Vegetable Industry Analysis

1. Production Management

Insects and disease pests are considered by the industry to be the major bottlenecks for commercial vegetable production in Hawaii. The incidence of pests is further increased when growers minimize the use of crop rotations due to intensive cropping practices and from the intensive use of pesticides (often due to a lack of alternative controls) which frequently leads to pest resistance and/or to the outbreak of secondary pests. Major pests which have affected the vegetable industry over the past decade include the spotted wilt virus in lettuce, peppers, and tomatoes; the sweetpotato whitefly in most vegetable crops; the diamondback moth in cole crops; the sweetpotato weevil in sweetpotato; leafminers, mites, nematodes, and thrips, in a variety of vegetables; as well as a variety of viral and fungal diseases in the melons. In addition, other crop losses caused by physiological causes or other organisms such as nematodes, viruses and weeds may go "undetected" by industry and extensionists due to a lack of loss-assessment characterization but productivity losses from as yet unidentified factors may be comparable or greater to some of the major known vegetable pests. Major pest problems as identified by the industry are described below.

1.1. Sweetpotato whitefly

Outbreaks of the sweetpotato whitefly, *Bemisia tabaci*, occurred in Hawaii in 1989 and has since become a major pest of a variety of vegetable crops in Hawaii. Similar pest outbreaks have occurred in Florida, California and other southern states in the Continental US. Studies conducted by the UH Entomology Team on whitefly control have been part of a coordinated nation-wide Sweetpotato Whitefly Project between USDA and land grant university scientists throughout the country. This nation-wide team was organized and holds annual meetings to streamline whitefly control activities and to prevent duplication of work. In Hawaii problems caused by the sweetpotato whitefly on vegetables and melons were compounded by losses already caused by the greenhouse whitefly. However, the sweetpotato whitefly is quite more damaging than the greenhouse whitefly under low population levels in the field. In addition the greenhouse whitefly is more resistant to insecticides than the sweetpotato whitefly. This means that an insecticide application treatments will vary depending on what whitefly species is present in the field. A first priority is thus that growers be able to identify what species is attacking their crops before a pesticide program is developed for the farm. Other priorities for long-term whitefly control within the framework of an Integrated Pest Management (IPM) program include a better understanding of local insect biology, loss assessment and description of symptoms, and preliminary assessment of possible alternative controls.

Work Conducted to Date

The vegetable industry has supported local research programs for control of the sweetpotato whitefly through GACC project "Management of Sweetpotato Whitefly" (M. Johnson) at a level of $162,000 over the past three years. In addition the vegetable industry supported related work for the control of greenhouse whiteflies and leafminers in tomatoes through GACC project "Tomato Insect Pest Management" (M. Johnson) at a level of $339,750 from 1986 to 1989. Major achievements obtained by the UH Entomology team included:

1) Developed a diagnostic technique to distinguish between the sweetpotato whitefly and the greenhouse whitefly.
2) Identified prevalence of sweetpotato whitefly throughout the state in relation to greenhouse whitefly populations and identify resistance of sweetpotato whitefly to major insecticides.
3) Identified the strain (type B) of sweetpotato whitefly present in Hawaii.
4) Identified the requirement that a symbiotic bacteria be present in sweetpotato whitefly immatures for silverleaf and irregular ripening symptoms to show on vegetables. Adults alone caused no symptoms. Similar studies found that high whitefly populations (> 100 per plant) could result in stunting, stem blanching and yellowing in leaf lettuce and cole crops.
5) Polyester row covers were shown to be effective in reducing damage caused by sweetpotato whitefly and to increase zucchini yields.

**Actions Required**
The vegetable industry needs management practices that will help them to control the sweetpotato whitefly. These include identification and registration of effective insecticides, and improved timing of applications and application efficiency. The industry also supports current work on classical biological control and support the development and expansion of natural enemy augmentation programs.

