based on the studies of Grenzebach (8). The net loss or profit is shown each year for the 12-yr cycle. Note that HLB begins to take its toll after the eighth year, the grove becomes unprofitable and will be pulled.

VECTOR CONTROL FOR HUANGLONGBING IN THAILAND

The fact that this disease has been destroying trees in Thailand for over 30 yr, or that trees decline after 5 to 8 yr, and that growers continue to plant new orchards with infected marcotted trees suggests that there is a lack of understanding by the farmers of the HLB organism and its mode of spread by its psyllid vector, *Diaphorina citri* Kuwayama. Much of the spraying in citrus orchards is primarily directed toward control of pests such as the citrus leafminer, thrips and mites. The control of the psyllids appears to be incidental to the control of these other pests. However, *D. citri* is the vector which transmits the liberobacter organism and is responsible for the field spread of HLB in Thailand. This is the primary pest for which a control program should be targeted.

Although a massive program is now under way in Thailand for the production of budded trees using budwood which is free of HLB, this is but one part of the total problem of control of the disease. If HLB-free trees are put in the field but are surrounded by HLB-infected trees, they soon will be subject to infection via *D. citri*. This persistent vector breeds and feeds on citrus and citrus relatives and readily transmits the pathogen from infected to non-infected trees. As an example of the rapidity of spread of greening disease, Azzaro *et al.* (2) showed that in two locations in India, 67% of certified HLB-free trees became infected 5 yr after planting. This was due to the transmission of the organism by

D. citri from adjoining infected properties.

In his consultancy report, Roistacher (14) stated that "*the control of greening disease in Thailand* is *possible provided the seriousness of the problem is understood by the highest officials in the Department of Agriculture, the Department of Agricultural Extension, and by the extension workers and the farmers. The losses to the farmers and to the country by this serious disease amounts to many millions of dollars each year. Investment in a strong program of control and a program of information and education will be rewarded a thousand fold by the increased production and profits to the farmer and to the country.*"

A PROGRAM FOR CONTROL OF HUANGLONGBING IN THAILAND:

Roistacher, (15) suggested the following program for control of HLB in Thailand:

1. *Eliminating marcotting:* The elimination of air layering or marcotting method of propagation is an absolute requirement for a successful HLB control program. Marcotted trees can harbor the greening organism and this practice has been primarily responsible for the distribution of the disease throughout Thailand.
2. *Certification:* The production of pathogen-tested and pathogen-free primary mother trees is paramount to the control of the disease. The planting of new orchards should be done only with HLB-free nursery stock grown under screen. These trees should come from certified mother trees which have been indexed and ascertained to be free, not only of HLB, but, of all graft-transmissible pathogens of citrus.
3. *Monitoring for HLB:* A program is needed for the continual surveillance and removal of HLB-infected branches and trees in existing orchards. All trees suspected of HLB which shows yellow or mottling or are in poor condition should be removed and replaced with healthy budded trees certified to be free of HLB.
4. *Psyllid control:* HLB-free trees will become infected by psyllids after they feed on nearby infected trees. Therefore, the development of environmentally compatible procedures for controlling psyllids in field orchards must be an integral part of any control program. This involves development of inspection procedures for the continual monitoring for psyllids in the orchards to effectively time the application of insecticide spray.
5. *Education:* An intensive program needs to be developed for educating administrators, extension workers and farmers on the specific cause of infection and the resulting destruction of citrus by the HLB disease, and the specifics on how this may be controlled. This program of education should be of the highest priority and should include information brochures and various programs with illustrated lectures and demonstrations. A color brochure has been developed to meet some of these needs.

THE ECONOMIC IMPACT OF HUANGLONGBING

Grenzebach (8) reported on the economics of citrus production in Thailand and calculated the financial returns from an average citrus farm producing tangerines under existing conditions of cultivation which included the practice of marcotting. Cost data was provided by the Department of Agricultural Extension and also by the Ministry of Agricultural Publications. He used a model representing an average sit-

uation in the country with a production of 12.5 T/ha which he felt represented the national average. He reported that yields reached 22.75 T/ha in 5 to 8 yr and then declined to 6.5 T/ha by the 12th year due to HLB, after which the entire orchard was replanted. There was constant replanting of individual trees throughout the entire production cycle. He calculated the costs and profits during this 12-yr cycle and this is shown in Fig. 1.

