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Incidence and Distribution of Banana Bunchy Top Virus in American Samoa

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ABSTRACT

Banana Bunchy Top Virus (BBTV) was first reported in American Samoa in 1967. The incidence and distribution of disease, however, had never been established. In March 1999, five survey teams visually inspected approximately 30,000 banana mats at 20 villages and 10 commercial farms on the main island of Tutuila. Ten thousand mats were inspected on four other islands in the territory. The virus was present in all villages and farms surveyed on Tutuila. Average percent infection for 18 of the 20 villages was 3.4 ± 1.3% and for the 10 farms, 5.4 ± 3.7%. There was no apparent pattern of BBTV distribution. The small, offshore island of Aunu'u, had a 5.3% incidence of infection. No symptoms of BBTV were observed on the three islands of Ofu, Olosega and Ta'u, located 110 km east of Tutuila. Survey results were conservative, as only mats with moderate to severe symptoms of BBTV were considered diseased; more importantly, farmers tend to remove symptomatic plants and suckers as a means of disease control. The relatively low level of BBTV and its slow spread may indicate small populations or inactivity of the aphid vector, *Pentalonia nigronervosa*. A public information campaign and community-based management program is being developed. The latter will destroy infected mats with glyphosate and offer virus-tested tissue culture replacements. Survey results are encouraging for BBTV control in American Samoa.

INTRODUCTION

The purpose of this project was to survey and record the incidence (percentage of diseased mats; Nutter, 1991) and distribution of Banana Bunchy Top Virus on the five principal islands of American Samoa. These islands are located between 14° 12' and 14° 23' south latitude and 170° 32' and 170° 52' west longitude. They are volcanic in origin with narrow coastlines rising abruptly to tapered ridges. The total land area of 197 km^2 is mainly forested slopes greater than 30% (Wingert, 1981). Highest elevations vary from 89 m on the small island of Aunu'u to 974 m on Ta'u. Traditional subsistence agriculture is concentrated along the coastal strip and lower slopes, with the exception of the Tafuna (Leone) Plain on the main island of Tutuila and a few upland areas on the outer island of Ta'u. The rainy season is November-March, the dry season June-September. Yearly rainfall averages from 3,200 mm on the Tafuna Plain (airport) to 7,620 mm on Mt. Lata, Ta'u. The average temperature is 26.4°C with an average high of 33.3°C and an average low of 16.6°C (Wingert, 1981).

In American Samoa, bananas are grown mainly as a subsistence crop and are an important source of starch in the diet. The first published report of Banana Bunchy Top Virus (BBTV) in the territory was by Magee in 1967 (see Dale 1987). It is one of the most severe diseases of bananas and is the most important virus disease (Dale, 1994). The virus is spread over short distances by the brown banana aphid, *Pentalonia nigrovervosa* Coquerel, and over long distances by planting infected pieces of the rhizome (mat), suckers from infected mats, or infected tissue culture plants (Dale and Harding, 1998).

New growth on virus-infected plants is stunted, with small, narrow emerging leaves that often have tattered, yellow edges. The leaves grow upright and have a bunched appearance. Mature plants usually do not produce fruit (Ferreira, 1991), or it does not completely emerge from the pseudostem. The virus systemically infects the whole rhizome, and banana production for that mat is permanently lost. These mats and their plants are a source of future virus infection.

There are no known banana varieties resistant to BBTV and no chemicals to control it (Magee, 1927; Dale, 1987). Programs aimed at managing

BBTV by controlling the aphid vector have been unsuccessful (Waterhouse and Norris, 1987). Plant quarantine, while essential, is notoriously difficult to enforce (Magee, 1927). Once introduced, BBTV has never been eradicated from a country (Dale and Harding, 1998). In 1998, Hawaii Department of Agriculture attempted to eradicate BBTV on the island of Kauai by destroying all banana plants in a 2.6 km^2 (1 mi^2) area of infection; results are pending.

A campaign by the American Samoa Community College Land Grant Program (Land Grant) extension service from 1996 to 1998 informed the public of the threat BBTV posed to the banana crop (James Currie, personal communication). Extension agents saw little response by farmers but in the absence of survey data, their observations are unsupported. Current efforts by government agencies to control BBTV are at a standstill. There is a Bunchy Top Law (Committee on Recodification, 1981), placing responsibility for BBTV control on the occupier of the land, but it is not enforced.

