Horticultural Prospects for Selected Greenhouse Production Areas in Indonesia

May 2007

This publication was produced for review by the United States Agency for International Development. It was prepared by Development Alternatives, Inc.

Horticultural Prospects for Selected Greenhouse Production Areas in Indonesia

The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

BRI II Building, 28th Fl, Suite 2806

Jl. Jend. Sudirman 44-46, Jakarta 10210, Phone: 62-21-571 3548/49, Fax: 62-21-571 1388

"Helping Indonesia to Grow"

Horticultural Prospects for Selected Greenhouse Production Areas in Indonesia

Dr. Robert Richardson, Greenhouse Consultant

Trip Report May 15 – June 2, 2007

For the

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

RAISE Plus IQC Task Order EDH-I-04-05-00004-00

May 28, 2007

A Project Implemented by Development Alternatives, Inc.

Executive Summary

There are many highland areas in the Indonesian archipelago that can be used for production of high value horticultural (HVH) crops in greenhouses and in field culture at appropriate times. Greenhouses are abundant in Indonesia, but have some commonalities that place an upper limit on their potential for high yields and quality. Environmental controls are an obvious limitation to high yields, and many of the reasons for their exclusion are sound. Since very high altitudes are rare in Indonesia, adiabatic cooling is inefficient. In addition, relative humidity is high in most areas, and pest populations abound that limit productivity.

Prices for finished produce from greenhouses are rather low, which does not provide sufficient incentive for investment in proper media for growing, high quality irrigation/fertigation systems, or the necessarily high cost of attempting to control the interior greenhouse environment. Little more than airflow techniques are available, and since these techniques are dependent on ambient conditions, they are relatively inefficient. For this reason, the choice to forego environmental controls is a rational one, as the wholesale market prices for current HVH products do not cover the necessary costs for environmental control equipment and instrumentation.

There are too many producers who experience these same limitations to growth but ironically cause excess supply, distorting the internal markets for high value products. Airfreight is expensive, and although colored bell peppers and tomatoes are of generally good quality, good markets cannot be profitably served due to competition with China and Malaysia in the developed regional markets, and phytosanitary concerns limit exports to Japan. This could change as growers diversify into unknown crops and markets. However, there are other anomalies in the high-end supermarket trade in Indonesia. For example, Australian grape tomatoes have been observed sold alongside Indonesian cherry type tomatoes in Jakarta at a substantial premium. The Australian grape tomatoes were packed in 200 gram punnets retailing for Rp 37,000 ($20.55/kilo), while Indonesian cherry types were packed as 250 gram punnets, with essentially no difference in quality, for Rp 17,000 ($7.55/kilo).

The perception that the Australian grape tomatoes are somehow superior to the Indonesia tomatoes indicates that there is room in the market for inimitable advantage in terms of packing, branding, and product placement. There is sufficient evidence throughout Indonesia that producers are capable of equaling or besting primary quality attributes when compared with Australian and Dutch grown produce. Packing, labeling, branding and the myriad features of marketing need to be explored in depth to compete with imported products.

Therefore, special niche markets for greenhouse products should be explored and developed to assist Indonesian producers. There are a great many candidates for specialty markets, and Indonesia has a abundance of excellent soils, good weather conditions, and much hand labor for the more intensively managed crops. The largest contribution AMARTA can make as a technological intervention that can assist the HVH sector in Indonesia is the introduction of high quality seed and diverse varieties, in

addition to the information that will allow Indonesian producers to take the cognitive leap to creative competition vis á vis imported produce and locally grown products. There are so many micro-climates and situations throughout the archipelago that no single recommendation can cover all the production possibilities. Small-scale mechanization should also be a main concern, in field production, cold chains, and fresh-cut and retail packing of fruits and vegetables.

AMARTA could assist the Indonesian horticulture sector by providing information, cultural planning, and day to day management techniques for both field and greenhouse growers. Crops for processing should be a priority, since the cold chain is rudimentary, poorly understood, and highly fragmented. This can mean processed strawberries, broccoli, asparagus, sweet corn and other commodities in demand that are simple to process and only require the most basic icing, chilling, or freezing facilities. Improved varieties of existing crops would also make a significant difference to the efforts and incomes of ordinary farmers.