The 12-yr cycle reported by Grenzebach (8) may be high for some areas in Thailand. In many of the citrus groves observed in the areas in the north around Phrae and Nan, entire orchards were dying and going out of production in 5 to 6 yr or less (14). Schwarz *et al.* (17) reported that citrus was going out of production in the Chanthaburi and Phetchabun regions of Thailand and today tangerines are no longer produced in these areas. The cause of this low production and decline of tangerine orchards at this early age was due to the HLB disease. This short life span of citrus was also indicated in the reports of the many consultants who visited Thailand and reported on the HLB problem they observed.

The projected costs and returns for a citrus grove with a life expectancy of 6, 8, 10 and 20 yr are shown in Fig. 2. If a grove lives for 6 yr (Fig. 2a), which occurs in some areas of northern Thailand, a farmer will suffer a loss of US $8,292 for each ha of citrus. Similarly, if a grove lives for 8 yr (Fig. 2b), a farmer will suffer a loss of US $3,660 per ha at the end of 8 yr. Only if a grove survives for 10 yr (Fig. 2c) will a profit of US $3,383 per ha be realized. Thus, it is apparent that profits will be low unless trees can be made to live for 10 yr or longer, and the longer trees can be made to live, the greater will be the returns to the farmer. In Thailand, some tangerine trees do live longer than 12 yr in a few individual groves which are regularly sprayed and well cared for. However, as a general average, orchards in Thailand become unproductive after 8 yr and many do not survive past 6 yr.

If HLB can be brought under control (along with other serious citrus diseases), there is no reason why citrus trees in Thailand cannot live for 20 yr or longer. Fig. 2d projects a grove of citrus which lives for 20 yr. Assuming decline after about 16 yr, the cumulative profits at the end of 20 yr would be US $125,000/ha or averaging US $6,250 per ha per yr. Citrus trees can and do live longer in other countries. If diseases can be brought under control, the life of a citrus tree can exceed 100 yr as exemplified by the parent navel orange tree in Riverside, California which is now 123 yr old and still thriving. In the past, seedling trees of citrus were known to live 300 yr or longer (3, 5).

SUCCESSFUL PROGRAMS FOR THE CONTROL OF HUANGLONGBING IN OTHER COUNTRIES

Studies in the Philippine Islands (6, 7), South Africa (4), and China (10, 11, 19) indicate that HLB can be controlled. All of these disease control programs followed a system of management which included (i) the planting of only disease-free, certified nursery stock; (ii) the monitoring for the psyllid vector and the timely application of pesticides for control of psyllids; and (iii) the removal of HLB-infected trees and all symptomatic plant tissue. In addition, the Chinese system for control of the disease include programs for the continual teaching of farmers and extension workers; giving them a clear understanding of the disease, the organism, and on the means of controlling the disease based on systems of management as outlined above.