The objectives of the survey are to: 1) record the incidence of BBTV in a random sample of villages on the main island of Tutuila and on the four off-shore islands; 2) record the incidence of BBTV on 10 commercial farms; 3) examine survey results for a pattern of disease distribution; 4) create a baseline for future surveys; and 5) develop a strategy for BBTV management in American Samoa.

MATERIALS AND METHODS

The survey area included Tutuila, Aunu'u and the outer islands of Ofu, Olosega and Ta'u, the latter three known collectively as Manu'a. The target population was all banana mats in home gardens, on commercial farms and in abandon areas. Due to its relatively large size and differing microclimates, Tutuila (137 km^2) was divided into 10 sections based on 1980 population census maps (Wingert, 1981). Two villages were randomly selected from each section. Most bananas are grown in home gardens and mapping borders between poorly defined plantings was impractical. This excluded a random sample of plantings based on area (Barnett, 1986) so a convenience sample of at least 1,000 mats was counted in and around every village. The Manu'a islands were each surveyed as a section and the small island of Aunu'u as a village. Survey teams also inspected 500 or more mats on each of 10 non-randomly selected farms on Tutuila. These commercial farms mainly grow the Cavendish variety, 'Williams', and sell their fruit in the main market and to the school lunch program.

Five teams of two or three surveyors each were formed from people experienced in visually identifying BBTV (Barnett, 1986). Team members were from the American Samoa Department of Agriculture and from the Land Grant divisions of extension, forestry, 4-H and research. Surveyors attended a BBTV field workshop that explained data collection methods and sought to improve inter-rater reliability by collectively establishing criteria for BBTV identification. Mats with any plants showing moderate to severe BBTV symptoms were considered infected. If symptoms were mild or indefinite, the mat was not counted. If all plants were without symptoms, the mat was counted as healthy. The number of healthy and BBTV-infected mats per village, commercial farm and island were totaled and the percentage of mats diseased calculated (Barnett, 1986; Nutter, 1991).

RESULTS

Banana Bunchy Top Virus was present in all villages (Table 1) and on every commercial farm (Table 2) surveyed on the main island of Tutuila. The percentage of BBTV-infected mats was calculated for 18 of the 20 villages surveyed on Tutuila. One village was excluded because less than 1,000 mats were counted and in the other, surveyors counted some mats twice. The average percent infection for the 18 villages was 3.4 ± 1.3%, compared to 5.4 ± 3.7% for the 10 commercial farms. On Aunu'u, 5.3% of the 1119 mats surveyed were infected. On Ofu, Olosega

and Ta'u, 2066, 2026 and 3767 mats were counted, respectively. No symptoms of BBTV were found in Manu'a.

The number of mats counted per village varied according to the size of the team, time available and accessibility of the mats. Poor accessibility due to steep slopes or heavy undergrowth in poorly kept plantings generally lowered counts. The lowest count was 941 for the village of Faga'itua; the highest was 2,758 for the village of Tula.

Every banana variety surveyed was affected by BBTV, including Giant Cavendish 'Williams' and Dwarf Cavendish (Fa'i Palagi), Bluggoe (Fa'i Pata), Mysore (Fa'i Misi Luki) and the Samoan variety Fe'i (Fa'i Soa'a) (Daniells, 1995).

DISCUSSION AND CONCLUSIONS

This was the first extensive survey for BBTV in American Samoa. Until now, information on the incidence and distribution of BBTV was unconfirmed. Survey teams found banana mats with severe symptoms of BBTV in every village inspected on Tutuila and on the island of Aunu'u. There appears, however, to be no clear pattern to its distribution. High and low numbers of infected mats were found in the drier eastern and northern parts of Tutuila as well as in the wetter southern and western areas of the island. The percent BBTV in the cool, wet upland villages of Aasu and Aoloau (360 m), located next to each other, was 0.2% below and 0.9% above the 3.4% village average, respectively. Distribution of infected plants within a field was usually clumped, rather than scattered (Barnett, 1986).

Manu'a is just 110 km east of Tutuila. Daily flights service the islands and cargo arrives regularly by ship. No apparent plant quarantine services are in effect yet banana plantings on Ofu, Olosega and Ta'u appear to be free from BBTV. Presence of the disease on the island of Tutuila and the neighboring islands of (Western) Samoa, however, suggest the apparently BBTV-free condition in Manu'a not be left to chance; public information campaigns have been recommended. In the future, Manu'a could be a source of BBTV-free plants for American Samoa and the surrounding island nations.