Assisting producers of disease-free seed for different species such as potato, strawberry, raspberry, and other crops would go far towards improving the efficiency of the horticultural sector. Indonesia has a large supply of good labor, and this element of the production requirement should be leveraged to improve yields and quality. Field production should become more mechanized, and the human abilities of manual dexterity, keen sight, and complex thinking should be used to do jobs that machines cannot perform, adding value and increasingly moving towards higher valued crops, specialty crops, and specialty operations such as tissue culture and hand pollination. Bureaucratic impediments to sophisticated production techniques and access to improved germplasm should also be addressed through policy and dialog with the Indonesian government.

North Sumatra, Berastagi

Horticultural crops in Berastagi range from small fruit such as strawberries to flowers including chrysanthemum, carnations, roses, gerbera, and a few other assorted vegetable crops. Some greenhouse crops are grown, principally tomato and bell pepper. The industry as a whole seems to be suffering from a lack of knowledge and marketing links, which affect all production phases from procurement of good seed to packaging materials and post-harvest concerns.

There are a great many small producers competing for markets that are fragmented and rather primitive. This is unusual since the area has fairly good roads and good proximity to a developed market, Singapore. However, few producers are coordinated enough to supply a developed market with any regularity and success. Farmers are atomistic and tend to follow others in the absence of clear market signals. This generally leads to spikes in market prices for many products and few farmers are sufficiently equipped and flexible enough to take advantage of seasonal surges and declines in the market.

There is also scope for much more intensified diversification of crops. Even investors in the agri-business sector show little change from established methods and crops. Although the largest crop is mandarin oranges (tangerine), holdings are small and difficult to operate since there are so many actors who do not coordinate their procedures. The area is very well placed for a number of strategic crops that could target Singapore with high value crops such as fresh potato, super sweet corn, and broccoli. The main exports in terms of short term crops are cabbage and flowers. Although flowers are widely grown, most species do not do especially well as the weather is not conducive to good growth and production of flowers.

It is rather warm and wet for many crops, since elevations run from 1200 to 1400 meters above sea level at approximately 3° north of the equator. The soils are excellent, with good internal drainage and structure and are sufficiently deep and stone free for most crops. Mechanization is rare, and plots are very small. The small size of holdings should not deter mechanization, as small plots are common in Asia, particularly in regions such as Beristagi. After the problem of seed choice, plant disease seems to be a continuous problem for fruit and vegetable growers.

However, the root of the problem seems to be a curious lack of information. Even horticulture for export to internal markets appears primitive and mistakes are common. Local expertise appears to be limited to experiential knowledge, with little theoretical knowledge. This is a dangerous situation for high value horticulture, especially in terms of pesticide use and knowledge of disease, insect, and weed control. Some products have reportedly been dumped by the authorities at the Singapore market due to high pesticide residues.

These information related problem are not easily solved, especially with the large number of farmers and few or no local experts in high value horticultural methods. It is unclear if there is a market for information services, as most farmers and investors seem to rely on experience or advice from their marketing partners. For example, one investor with a number of greenhouses producing hydroponics tomato and bell pepper

did not know the nutrient solution *pH* should be adjusted to conform to the demands of the crop.

Many input suppliers are obscuring information with inadequate labeling to prevent others from competing with similar products. This was the case for several fertilizer blends, and although chemicals had rudimentary labels in the local language, it was apparent that only a basic explanation of how to safely use the product was given. Therefore, it is also unclear, but probable, that farmers regard pesticides as "medicine" with little idea of how to properly manage their uses. This can be rectified with basic training courses in disease and pest identification, proper storage and use of pesticides, and more advanced knowledge of pest cycles and how to effectively manage IPM programs.

Greenhouse crops are frequently found in the area in an attempt to control pests and diseases that occur with high rainfall. However, it is not certain that an investment in such structures can be profitable, since competition is high in the few species that warrant protection, and local designs are poor in comparison with rain shelters or poly-tunnels found in other countries. Local designs are based on bamboo and plastic roofing, which causes shading and too little available light for most species. Imported greenhouse designs are generally high quality in the case of Israeli made frames and medium to poor quality Chinese greenhouses.

