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Survey of Bacterial Wilt on Fresh Market Hybrid Tomatoes in Taiwan

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ABSTRACT

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Bacterial wilt of tomato, caused by *Pseudomonas solanacearum*, is the most important disease of tomato throughout the humid tropics. Breeding for disease resistance has been the primary means of control and a few moderately resistant hybrids are available to growers in Taiwan. In this survey, the incidence of bacterial wilt on hybrids averaged 15% in 11 fields and 26% in 17 fields for Hualien ASVEG No. 5 and Taichung ASVEG No. 4, respectively, whereas other hybrids averaged 55% in 16 fields. Within the same field, the population density of *P. solanacearum* was 34 times higher in the soil associated with roots of wilted plants than from nonwilted plants. Based upon average price per kilogram of fresh market tomatoes (June to October), the estimated monetary losses on the surveyed fields was NT$ 496,000/ha.

(Key words: crop loss, bacterial population)

INTRODUCTION

Fresh market hybrid tomato (*Lycopersicon esculentum* Mill.) is one of the most important cash crops in the summer season in Taiwan. Tomato production as a first and second crop (excludes winter season) averaged 35,000 tons between 1982 and 1987[1]. Both fresh market and processing tomatoes are grown as first and second crops, and during those seasons plants are vulnerable to infection by bacterial wilt.

Pseudomonas solanacearum (Smith) Smith causes bacterial wilt, and is consistently the most important disease of tomato in subtropical and tropical regions. In Taiwan, Hsu [9,10] reported that strains of *P. solanacearum* have a broad host range. All of the strains

tested were classified as race 1, biovar 2, 3 and 4[10,12,13]. Race 1 (solanaceous race) has the broadest host range, it predominates in the lowland tropics, and was considered as the most difficult of the races to control[7].

Bacterial wilt is difficult to control, and like other diseases, research on host plant resistance has been one of the primary means of control[3,4,5,16,18]. In 1989 and 1990, two hybrids (Taichung ASVEG No. 4 and Hualien ASVEG No. 5) developed by the Asian Vegetable Research and Development Center (AVRDC) were released in Taiwan. The parental stocks of these hybrids had been screened for bacterial wilt resistance[1,8,10], and before they were released as cultivars, they were rated moderately resistant to bacterial wilt in regional yield trials[6]. However, problems associated with using resistant varieties include lack of consistency in the level of resistance. For example, it has been shown that resistant lines when grown under high temperatures or challenged with different strains may wilt[12,17]. Another major barrier in breeding for bacterial wilt resistance has been that lines with smaller fruit size often have more resistance than large-fruited types which are preferred for fresh market consumption[19]. Because of the difficulties associated with using host plant resistance, other control methods like the use of soil amendments have been tested[5,8,11], but not fully adopted by growers.

Our objectives were to survey the incidence of bacterial wilt on fresh market hybrid tomatoes in growers' fields in the major tomato production areas during the summer season in Taiwan, and to estimate the population levels of *P. solanacearum* commonly found in production fields.

MATERIALS AND METHODS

A questionnaire was distributed to tomato growers in Hsinchu, Ilan, and Nantou counties in Taiwan with the help of Miss Fan, Tao Yuan DAIS, Tao Yuan County; Mr. Ts'eng, Hualein DAIS, Lanyang substation, Ilan County; and Mr. Hong in Taichung DAIS, Puli substation, Nantou County. A total of 27 growers responded to the following questions: date and tomato variety planted; crop planted previous to tomato; number of plants and hectarage grown; and the incidence of bacterial wilt and other diseases.

Along with the questionnaire to the growers, the incidence of bacterial wilt was assessed at fruit-setting stage in Ilan (17 July 1990); Nantou (20 September and 18-19 October 1990) and Taitung Counties (31 July - 1 August 1990). In Ilan County, eight fields were assessed by averaging several surveyors' estimations made while walking between rows and around the fields. Soil samples were collected from the rhizosphere of three or more diseased plants from five of the eight fields. In Nantou County, 10 fields were assessed by counting the number of wilted and nonwilted plants in smaller fields and estimated in larger fields by counting the percent incidence on 100-200 plants at 4-5 locations in the field. Soil samples were taken from the rhizosphere of three or more wilted and nonwilted plants from three fields at Hsinyi and Yuchih, and from nine entries of mostly breeding lines at Taichung DAIS, Puli substation. Two fields in Kuanshan, Taitung County, were assessed for the incidence of bacterial wilt, and soil was sampled and pooled from three or more wilted plants from each field.