### 1.2. Tomato Spotted Wilt Virus

Annual volumes of local production in Hawaii have decreased by 25% in tomatoes and by 60% in lettuce over the past decade due to production losses caused by the tomato spotted wilt virus. This virus is transmitted by thrips so control activities have involved development of crop resistant varieties and development of pesticide control recommendations. First described in Hawaii in 1916, TSWV is now wide-spread throughout the world. The virus has an extensive host range of over 200 plant species. Estimated crop losses on tomatoes and lettuce from TSWV since the mid 1980s is estimated at ca. $20 million.

**Work Conducted to Date**

**Industry Supported Research.** The Vegetable Industry has supported local TSWV research in Hawaii through GACC project "Evaluation of Pesticides for Controlling Thrip vectors of SWV of lettuce and tomato" (R. Mau) at a level of $648,599 over the past decade, through GACC project "Management of Tomato Spotted Wilt Virus on Maui" (R. Mau) at a level of $74,750 from 1988 to 1992, through GACC project "Management of Virus Diseases of Cucurbit and Solanaceous Crops" (R. Mau) at a level of $127,600 over 3 years, and earlier on through GACC project "Solanaceous and Cucurbit Crops- Insect Control" (R. Mau) at a level of $75,300 from 1980 to 1984. Total level of support by the industry through GACC funds has been $946,249 over the past decade.

**Extramural Funded Research.** In addition, UH Researchers have independently obtained extramural funding to gain greater understanding of TSWV disease dynamics or potentials for genetic engineering. These projects included the USDA project "Genetic Analysis of Virus Resistance in Lettuce Using Molecular Markers" by Dr. John Cho at a level of $95,000 over two years; USDA project "Molecular Approaches to Protect Plants from TSWV infection" by Dr. S. Sun at a level of $142,600 over the past 4 years; and USDA project "Physiological and molecular determinants of thrips infectivity: A basis for prediction and control of TSWV" by Dr. Diane Ullman at a level of $149,000 over the past three years.

A major achievements obtained by the UH Pest Control Team (Plant Pathology and Entomology) in cooperation with PetoSeed Company has been the development of a tomato spotted wilt virus resistant variety (however field reports at time of printing indicate that resistance may have been broken in the current commercially available PSR-55289 variety). This new TSWV resistant variety has been adopted in the major tomato production of Hawaii, Maui, and Oahu. Related achievements obtained by the UH team on TSWV control has included:

1) Havana tobacco, *Nicotiana tabacum* havana, was identified as a suitable host plant for detecting the presence of thrips vectoring the TSWV virus. Growers can use this potted crop as an indicator in their fields to determine if plantings should be delayed due to high disease pressure. Havana tobacco is also a good indicator for PVY, a disease which may become as serious a problem in Hawaii as TSWV has been in tomatoes over the past decade.
2) Significant progress has been obtained in developing TSWV resistant lettuce varieties through genetic engineering. A resistant gene was incorporated into romaine, semihde, and butterhead lettuce varieties. Genetic engineering is being emphasized since no TSWV resistant gene has yet been identified in existing lettuce germplasm.
3) Newer advanced TSWV resistant lines have been selected by researchers and by growers through several field days organized by the UH Plant Pathology/Entomology Research Team and by Maui Cooperative Extension.

**Actions Required:**
The industry supports continued work on lettuce and tomato to develop TSWV resistant cultivars. The industry also supports development of alternative management techniques as well as marketing strategies such as quarantine regulations, plans to recover market share, and consumer awareness programs. The industry supports further work in this area at the recommended level of $81,000 over the next 3 years.

### 1.3. Diamondback moth

The diamondback moth is the major pest on plants of the cabbage family. Head cabbage production volumes decreased by 20-40% during the summer months of 1991 and 1992 due to outbreaks of the diamondback moth in Kula and Kamuela.
ornamental and vegetable growers. Caused great financial hurdles to many of the state's (over 80 open lawsuit cases currently in the state) and has received label recommended rates of Benomyl over the years. Serious re-cropping problems in areas which they alleged had vegetable growers throughout the world continued to have rid Benomyl of the contaminant. However, ornamental and recalled the product and altered their manufacturing process to the late 1980s. The manufacturer of Benomyl, DuPont, fungicide Benomyl were detected in the continental U.S. in Atrazine contaminated batches of the widely used systemic moth. Extramural funding was also obtained for USDA project "Genetic Basis of Resistance to Biorational and Conventional Insecticides" by Dr. Bruce Tabashnik and Dr. M. Johnson at a level of $111,400 for a period of 3 years.