These structures are seen throughout Indonesia, but are not specifically well suited to the local environment in many cases. For example, saw tooth design greenhouses that depend on convectional air currents to remove large masses of heated air from taller greenhouses have recently been replaced with Quonset type greenhouses. These Quonset designs have no escape vents or forced airflows and are consequently very hot. The probability of a successful fruit or vegetable crop when environmental controls are not made available diminishes quickly when root and foliage temperatures are too high for a specific species. Moreover, the plastics that are used to cover greenhouses in Indonesia have some local constraints and differences that should be addressed; heat and humidity affect the usability of plastics via promoting the growth of algae, which diminishes light quality very quickly. Israeli, Dutch, and American plastics are imported for greenhouse structures, and there are local manufacturers. The main difference is the manufactured longevity of the plastic.

Typically, foreign plastics are manufactured with high amounts of UV inhibiting chemicals that allow them to be used for up to 5 years; local plastics do not use high amounts of these chemicals and consequently last only about 2 years. However, by the time the plastic has been covering a structure for 2 years, so much algae has grown on the plastic that it should be replaced. Therefore, it is probably best not to use imported plastics designed for long life under intense light with high structural strength.

There is no good way to stop or clean algae from greenhouses due to their many different designs in Indonesia, and therefore, an exchange of plastics when algae interrupt light to less than 800 mmoles/sec/m^2 PPF as measured by a SpecMeter Quantum meter available from www.specmeters.com should occur. This is probably the best financially acceptable solution. In addition, the Chinese Quonset structures are too

difficult to manage in terms of the interior environment and new designs should be worked out. The saw tooth design is best for the humid tropics, but can be expensive. If the market does not reward investors for buying proper equipment, then a new design should be made, such as the Mexican example that controls costs while maintaining acceptable environmental and production conditions.

Crops commonly grown in these greenhouses are grape tomato, salad tomato, flowers, bell peppers, and a few others such as potato for seed crops and fruit trees for budwood. The market prices for greenhouse grown vegetables such as tomato and bell pepper seem quite low in comparison with most other markets. For example, grape tomatoes packed for Singapore retail were quoted at Singapore $2.00 per kilo, with high quality greenhouse tomatoes quoted at Singapore $1.00 per kilo. If accurate, these are extremely low prices for these crops, especially when Australian grape tomatoes were observed to be selling for US$20.55 per kilo in nearby Jakarta. Another example from Jakarta is yellow grape tomatoes, which should be comparatively high priced than red, were observed selling at retail for US$8.00 per kilo in a Food Hall outlet.

It is also doubtful that many of the observed production methods learned from experience or from input market sources are sound, as most seem to be better suited for desert areas with high light availability, low humidity, and cool to cold temperatures. The actual situation is the reverse; low light availability and warm, humid temperatures with little temperature differential. For this reason, the credibility of the production systems is suspect; little effort seems to have been developed to originate a greenhouse production system that takes the local environment into account, offsetting its disadvantages and leveraging its advantages.

In terms of areas that can be addressed by AMARTA with good results, it appears that the widespread dissemination of information on local crop production would be advantageous, as would the encouragement of higher quality seed production, especially for potato. Another excellent avenue for AMARTA is assisting the development and diversification of new crops via providing seed and technology to growers who wish to experiment and learn. Potato is a good candidate for seed improvement, as Indonesian economic policy discourages imports of potato tubers for seed. Sweet corn, especially the sh_2 gene super sweet varieties, can be easily introduced from existing Asian suppliers such as the East-West Seed Company, located in Bangkok, but will require specialized crop production knowledge and appropriate post-harvest technology.

Micro-tuber technology is known in the area and although it is currently being used on a very small scale, it is more or less successful. Micro-tubers of the varieties used in commercial markets can be produced that are free of virus infections and tuber diseases using basic methods in common low-tech greenhouses. Transplants are produced from disease-free tissue culture explants and grown at high intensity in sterile beds of sand, rice hull, and coco-peat. The resulting G_0 micro-tubers are then planted in sterile beds to produce G_1 tubers, up to G_3 or G_4, where they are then sold to local farmers as seed tubers. This currently requires approximately 35 months from explants to final seed tubers. However, the prices are good for both seed tubers and commercial potato crops, at 13,500 and 3,000 Indonesian rupiah per kilo, respectively. The USD exchange rate is 9,000 rupiah per $1.00. Tissue culture potato explants are already being

produced on demand for small growers of micro-tubers. Bolstering the current base of tissue culture technology could also be a target for AMARTA assistance, especially since many species could be considered for improvement using the technique.