Soil samples were assayed for *P. solanacearum* using dilution plating and a modified selective medium[20]. Populations of *P. solanacearum* are presented as cfu per gram of dry soil.

RESULTS AND DISCUSSION

Based on the results from the questionnaire, the incidence of bacterial wilt in Hsinchu County averaged 17% for Taichung ASVEG No. 4, 11% for Hualien ASVEG No. 5, and 65% for Known You 301 (Table 1). In Ilan County, Hualien ASVEG No. 5 averaged 3% wilt, and Known You 283 and 301 averaged 65% wilt. In Nantou County, Taichung ASVEG No. 4 averaged 11% wilt and Known You hybrids averaged 49%. Growers were also asked to indicate what crop was grown previously which in most cases was rice. This did not appear to have any effect on the incidence of bacterial wilt. The range of bacterial wilt incidence in Hsinchu County was 11-65% even though rice was grown previous to tomato. In Ilan County, the incidence of bacterial wilt in two fields was 49 and 86% following rice. Although crop rotation may be important in reducing the incidence of bactereial wilt, management practices to curtail the introduction of inoculum is also very important especially under irrigated conditions.

In our field surveys, the incidence of bacterial wilt averaged 24% for Hualien ASVEG No. 5 from six fields and 90% for Known You 301 in Sanhsing area of Ilan County. In Nantou County, the average incidence of bacterial wilt was 16% on Taichung ASVEG No. 4 and 30% on all other hybrids (Table 2).

Our data showed that bacterial wilt was extremely severe, averaging 29% over all fields surveyed. Those hybrids that were not apparently bred for bacterial wilt resistance had more bacterial wilt in all locations. In a few cases, the resistant hybrids also had unacceptable levels of bacterial wilt. The reasons for this lack of resistance in some fields were not included in the scope of this study, but environmental factors and microbes associated with the rhizoplane and rhizosphere of those particular fields no doubt influenced the host-pathogen interaction.

Bacterial population in soil associated with wilted plants averaged 3.5×10^6 cfu/g of dry soil from growers' fields in Nantou County, 2.1×10^6 in Ilan County, and 1.9×10^4 in Taitung County. Bacterial population in soil associated with the nine entries at Puli averaged 5.9×10^4 cfu/g of dry soil ($1.5 - 190 \times 10^3$) from nonwilted plants and averaged 2.0×10^5 cfu/g of dry soil ($1.7 - 95 \times 10^3$) from wilted plants. Averaged over nine lines, the bacterial population was 34 times greater in soil associated with wilted than nonwilted plants.

Bacterial populations in soil are important in the dynamics of the host-pathogen interaction. Specific studies dealing with population levels of *P. solanacearum* in the field in relation to various tomato genotypes, and field studies showing how tomato root exudates influence the population of the bacterium are lacking. Further research to determine what factors affect population levels in the soil and how bacterial densities may influence host susceptibility to the pathogen is needed to fully understand the relationship between inoculum density and resistance /susceptibility in the host plant. In this study, we showed that even symptomless plants have high levels of *P. solanacearum* associated with their root systems, but these levels are still lower than those associated with wilted plants.

Economic losses caused by bacterial wilt on tomato are somewhat difficult to ascertain and not commonly reported. Kelman[14] has reviewed the literature up to 1953 and has cited some examples where losses have been

Table 1. Incidence of bacterial wilt, caused by *Pseudomonas solanacearum*, on hybrids of fresh market tomatoes in Hsinchu, Ilan, and Nantou Counties, Taiwan, 1990 [1]