Preliminary work by Dr. Ron Mau and Dr. H. Valenzuela identified the head cabbage cultivar Scorpio as having a greater tolerance to diamondback moth feeding than other industry standard cultivars. In addition, over the past two years, Dr. Ron Mau has conducted workshops in the major cabbage production areas of the state to provide a recommended program for management of the diamondback moth.

Actions Required
The Vegetable Industry supports work which has already been initiated by a DOA-UH Entomology team on a parasite augmentation program. Work has been initiated in this area through an industry sponsored legislative provisal. Along with this program the industry supports ongoing timely technology transfer activities, identification of alternate hosts for natural enemies, alternative pest control programs, release of timely marketing information (volumes of production), and insect population monitoring programs.

1.4. Agri-chemical contamination- Benlate
Atrazine contaminated batches of the widely used systemic fungicide Benomyl were detected in the continental U.S. in the late 1980s. The manufacturer of Benomyl, DuPont, recalled the product and altered their manufacturing process to rid Benomyl of the contaminant. However, ornamental and vegetable growers throughout the world continued to have serious re-cropping problems in areas which they alleged had received label recommended rates of Benomyl over the years. This re-cropping problem which cause is still undetermined (over 80 open lawsuit cases currently in the state) and has caused great financial hurdles to many of the state's ornamental and vegetable growers.

Work conducted to Date
The ornamental industry in the state has supported local research on the "benomyl problem" through a GACC project. These work has been conducted by a team from the UH Plant Pathology and Environmental Biochemistry Departments. This timely research has not been conducted anywhere else in the world, other than perhaps by DuPont researchers. Dupont as well as growers and lawyers from Hawaii and the mainland have all used UH-based research in their cases.

Actions Required
Areas of work that the vegetable industry deems necessary include research on the re-cropping problems in fields that have been exposed to benlate as well as improved communication between governmental agencies and growers to develop protocols of communication and to identify resources and services available to farmers which have re-cropping problems in their fields.

1.5. Mosaic Virus in Cucurbits, Turnip Mosaic, and PVY
Mosaic viral diseases consistently cause serious losses in local vegetable and melon crop production. Field control strategies are complicated because these entail control of vector populations. Vector control is complicated due to their explosive reproduction rates and to their concomitant ability to rapidly develop resistance to registered insecticides. For example, in the late 1980s local watermelon growers complained that certain insecticides no longer controlled the melon aphid. Entomologists recommend the rotation of pesticide families to reduce the incidence of insect resistance to pesticides but this approach is difficult with some of the local specialty crops which have few pesticides registered for their use.

Work Conducted to Date
The Vegetable Industry has supported work on viral pest management through GACC project: "Development of Basic Knowledge about Zucchini Yellow Mosaic, Watermelon Mosaic 1 and 2, Cucumber Mosaic, and Potato Y viruses, their aphid Vectors, Weed Reservoir Hosts and Crop Cultivars and Evaluation of Available Control Measures" (J. Cho and D. Ullman) at a level of $128,350 over the past decade; through GACC project: "Pesticide Resistance Management for Sustainable Aphid Control in Watermelon" (D. Ullman) at a level of $48,500 for a period of 1 year; and through GACC project "Breed and/or Introduce new Cucumber Varieties with Multiple Disease Resistances and Desirable Market Quality" (J. Cho) at a level of $95,760 over the past 5 years. The overall level of support by GACC over the past decade for virus control projects has been $272,610.

Major achievements obtained to date on mosaic viral control by the UH Plant Pathology/Entomology team led by Dr. John Cho include:

1. Development of viral cross-protection technique for control of ZYMV on zucchini. This technique conducted in collaboration with Cornell University and other institutions, was successful and now has been adopted by commercial
zucchini growers in Kula (a major production area for zucchini in the state). Cross protection was effective by 100% in eliminating severe ZYMV in zucchini. Maui growers have accepted this control as a means to produce a stable and reliable crop. A nursery enterprise is currently producing cross protected zucchini seedlings for commercial growers.