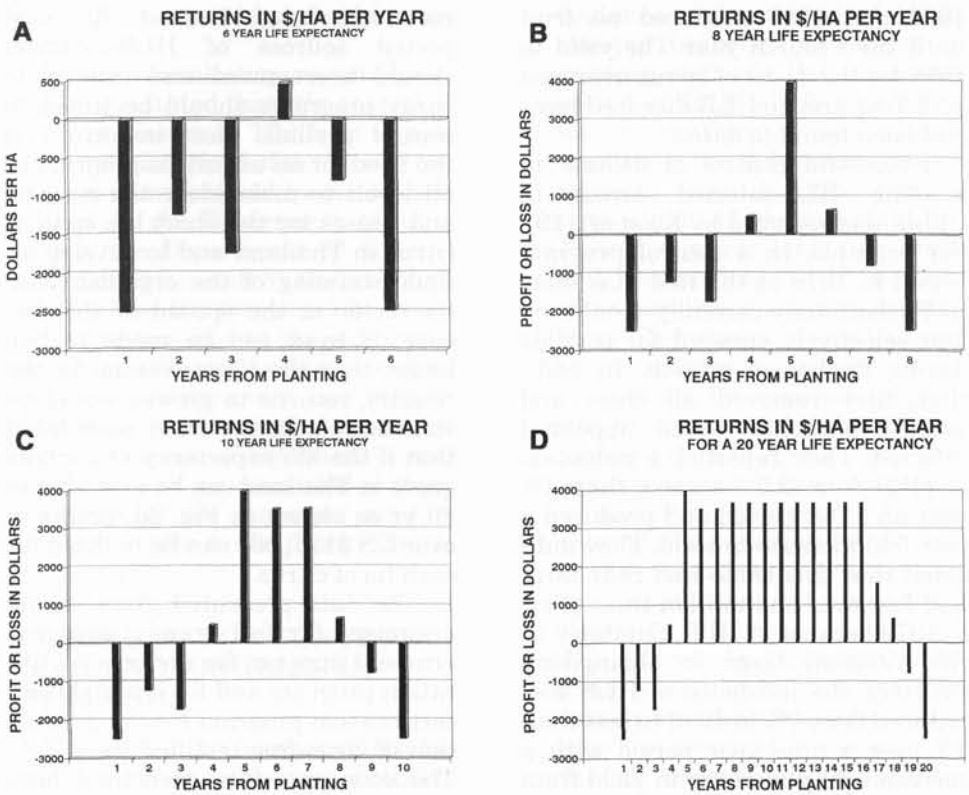

Fig. 2. An interpolation based on studies of Grenzenbach (8), but projecting for life cycles of 6 yr (a), 8 yr (b), 10 yr (c) and 20 yr (d). The cumulative losses in US$/ha would be $8,292 and $3,660 for a life expectancy of 6 and 8 yr. A cumulative profit of $3,383/ha would be realized if a grove would live 10 years. However, if HLB control practices are used and a grove could be made to live for 20 yr, a cumulative profit of $125,000 would be realized for each ha of citrus.

As an example of the successful control of HLB by using these management strategies, Ke and Xu (10) reported on a new planting of citrus in northeast Fujian Province at the Donghutang Overseas Chinese Farm. In 1985, rice paddy fields were converted to citrus and the following measures for control of HLB were undertaken:

1. All backyard citrus trees in the area were eradicated. This included a number of HLB-infected trees, plus all wild trees and shrubs of *Murraya paniculata* and *Clausena lansium*.
2. Windbreaks were established.
3. All newly planted trees were supplied by the Fujian Academy of Agricultural Sciences and were tested as free of HLB.
4. Trees were examined regularly for HLB. Any suspect or infected trees were immediately removed and replaced with healthy trees. Trees were sprayed specifically for psyllids only during flush periods and the number of sprays averaged 10 to 13 per year.
5. The introduction of any citrus or Rutaceous plants were strictly forbidden in the area.

In a personal communication of February 1995, Ke Chung reported that this farm which was located 2.4 km from an old infected orchard, was carefully evaluated each year. The trees which were planted in

1986 and 1987 produced no fruit until their fourth year. The yield in 1993 for the 31 ha of citrus averaged 31.3 T/ha and no HLB-diseased trees had been found to date.

Successful control of disease in existing HLB-infected farms in China was reported by Xu *et al.* (19). For example, in a control program begun in 1978 at the Red Star farm in Fuzhou, they carefully monitored and selectively sprayed for psyllids during flushes of growth. In addition, they removed all trees and pruned branches which appeared infected. They reported a reduction of HLB from 2.5% to less than 1% over an 11 yr period and produced a four-fold increase in yield. They indicated that this same Red Star farm had lost over one million trees prior to 1979 because of HLB. Similarly, in the Yangcun farm in Guangdong Province the incidence of HLB was reduced from 7% in 1978 to less than 1% over a nine year period with a corresponding increase in yield from 10 T/ha to over 22 T/ha.

CONCLUSION

Currently, the losses to the citrus industry of Thailand sustained by HLB are extreme due to lack of effective programs for controlling the disease or its vector. Systems for control of HLB have been tested in other countries and continue to be successful. The practice of marcotting as a way of propagation must be eliminated in Thailand and pathogen-free budded trees grafted on compatible rootstocks used instead. All suspected sources of HLB-infection should be removed and insecticide spray programs should be timed to control psyllids. Most important is the need for an education program at all levels to make clear the reasons and causes for the short life span of citrus in Thailand and to develop an understanding of the organism and its vector in the spread of the disease. If trees can be made to live longer than the 12 yr average for the country, returns to grower would be substantial. It has been postulated that if the life expectancy of a citrus grove in Thailand can be extended to 20 yr as shown in Fig. 2d, profits of over US $125, 000 can be realized for each ha of citrus.

The data presented gives strong argument for full grower and government support for a citrus certification program and for a mandatory certification program for the production of virus-free certified trees (13). The economic data presented here suggests that the costs needed for training of personnel, developing a laboratory, building a screenhouse with a cool temperature room for indexing, and obtaining the equipment and supplies required to support a program of indexing and certification are relatively small when compared to the immense losses which are currently being sustained and the possible future losses if certified budwood is not produced as soon as possible and incorporated into a mandatory certification scheme.