The spread of BBTV in American Samoa is relatively slow compared with other countries. In New South Wales, Australia, in 1922, there were approximately 1,000 banana plantations covering over 2,430 ha. A 1925 survey of the same area by Magee (1927) reported only 90 plantations on 223 ha still profitable. Kerala State, India, first reported BBTV in 1940. In three years, 233,100 ha were affected and 600,000 plants were ordered destroyed. The eradication effort was unsuccessful, however, and by 1950 BBTV had spread over 777,000 ha (Mehta et al., 1964). In the Hawaiian Islands, BBTV was first identified on Oahu in 1989 (Ferreira, 1991; Hu, 1994). After five years of continuous control efforts, reported infections were still increasing in residential neighborhoods and commercial fields (Matayoshi and Isherwood, 1994). In 1998 an eradication program took place on Kauai and in 1999 the program was extended to Kona, Hawaii (Guy Nagai, personal communication). After a 30-year presence in American Samoa, on the other hand, the average percent BBTV infection on Tutuila is still less than 5%. This may be due to the low number of banana aphids observed on lamina, petioles and in leaf sheaths of infected suckers. Suckers that are dissected often show no aphids; winged forms are rare. Extension agents state that virus spread within and between plantations can usually be traced to infected suckers used in propagation. Future studies on the spatial and temporal distribution of *P. nigronervosa* may clarify the aphid's role in the spread of BBTV in American Samoa.

Results of the survey are conservative, and several factors may have contributed to a low reporting of BBTV. First, during the incubation period, infected plants do not show symptoms of the disease (Fry, 1982; Dale, 1987): These plants and others with early, mild symptoms were not counted. In many areas, dense undergrowth

in unkempt plantations may have hidden stunted suckers from view. Mats recently destroyed by the disease were not counted. Finally, American Samoans remove suckers and plants with symptoms of BBTV as a method of disease control. This was probably a major determinant in the low number of BBTV-infected mats counted.

A limiting factor in BBTV control is the hard, time-consuming labor involved in digging up and destroying virus-infected mats. Application has been made to the U.S. Environmental Protection Agency to register the herbicide glyphosate as a 'bananacide' (see Hawaii Department of Agriculture, 1996). Using a method refined by the Hawaii Department of Agriculture, a hole is made in each pseudostem of the infected mat and approximately 1 ml of glyphosate is sprayed into the hole; within 6-8 weeks the mat is destroyed (Matayoshi and Isherwood, 1994). A follow-up visit inspects the treated mat, including surrounding plants that may have been infected by virus-carrying aphids. Using this approach on Kauai, the Department of Agriculture had a 97% success rate with the first application of glyphosate (Guy Nagai, personal communication).

A virus eradication program that destroys all banana mats in American Samoa is not practical since most bananas are grown in home gardens over a wide, unmapped area (Dale, 1987; Barnett, 1986). The low incidence of disease detected in this survey, however, suggests the use of a control program that regularly destroys BBTV-infected mats and replaces them with virus-tested tissue culture plants. This approach may be sufficient to protect banana production in American Samoa.

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Table 1. Result of villages surveyed for Banana Bunchy Top Virus on Tutuila, American Samoa, in March 1999.

Location	Mats Counted per Village	% BBTV
Aasu	2067	3.2
Agugulu	1278	1.3
Aoa	1043	4.1
A'oloau	2090	4.3
Aua	1074	5.4
Faga'alu	1025	2.4
Faganeanea	1022	2.2
Foga'au	1059	5.6
Futiga	1022	2.2
Ili'ili	1143	2.2
Lalopua	1039	3.8
Masausi	1022	2.2
Nu'uuli	1044	4.2
Pava'ia'i	1032	3.1
Se'etaga	1405	4.6
Taputimu	2151	5.2
Tula	2758	2.8
Utumea	1026	2.5

Total: 24,300 Average: 3.4%

Table 2. Result of commercial farms surveyed for Banana Bunchy Top Virus on Tutuila, American Samoa, in March 1999.

Location of Farm	Mats Counted per Village	% BBTV
Aoloau	560	10.7
Futiga	557	10.2
Malaeloa	1059	5.6
Malaeloa	510	2.0
Malota	532	6.0
Nu'uuli	560	10.7
Pava'ia'i	1011	1.1
Pava'ia'i	518	3.5
Vaitogi	520	3.8
Vaitogi	513	2.5
	Total: 6,340	Average: 5.6%