Hybrid	Date planted	Area planted (ha)	Plant population	Bacterial wilt(%)
		Hsinchu		
Taichung ASVEG No. 4	July 16	0.20	5,900	21
Taichung ASVEG No. 4	July 30	0.60	12,000	24
Taichung ASVEG No. 4	August 1	0.15	4,500	17
Taichung ASVEG No. 4	August 4	0.10	3,000	10
Taichung ASVEG No. 4	August 7	0.15	4,000	11
Hualien ASVEG No. 5	Sept. 10	0.35	10,500	11
Known You 301	July 26	0.02	500	65
		Ilan		
Hualien ASVEG No. 5	May 3	0.14	2,680	1
Hualien ASVEG No. 5	June 10	0.20	4,800	1
Hualien ASVEG No. 5	May 21	0.18	3,400	5
Hualien ASVEG No. 5	May 23	0.21	4,900	4
Known You 283	April 28	0.11	2,400	87
Known You 283	April 30	0.15	3,100	49
Known You 301	April 30	0.15	3,100	49
Known You 301	April 14	0.15	3,200	8
Known You 301	May 1	0.12	2,600	86
Known You 301	April 12	0.12	2,700	85
Known You 301	May 11	0.10	2,100	92
		Nantou		
Taichung ASVEG No. 4	April 16	0.16	4,925	3
Taichung ASVEG No. 4	April 30	0.10	3,015	5
Taichung ASVEG No. 4	May 4	0.15	4,560	32
Taichung ASVEG No. 4	April 8	0.12	3,700	20
Taichung ASVEG No. 4	April 18	0.11	3,500	6
Taichung ASVEG No. 4	March 29	0.12	3,200	2
Known You 202	April 16	0.05	1,496	69
Known You 658	May 1	0.12	3,650	68
Known You 658	April 17	0.05	600	11

1) Data were collected from questionaires distributed to tomato growers.

Table 2. Incidence of bacteral wilt, caused by *Pseudomanas solanacearum*, on hybrids of fresh market tomatoes from the Sanhsing area in Ilan and Nantou Counties, 1990.

Hybrid	Area planted (ha)	Plant population	Bacterial wilt (%)
	Ilan		
Hualien ASVEG No. 5	0.05	—[1]	33
Hualien ASVEG No. 5	0.05	—	60
Hualien ASVEG No. 5	0.08	—	20
Hualien ASVEG No. 5	0.08	—	8
Hualien ASVEG No. 5	0.05	—	15
Hualien ASVEG No. 5	0.05	—	10
Known You 301	—	—	90
	Nantou		
Unknown	0.12	3,328	30
Taichung ASVEG No. 4	0.05	1,152	10
Taichung ASVEG No. 4	0.07	2,000	15
Taichung ASVEG No. 4	0.12	3,000	5
Taichung ASVEG No. 4	0.14	4,600	10
Taichung ASVEG No. 4	0.07	2,600	40
Taichung ASVEG No. 4	0.05	1,500	18
Known You 658	0.14	4,500	16
Mixed	0.18	6,000	10
Unknown	0.05	1,200	65

1) Data not recorded.

estimated in general terms. When utilizing given information of prices and production, we broadly estimated the monetary losses due to bacterial wilt in Taiwan as follows. Growers sold fresh market tomatoes for an average of NT$ 31/kg from June to October 1990 [2]. The production of fresh market hybrids in regional upland yield trials averaged 54 t/ha over four locations and seven lines [6]. Incidence of bacterial wilt in our survey was 29% which could potentially reduce the yield to 38 t/ha causing an economic loss of NT$ 496,000/ha. If the losses of 29% are representive of the entire production area (35,000 tons annually-excluding winter season), then an estimated annual loss of NT$ 310 million could be possible. If susceptible hybrids represented most of the production area, then losses could be much greater. Although these estimated losses are derived by making some assumptions, the actual losses that occur due to bacterial wilt may be difficult to predict without surveying all areas planted to tomato. The information presented in our study does, however, indicate the economic importance of bacterial wilt on fresh market hybrid tomatoes in Taiwan.

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摘　要

Hartman, G. L., 康慧鳳、王添成 1991 台灣生果番茄之青枯病調查 植保會刊 33: 197～203。（台南縣善化鎮亞洲蔬菜研究發展中心）

Pseudomonas solanacearum 引起的番茄青枯病是高溫多溼的亞熱帶和熱帶地區番茄生產的最重要病害。抗病育種爲主要的防治方法。在台灣，已有數種具中等抗病性之雜交品種可供農民栽種。本調查指出，花蓮亞蔬5號（Hualien ASVEG No. 5）和台中亞蔬4號（Taichung ASVEG No. 4）兩品種的青枯病平均發病率分別爲15%（11塊田之平均值）和26%（17塊田之平均值）比其他雜交品種的平均發病率55%（16塊田平均值）明顯爲低。同一塊番茄田中，發生萎凋病徵的植株根系旁土壤中青枯病菌量比無萎凋病徵的植株高達34倍。根據民國七十九年六月至十月份之生果番茄在批發市場之平均價格來做計，番茄青枯病造成之每公頃損失高達肆拾玖萬陸千元。

（關鍵字：作物損失，細菌族群）