It is also possible that the best use of AMARTA resources for Beristagi would be the development of an information center that farmers could turn to for crop problem diagnosis, recommendations, and theoretical training based on the extant crops. Pesticide use and IPM would be very valuable training programs, as well as post-harvest management and general horticultural methods. Such an information center could act as a sort of crop clinic, where crop inputs, new varieties of seed, and improved practices could be recommended, and diagnosis of problems could be made by qualified personnel on a case by case basis with relatively few field visits. This would reduce the transaction costs for farmer assistance and allow professionals to make the best use of time and resources.

One specific constraint to hydroponics production of HVH crops is the lack of information relating to one of the most expensive inputs; the soluble fertilizers. There are suppliers of soluble nutrients in Jakarta that go to great lengths to obfuscate and disguise their ingredients in order to maintain a captive market. Formulation of high quality hydroponics fertilizer is not difficult in Indonesia as all the required chemicals are readily available. The best method is to use a Web-based linear programming site dedicated to hydroponics fertilizer formulations and simply follow the instructions. The site can be found here: http://www.hal-pc.org/~menendez/hydrocal.html. In addition, there are other tremendous resources on the internet that can help farmers make correct choices. For example, on one specific website there are literally tens of thousands of agricultural calculators published by many universities that assist the producer to make budget spreadsheets, ascertain profit and loss calculations and cultural planning, and easily and specifically spell out the requirements for almost any crop or production scenario. This website can be found at: http://www.martindalecenter.com/Calculators1_2_Ag_Crops.html

Bali, Bedugul

The highland areas of Bali differ from those of Sumatra in that although soils are very well drained and friable; the elevations are somewhat lower and prone to more cloudy weather. However, closer proximity to markets and specifically, higher value markets due to the tourist trade make them very attractive for development. Unfortunately, many of the same problems that inhibit high value horticulture and greenhouse production in Sumatra are apparent in Bali. The crop mixes are essentially the same, but many of the same information problems exist. It appears to be difficult to obtain good seed, materials, and supplies, and skills and knowledge of the demands of sensitive high value crops are lacking.

The greenhouses that abound in Bali range from very primitive wood and bamboo structures to more modern Quonset frames, in which crops such as tomato, bell pepper and strawberry are grown. The main problems with HVH production and marketing are the poor practices used on farms and the curiously low prices producers receive for their products. In addition, post-harvest methods and cold chains are

virtually nonexistent and poorly understood. The lack of proper post-harvest handling, transportation, and storage may be an artifact of the low market prices that do not reward producers for top quality. There are many well developed demand forces such as supermarkets catering to tourists and foreign residents, and many upscale hotels and restaurants, but there is a lack of an obvious premium for high quality. Many greenhouses constructed of wood and bamboo actually inhibits production of the species that are chosen for protection. These structures diminish light intensity, which is further exacerbated by long periods of cloudy weather in the early afternoons.

Data on environmental parameters was not available for a close analysis, and this may be a very attractive function AMARTA could perform. Small weather stations that record temperature, relative humidity, rainfall, and light intensity would be very beneficial to local farmers. Scattered stations can record such data many times per minute and subsequently transmit the data wirelessly to a laptop at specific intervals. This data could be stored and analyzed to provide farmers with a sound basis for selection of almost any high value species. Off-the-shelf technology and software is available to perform these tasks and produce charts and baselines that could guide farmers and investors and help them select appropriate species that could perform well under local environmental condition. After a period of a couple of years, such a dataset would be quite valuable to agricultural investors and farmers since the dataset would be quite large and show environmental trends and crop production parameters that could guide decision making.