LITERATURE CITED

1. Aubert, B.
1989. Report on citriculture in Thailand. Project RAX/86/022 - Feb. 16-23, 1989. 7 pp.
2. Azzaro, A., S. Leocata, and G. Polizzi
1993. Greening spread in two locations of Uttar Pradesh (India). P. 443-444. *In*: Proc. 12th Conf. IOCV., IOCV, Riverside.
3. Bonavia, E.
1888. Oranges and lemons of India and Ceylon. W. H. Allen Co. London. 334 pp.
4. Buitendag, C. H., and L. A. von Broembsen
1993. Living with citrus greening in South Africa. P. 269-273. *In*: Proc. 12th Conf. IOCV. IOCV, Riverside.

5. Fawcett, H. S.
1936. Citrus diseases and their control. 656 pp. McGraw Hill Book Co. Inc. New York, London.
6. Gonzales, C. I. and R. C. Viñas
1981. Field performance of citrus varieties and cultivars grown under control Measures adapted against leaf mottling (greening) disease in the Philippines. Proc. Int. Soc. Citriculture 1: 463-464.
7. Gonzales, C. I., A. D. Toreja, and U. V. Molino
1984. Status of citrus plantings on the ninth year under study for control procedures of greening disease in the Philippines. Proc. Int. Soc. Citriculture. 1: 409-412.
8. Grenzebach, E.
1994. Integrated pest management in selected fruit trees. Report No. 42 on a short term consultancy mission: Feb. 27-March 12, 1994 on behalf of Deutche Gesellschaft Für Technische Zusammenarbeit (GTZ).
9. Imada, J., M. Prommintara, and N. Deema
1992. Studies on virus and virus-like diseases of tropical fruits. Cooperative research work between Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fisheries, Japan and Department of Agriculture, Ministry of Agriculture Cooperatives, Thailand. 47 pp.
10. Ke, C. and C-F. Xu
1990. Successful integrated management of Huanglongbing disease in several farms of Guangdong and Fujian, by combing early eradication with targeted insecticide spraying, p. 145-148. *In*: Proc. 4th Int. Asia Pacific Conference on Citrus Rehabilitation. FAO-UNDP, Chiang-Mai, Thailand.
11. Ke, Chung
1991. The present status of citrus huanglongbing and its control in China, p. 10-14. *In*: Rehabilitation of citrus industry in the Asia Pacific region. Proc. 6th Int. Asia Pacific Workshop Integrated Citrus Health Management. Kuala Lumpur, Malaysia.
12. Koizumi, M., M. Prommintara, N. Deema, and D. Choopanya
1994. Phytopathological studies on citrus greening disease in Thailand. Cooperative research program between Japan International Research Center for Agricultural Sciences, Ministry of Agriculture, Forestry and Fisheries, Japan and Department of Agriculture, Ministry of Agriculture Cooperatives, Thailand. 58 pp.
13. Roistacher, C. N.
1993. Arguments for establishing a mandatory certification program for citrus, p. 18-34. *In*: Proc. 4th Conf. Int. Soc. Citrus Nurserymen, Johannesburg, South Africa.
14. Roistacher, C. N.
1994. A report on a technical visit to Thailand to assess citrus certification and the production of disease-free citrus. With special emphasis on the greening problem and recommendations for rootstocks for Thailand. 33 pp.
15. Roistacher, C. N.
1995. A report on a short term consultancy to outline a citrus certification program for Thailand and to develop an educational brochure on greening and its control. Report No. 53. Thai-German Technical Cooperation Program. 42 pp.
16. Schwarz, R. E., and L. C. Knorr, and M. Prommintara
1973a. Presence of citrus greening and its psylla vector in Thailand. FAO Plant Prot. Bull. 21: 132-138.
17. Schwarz, R.E., and L.C. Knorr, and M. Prommintara
1973b. Greening-Cause of a recent decline of citrus in Thailand. Plant Protection Service Technical Bulletin No. 20. October, 1973. Dept. Agric., Min. of Agriculture Cooperatives, Thailand. 17 pp.
18. Su, H-J. and I. S. Tolley
1992. First consulting visit to Thailand. Reports No. 10 and 11 on behalf of Deutche Gesellschaft Für Technische Zusammenarbeit (GTZ). 49 pp.
19. Xu, C-F, D-C Wang, and Ke C.
1991. A report of implementation of integrated control programme of citrus huanglongbing, aiming at renovating old infected orchard in epidemic zone and protecting new non-infected orchard in non-infected zone, p. 55-61. *In*: Rehabilitation of Citrus Industry in the Asia Pacific Region. Proc. 6th Int. Asia Pacific Workshop on Integrated Citrus Health Management. Kuala Lumpur, Malaysia.