2. Stylet-oil applications were found to delay ZYMV and Papaya Ringspot virus (formerly called WMV) infectivity by 4-11 days. Reflective mulches delayed infectivity of ZYMV by 6 days. However, these results would be ineffective under high disease pressure conditions.

The cowpea aphid, *Aphis craccivora*, and melon aphid, *A. gossypii*, were identified as the primary vectors of ZYMV among the 22 aphid species identified in zucchini.

4. In collaboration with DOA introduction of the aphid parasitoid *Aphidius colemani* for aphid control in watermelons.

5. Based on work in Oahu, Maui, Kauai, and Hawaii it was found that growers should discontinue use of Metasystox-R (oxydementon-methyl) to control the melon or cotton aphid, *Aphis gossypii*, but instead should use with caution (to prevent development of insecticide resistance) Asana (esfenvalerate) and Lannate (methomyl).

6. Preliminary data indicates that beneficial predator populations are abundant in the absence of insecticide applications. These natural enemy populations in insecticide-free zones are able to maintain aphid levels below the economic damage threshold level of 20 aphids per leaf in watermelons.

**Actions Required**

The vegetable industry supports a research project on "Development of Potato virus Y resistant tomato suitable for Commercial Production in Hawaii" (John Cho) at a level of $85,000 over the next 3 years. The PVY virus has the potential of becoming a production bottleneck of a magnitude similar to that of the TSWV. The industry also supports commercialization for distribution of mild strain propagation materials, further development of resistant varieties, and development of cultural practices such as crop rotation and row covers for management of these important viral diseases.

### 1.6. Leaf Miner

Leafminers are important insect pests which often result in losses in vegetable and melon crop production. For example, celery growers have reported significant losses from leafminer outbreaks over the past 5-10 years. In fields which receive no insecticide applications, leafminers are normally controlled by natural enemies. However, in fields that receive the typical calendar insecticide treatments, leafminer outbreaks are common because the insecticides have killed the natural enemies of the leafminer. Leafminers are difficult to control with insecticides because the larvae burrows below the leaf epidermis, out of the reach of contact insecticides.

Two leafminer species of importance in Hawaii are the vegetable leafminer, *Liriomyza sativae*, and the celery leafminer, *L. trifolii*. While *L. sativae* is difficult to control with insecticides, *L. trifolii* is already resistant to most of the insecticides registered for vegetable crops. Parasitic wasps are usually effective in controlling leafminers, but growers are often forced to use insecticides for control of other pests and in the process cause leafminer resurgences. In these situations, growers not only lose the benefit of naturally occurring biological control agents, but also select for multiplication of the pesticide resistant *L. trifolii*.

**Work Conducted To Date**

The vegetable industry has supported work on leafminer management through GACC project "Celery Pest Management" (Johnson) at a level of $58,200 over a period of two years. Initial work, as typical of the early stages of all Integrated Pest Management (IPM) programs was to study pest biology and ecology, to develop sampling techniques (necessary for pest scouting), and evaluate the potential of beneficials to keep leafminer numbers below the economic damage threshold level.

The initial work was successful in identifying crop losses with respect to leafminer numbers and stage of crop growth; in developing sampling techniques for the important leafminer species, and in the evaluation of natural enemy populations in celery fields. Important or potentially important natural enemies of leafminers in Hawaii include *Ganaspidium utilis*, *Halticoptera circulus*, and *Chrysoscharis oscinidis* larval/pupal parasitoids. Larval parasitoids include *Diglyphus intermedia* and *D. begini*. *Chrysonomotyia punctiventris*, which is an important parasitoid in California is established in various locations of the State but was not detected in Kamuela celery fields. Lower numbers of beneficials were found in fields that had received insecticide applications compared to untreated fields. A difference in damage between the leafminer species was found in celery. Major damage to the stalks, the marketable part of celery, was caused by the leafminer *L. huidobrensis*, while low numbers of *L. trifolii* were found in the stalks. This indicates that celery can tolerate greater numbers of *L. trifolii* with little damage occurring to the stalk. Therefore proper identification of the leafminer species would allow growers to improve their pest management program. Several informal grower workshops were presented by Dr. Marshall Johnson with updates on the celery leafminer project.