The current situation is that agricultural information is very short in supply and choices are few in terms of seed and required inputs. For example, in some greenhouses, strawberries are grown out of season to protect them from rain that promotes post-harvest rots and reduces berry quality. However, the value of doing this is dubious since the plants are rarely from fresh imported stock, the structures are tightly enclosed, which impedes insect pollinators, and environmental control mechanisms such as fans or other ventilation equipment is not installed. These limitations tend to cancel the advantages of using greenhouses since without fresh strawberry plants, few fruit bud primordia are produced, diseases occur when relative humidity is out of control, and light levels are greatly diminished with the wooden structures. Low light causes fruit albinism in strawberry, and light colored, insipid tasting fruit. In addition, the fruit all tend to have size and shape problems when grown in the greenhouses due to poor pollination.

Other crops grown in greenhouses in Bali are tomato and bell pepper in the main, although there are very limited areas of herbs, leafy salad, and flower crops. The tomato and bell pepper are grown using a high light-low temperature strategy, when environmental conditions require the opposite. Many growers use very expensive Dutch seed for indeterminate tomato and peppers, and invest large amounts of hand labor in their production techniques, such as trellising and pruning. This is the exact opposite of what is actually required. Better adapted varieties and short cropping cycles common to determinate tomato and bell pepper varieties should be substituted for the long life technologies that are used. In this way, much cheaper seed and production techniques can be used to obtain essentially the same yields and quality, and reduce the financial

burden and production risks the growers face, especially when the market refuses to pay a premium for the quality they require.

According to sources in Bali, Winrock has granted or is going to grant a large number of very small cold-frame type rain shelters for out of season field production. This idea is doubtful for a number of reasons:

1. The very small size of the structures ($15m^2$) with 1.5 meters clearance
2. The low impact on production and quality
3. The underpinning idea that they are portable
4. The plan to simply grow in soil and provide shelter from rain
5. The simplification that rainfall is the most limiting factor to production

In fact, lower cost rain shelters can be made from local materials such as plastic sheeting, galvanized pipe, concrete reinforcement rods, and nylon rope. These are small structures, well suited to the environment, allow good air access to reduce heat build-up and increase insect and wind pollination, and are comparatively cheap to build. They also do not interfere as much with light transmission as local designs based on wood and bamboo frames. The following photos illustrate the simplicity of design, and ease and cost effective construction of steel, plastic, and rope rain shelters:

Growing many crops during the heavy rainy season is sometimes impossible due to many other factors rather than rain; low light levels reduce production potentials, plant disease is far more common, rainfall easily intrudes covered field production via capillarity and lateral movement of soil water, and some crops simply do not produce well when the ambient relative humidity is too high. These are problems of information as well, and the same approach that may work in Sumatra could just as well work in Bali, that is, establishing a base of information that can be practically applied to the local situation. In Sumatra, the main problems seem to be market information; in Bali, the

problems are essentially a lack of updated, modern greenhouse agricultural production skills and knowledge. The striking difference between Bali and Sumatra is the ownership of the production base.

In Sumatra, the farmers are dependent on producing a crop for economic survival; in Bali, there are very small, almost hobbyist production units that do not apply or seem to acknowledge established horticultural science. There are certainly bona-fide farmers in Bali, but most seem to plant staple crops such as cabbage and carrots. The HVH growers are financially elite and seem to be able to afford losses, but not sustained losses. If Bali is to develop a sustainable high value horticultural base, farmers must be drawn into cultivation of unknown crops in an organized manner. This requires good, timely information in the form of baseline data, production planning, analyses, diagnoses and recommendations, agricultural finance, post-harvest techniques, packaging, and marketing.

With the market opportunities that are apparent in Bali, many more species can be grown than the ubiquitous cabbage and carrots. With the large number of affluent foreign visitors that come to Bali annually, there are unique niches that can be filled, concentrating on European and Japanese tastes. In some cases, this is being attempted, albeit haphazardly by amateurs and a few entrepreneurs wishing to form linkages with retail supermarkets. This is generally a good sign for the agricultural economy as someone has to make the initial attempt and introduce new ideas and technologies. The main problems with production in Bali, in greenhouses or in the field, are complex and not easily sorted out.

Even though there are attractive markets, the horticultural sector is small, fragmented, and unskilled. New crops are planted and grown based on experiential knowledge, even though experience or success with traditional crops such as cabbage or carrots does not necessarily mean sure success with more sophisticated farming systems. In addition to a lack of knowledge and skills, inputs are difficult to procure, and there is essentially no effective packaging or cold chain system to deal with sensitive fruit and vegetable crops. The lack of a proper packaging and cold chain system introduces unnecessary and substantial risk, as growers must sell their products quickly after harvest. In contrast, with proper packaging and cold chain techniques, producers can afford to look for the best market opportunity without excessive fear of losing yields and quality. This is perhaps the most serious problem in the production system as too many spikes occur in the cropping cycles of short supply followed by gluts. This exposes producers to excessive risk and depresses incentives to improve the production and marketing systems.

In terms of how AMARTA should expend its resources in Bali, there is so little organized development that almost any effort would be welcome and could make dramatic improvements in the current system. Information dissemination, training, data collection, analysis, and distribution regarding basic growing conditions, cropping systems, post-harvest management, and marketing strategies would help overcome many of the problems in the horticultural sector. A multiple approach strategy may be best using local resources. Some of the main constraints and their possible solutions are:

1. **Skills, knowledge, and abilities**; data collection and analysis, demonstration of proper production and management techniques, and training are needed to make producers more aware of how to produce high quality vegetable crops and manage their environment and crop rotations. Better rain shelter construction techniques are necessary to overcome costs, ventilation, pollination, and light transmission constraints. Historical data regarding local environmental conditions and climatic parameters would assist farmers and investors when making decisions to grow specific crops and rejecting obvious failure-prone crops.
2. **Good quality inputs**; AMARTA could use some resources to assist in the introduction of better varieties adapted for the humid tropics and provide price discovery information for other inputs to help put producers on a more equal footing with input suppliers. New seed varieties of crops such as bunching green beans, Nagi onions, Japanese burdock (Gobo) high quality baby carrots (Cut & Peel), and super sweet corn are obvious candidates for improvement.
3. **Post-harvest, packaging, and markets**; many crops do not require more than simple packaging such as plastic crates due to the nature and proximity of Bali markets. Older post-harvest methods such as hand sorting and hydro-cooling, top-icing, or using liquid ice are established techniques for many tolerant crops such as green beans, asparagus, sweet corn, spinach, edible-pod peas, broccoli, and cauliflower, among others.
4. **Forced air coolers on a small scale**; many high value crops cannot be effectively hydro-cooled or iced. Strawberries, some flowers, and other crops benefit from small scale air cooling such as the examples based on a simple air conditioner developed in North Carolina and Florida. This method will effectively chill a single pallet of strawberries, tomatoes, peppers, squashes, or flowers. Small reefer trucks to avoid breaking the cold chain are necessary for delivery to Denpasar hotels, restaurants, and supermarket distribution centers. In addition, growers, packers, and shippers must understand the post-harvest temperature requirements and ethylene sensitivity of their crops to prolong quality and shelf-life.

West Java (Pangalengan and Bogor)

The highlands of West Java are well suited for greenhouse culture of many fruits and vegetables. However, the common element with all the greenhouses we have surveyed throughout Indonesia is that environmental controls are lacking. Even though high quality Dutch, Israeli, and other makes are available, the absence of proper environmental controls means that they are essentially no better than simple rain shelters in terms of crop production. The highland tea plantations afford an excellent environment for greenhouse crops in West Java and this environment is far better than conditions in either Sumatra or Bali. The altitudes that can be reached with arable land at approximately 7° south are more than 1500 meters above sea level and some

approach 1700 meters high. This is far better in terms of adiabatic cooling, since for each 100 meters increase in elevation, temperature drops approximately 0.6° Celsius.

In the specific areas we inspected in Pangalengan, there was great interest in clean, disease free potato seed production. The grower (Mr. Mustofa, PD Hikmah) was doing an excellent job with the resources at hand, but there are severe limitations to production of certified clean seed in Indonesia. For example, according to the growers we interviewed, the government severely limits the introduction of new germplasm with red tape, delays, difficulty in obtaining import permits, and a very short duration of importation once the permit is procured. This has lead to an unfortunate situation in Indonesia in terms of high quality seed, not only for potato and should be investigated by AMARTA as a priority action.