**Actions Required**

The vegetable industry supports ongoing timely technology transfer activities, identification of alternate hosts for natural enemies, alternative pest control programs, release of timely
marketing information (volumes of production), and insect population monitoring programs.

1.7. Quarantine Regulations

The Vegetable Industry believes that stringent quarantine regulations should be in place to prevent the entrance into the state of potentially devastating diseases such as the sweetpotato whitefly transmitted geminivirus which is devastating several vegetable operations in South Florida and in other areas, but which has not yet been introduced in Hawaii.

**Actions Required**
The Vegetable Industry believes that required steps to improve pest quarantine programs include: Identify sources of plant materials; Identify the origins where pests are arriving from; Identify the vectors of important exotic viruses; Develop interception measures, and to; Develop monitoring mechanisms.

2. Marketing

The prospect exists for continued strong consumer demand of vegetable products. Sound marketing programs developed by the local industry will determine whether local vegetable and melon growers can take advantage of the ongoing opportunities to provide steady volumes of high quality product to local consumers and for the large tourist and restaurant industry. Important marketing bottlenecks currently faced by the industry include:

1) The structure and organization of the industry is not well understood by all industry participants. This hampers their ability to make informed and correct management decisions. Better information is needed regarding 1) How production responds to changes in market prices; 2) How consumers respond to change in prices; 3) How is information about consumer demand transmitted to the farm level; 4) What is the potential for increased production of locally produced vegetables; and 5) What alternative mechanisms are available to increase the flow of information throughout the marketing system.

2) Little is known about the relationship of the local market and mainland imports and markets. A more systematic understanding regarding the influence of mainland supplies and prices would enable producers to make better management decisions.

3) Consignment sales continue to be a problem.

4) Some growers continue to face problems with late payments. Although there are legal provisions for timely payments, these may be ineffective since growers may not be willing to risk losing a buyer. The problem is compounded since retailers are not required to make payment within a specified period. Greater use of written forward contracts might be useful in reducing this problem.

**Actions Required**
The Vegetable Industry encourages a program which will help the industry to develop marketing strategies for industry members; To identify market gaps and niches; Which will help to professionalize the producer; Which will develop a marketing plant for the industry state-wide; and Which will develop an arbitration system to address late payment and non-payment problems.

3. Land and Water Resources

The Vegetable Industry believes that reasonable agricultural land costs and water rates are necessary to allow for local vegetable and melon producers to compete with out-of state markets. Limiting factors for irrigation water include either high rates or unreliable supplies during the different parts of the year. Actions required to improve local irrigation water rates include: Development of a system to establish equitable state-wide water rates; Development of alternative sources of irrigation water. Actions required to improve the availability of agricultural lands for vegetable production include: To encourage the state or private ventures to develop agricultural parks, and; Dedicate specific land parcels for specific uses such as for vegetable production.

4. Information Transfer

In today's competitive market environment, producers require the most updated information with regards to technologies of production and with regards to marketing trends for their products. The Vegetable Industry feels that currently there is a lack of timely information flow from governmental agencies and the university to the farm. This information gap reduces the competitiveness of local producers and places them at a disadvantage with out-of state producers. The industry in the past encouraged improvement in this area through GACC project "Improved Communication between Agents, Specialists, and Farmers Involved in Leafy Vegetable Production and Marketing" (S. Fukuda) over a period of 1 year. Actions required to ameliorate this bottleneck include to develop a protocol or system to improve communication, and to identify sources and services available.

5-7. Others

Other important bottlenecks currently faced by the Vegetable Industry include:

1) Government Affairs, which involves the increased burden placed on farmers by greater regulatory restrictions and by the confusion that arises through all the paper work and by the overlapping of responsibilities by the different government agencies. The industry encourages the creation of a clearinghouse on regulations for the farming community of the state.

2) Labor. The industry encourages the creation of Agriculture Labor Trainee programs to increase the limited pool
currently available to work in specialized agricultural operations of the state.

3) Transportation. The industry supports the creation of an Industry/Transportation Advisory Committee which will help to improve the quality of transportation service currently available for inter-island shipment of produce.

RESEARCH NEWS/UPDATES

Fall Eggplant Living Mulch Field Day

About 35 people attended the Oct. 22nd field day for Weed Control at the UH Waimanalo Research Station. Growers were shown a cultivar trial with 10 eggplant varieties under both living-mulch and conventional system. The plants were on the fruiting stage and had been picked for 5 months. On an earlier field day on 7 May growers were shown the early stages of eggplant establishment on the living mulch system. Other activities during the field day included: a) A video of Non-circulating hydroponic systems produced by Dr. Bernie Kratky; b) Follow-up on heart of palm plots with presentation on solar time clocks; c) Display of 1.6 Acre ongoing compost trials; d) Design and field demonstration of fertilizer injector (proportioner) by Dr. Joe DeFrank; e) Follow-up on herbicides and cover crops on heart of palm; and f) Follow-up on genetic engineering trials for PRV resistance in papaya by Dr. Richard Manshardt. Roger Corrales, Farm Manager, and the Staff at Waimanalo Station once again did an excellent job in preparing the fields and the auditorium for the field day.

K-Silicate for Disease Control, Follow-up

The news that Potassium Silicate may be effective to suppress powdery mildew (See Vegetable Crops Update Vol 3, No. 3, May 1993) caught the attention of several county agents and chemical sales reps. 1.8 g of sodium meta silicate are needed to prepare 100 ppm SiO2 in one gallon of water. For additional references on this subject see:


(Thank-you to Randy Hamasaki and Richard Nakano for providing some references and information).

Other Research Notes

◊ Wind and wind-blown sand resulted in greater bacterial spot pathogen (Xanthomonas campestris) infection on ‘Jupiter’ Bell Peppers than on unwounded plants. Varietal differences were observed in response to disease infections caused by wind damage (Pohronezny et al., Pl. Disease, 76:1036(1992)).
◊ Based on mating and phylogenic studies USDA Researchers in Albany, CA refute reports that the sw. potato whitefly is a new species. The argument continues. (Campbell et al., Science 261:1333(1993)).
◊ Pepper Weevil Control: Spray after finding one adult per 200 plants (inspecting two terminal buds per plant). Effective chemicals: Asana XL, permethrin, or Lannate in combination with Vydate L (Cit. Veg. Mag. Sept. 93).
◊ Horticultural Oils and Virus Transmission. In Florida JMS stylet oil may help to delay first infections of potyviruses in watermelons when inoculum sources are limited. In Ontario, oil, insecticidal soap, and film-forming products (Wilt-Pruf, oil, and Dow Corning 36) reduced transmission of Tomato Spotted Wilt Virus on petunia from 46-73%, as well as feeding activity from 4-41% but only Dow Corning 36 reduced thrips reproduction by 66% (Plant Disease 77:869(1993) and 77:915(1993)).

UPCOMING EVENTS

Community Supported Agriculture (CSA): A new marketing opportunity. Workshop and Tour. 6 Dec. 1993, UC Davis, Contact: Tom Haller, CAFF POB 464, Davis, CA 95616, Tel. 916-756-8518.


11th Annual California Farm Conference, 3-6 Feb., 1994, Ventura, Contact: Pasadena Certified Farmers Assoc. 454 Euclid Ave., Pasadena, CA 91101, Tel. 818-449-0179.

91st Annual Meeting of the American Society for Horticultural Sciences. 7-11 Aug. 1994. Oregon State University, Corvallis. For Information Contact: Conrad Weiser, 126 Strand Ag Hall, OSU, Corvallis 97331, Tel. 503-737-2331

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