In the case of potato, the certified seed grower sources tissue culture plants from a government run lab and proceeds to produce mini-tubers from explants. This would work fine in theory, but unfortunately, the explants come from uncontrolled seedstock, meaning they can be taken from late generation tubers and therefore be completely infected with potato viruses such as Potato X, Y, and leaf-roll virus. This is the case at present, in addition to the high risk of mechanical transmission of tobacco mosaic virus from the hands of workers who smoke tobacco. What is required to rectify the situation is to import small amounts of certified clean mini-tubers and proceed with tissue culture, maintaining and assuring quarantine for an almost limitless supply of clean potato germplasm.

The grower plants the resulting explants in carbonized rice hulls in a screen-house that does a fairly effective job of excluding virus vectoring insects such as aphids. However, one of the more serious problems we observed is the high incidence of bacterial wilt disease (*Ralstonia* spp.). All affected plants with bacterial wilt should be immediately rouged as the disease will only spread and infect the entire seed crop very quickly if left to develop. It is generally carried by irrigation water from streams and rivers, where riverbank weeds provide alternate hosts for the bacterium. The grower also has plans to expand his operations extensively, but is constrained by a lack of efficiency in his current procedures.

The obvious solution is to convert the main screen-house into an aeroponics production unit that would produce many times the micro-tubers from certified clean tissue culture stock that Mr. Mustofa requires. We have explained the basic concepts and the grower is confident he can replicate our recommendations. However, to give a much better idea of the technology of aeroponics production of micro-tubers, it is recommended that a small, self-contained, aeroponics unit be purchased and used to learn the technology and its specific application to potato. An inexpensive unit can be purchased from: http://www.biocontrols.com.

Another operation we visited in Bogor, headed by Mr. Theo Hadinata, PT Saung Mirwan, also produces many different flower and vegetable crops for retail packaging and sales in Jakarta. In addition to approximately 10 hectares in greenhouses on various sites, local farmers also supply the operation with specialty vegetables for processing and packaging. The observed quality was very high for most fresh vegetables and fresh cut

vegetables such as head lettuce and onions were being packed in vacuum bags for the fast food trade. Although general seed quality was obviously high, there were complaints about the entry of fresh seed for specific species. The principal species for which seed is most needed was green beans. With the exclusion of the French small beans (*haricots verts*), most green beans are of the old Kentucky Wonder climbing pole bean. However, saved seed over many generations has caused a degeneration of the varietal characteristics to produce light colored, tough, and stringy pods. The solution is to abandon the current practices of erecting bamboo poles and all the hand labor associated with the practice and turn to high quality, high yielding processing bush beans, such as one of the Blue Lake cultivars. Other seed companies that sell high quality vegetable seed for commercial growers are www.johnnysseeds.com, www.harrismoran.com, and www.sakata.com. Other vegetables such as broccoli, colored bell peppers, cucumbers, and tomato were of excellent quality. Unfortunately, the same could not be said of the cold chain, and finished quality in retail packs suffered as a result.

New cultivars of self-blanching cauliflower would be an excellent improvement, as would better varieties of carrots. There was also great interest in production of the "Cut & Peel" type of baby carrot for the supermarket and institutional trade. Apparently, there is a market, but recent attempts to produce a machined baby carrot from local stock have failed. In order to produce and package true baby carrots, the variety Sugar Snax 54 is recommended. There are other varieties, and several should be tried to discover the production problems and find a suitable variety for the local environment in West Java.

To successfully produce baby carrots, high sugar varieties are required and are planted at ultra-high densities on raised beds. When the carrots have reached the proper dimensions for the market, they are pulled, cleaned, and the top are removed. After transport to the fresh cut facility, they are washed again in appropriate solutions of chlorinated water, the tops are trimmed to approximately 1 cm, and the carrots are hand-peeled. After a final wash, the peeled carrots are packed in vacuum bags according to market specifications. In the USA, Cut & Peel high sugar baby carrots are for the institutional and restaurant trade and are packed in 5 kilo vacuum bags and held at 0° C.

One of the more interesting observations we made on a specific potato seed production farm at 1700 meters above sea level was the fact that it is not a frost-free zone. This is a unique situation in the SE Asian tropics. Apparently, there are several weeks during December when the temperature drops below 0° C at night. This is quite interesting due to specific phytosanitary and production possibilities. For example, if a greenhouse were situated in this area, it would be relatively free of many of the pests that plague lower elevation greenhouses, making it highly suitable for aeroponics culture of disease free potato seed. In addition, it is an area of approximately 30 hectares of excellent volcanic soils, surrounded by thousands of hectares of 100 year old tea bushes. This improves the prospects of phytosanitary exclusion of pests significantly. Irrigation and power are available, and a modern disease free seed production unit could easily be established and operated in the area with a high probability of success.

In addition, although strawberries are widely grown in the highlands of Indonesia, the plants are not replaced with any regularity. This lack of good strawberry planting material is the proximate cause of low yields and quality throughout Indonesia due to the physiology of the strawberry plant when planted in the tropics. Strawberries have an absolute requirement for specific photoperiod and temperature related triggers to produce fruit bud primordia.

In most June bearing varieties used for fresh and processed strawberries, daughter plants are harvested from fumigated soils in temperate nurseries after exposure to specific chilling hours, depending on variety. When the days are short and cool weather predominates, the strawberry produces fruit buds as differentiated cells in the crown of the plant. These differentiated cells become flowers and fruit after a triggering event during the following temperate spring, i.e., long days and warming temperatures. If the daughter plants are planted in the tropics after undergoing chilling and fruit bud differentiation, they produce well in 12 hour photoperiods for approximately 2 years and are then essentially exhausted. More fruit buds will form and produce under tropical conditions, but the quantity and quality cannot be compared to fresh temperate grown plants, although the production costs for the fruit remains the same. For this reason, it is imperative that serious strawberry farmers procure fresh plants from good nurseries in temperate areas.

However, with the existence of a frost zone in West Java, it may be possible to produce daughter plants with their chilling requirement, irrespective of photoperiod, since short days predominate, and allow the formation of high quantities of new fruit bud primordia. In this scenario, mother plants can be planted in the 30 hectares of excellent soil and runners will develop and root into daughter plants. As the temperature drops in December, sufficient numbers of these plants can be harvested, cleaned, and kept in cold storage at -1 to 0° C for later distribution to strawberry farmers. The plants will keep for months when packed in plastic-lined cardboard boxes at the required temperatures. This can be a very profitable business as good strawberry plants sell for as much as $125.00 per thousand plants, including airfreight to Indonesia. This also avoids the red tape and bureaucratic obstacles to importation of new planting material. Good varieties that resist tropical pests, heavy rain, and warm conditions are Chandler, Camarosa, and Oso Grande. These are older cultivars, but highly productive and good shipping berries that resist rough roads and breaks in the cold chain.

Bio-fumigation of the soil in this area is a requirement, since soil pathogens and nematodes can be very persistent. The most acceptable method for such a large area in the absence of methyl bromide is bio-fumigation using highly pungent tropical mustards and forage brassicas from India and Thailand during the rainy season. If these plants are allowed to grow vegetatively during the rainy season, they can subsequently be plowed down for decomposition. It is during this decomposition that the value of the biofumigant plant appears. In addition to adding to soil organic matter, the breakdown products of these pungent mustards form isothiocyanates, which easily kill harmful bacteria, nematodes, and other soil pests. For fast, effective decomposition and good results, 200 kilos of urea should be applied per hectare, the mustard crop is then disked for crop destruction, and mixing of the urea with a moldboard plow gives best results to

mix the vegetative materials down to 20 cm and provide a seal. Local land preparation methods with available light machinery or hand preparation methods will not work. It is imperative that soil not be worked wet as well.

These cultural methods for chill requirements also work for specific varieties of red raspberry, especially Heritage, a red, very high quality floracane raspberry that can be propagated and grown from tissue culture or from roots in fumigated soils. During the growth of red raspberry, floracanes and primocanes are produced. The primocanes are vegetative and manufacture and store assimilates from photosynthesis in the crown of the plant. These crowns also require a triggering event such as chilling to produce floracanes, and hence flowers and fruit. The physiological mechanism is not absolute in terms of photoperiod and chilling in comparison to strawberries. In fact, the chilling requirement for Heritage can be simulated and satisfied by placing freshly dug crowns with developed primocanes that have been cut back to a short length (0.50 meters), stacked in a reefer container and held at low temperatures (0° C) until the chilling requirement is met.