Ecology of Banana Bunchy-Top Virus Disease

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Introduction and Research Methodology

Banana bunchy-top disease has been the most common and destructive virus disease in Taiwan since the beginning of this century. The causal virus (BBTV) was first purified to a small, spherical virus with a diameter of 22 mm, consisting of ss-DNA (1.2Kb) and coat protein of 21K dalton. Monoclonal antibodies (McAb) specific to BBTV were prepared for disease indexing and virus detection.

Results and Discussion

Using direct ELISA with the McAbs, different BBTV strains were detected, and garland flower (*Hedychium coronarium* Koenig) and canna (*Canna indica* Linn) were found to be the intermediate hosts of the virus (Table 1). Considerable number of healthy-looking Cavendish banana plants in the field was examined to be infected with BBTV. BBTV was commonly detected in tissue-culture plantlets and field plants of Cavendish (AAA), AAB and ABB bananas showing healthy, or mild chlorosis or stunt, collected from Malaysia, Thailand, South Africa, and India (Table 2). The distribution of BBTV in banana and intermediate host plants was uneven in different tissue, i.e. high virus titer was detected in midrib, petiole and leafsheath (pseudostem) of younger banana leaves (Table 3); the virus was detected only in the younger leaves of garland flower (Table 4); and higher virus titer was detected in younger leaf of canna and low concentration was observed in leafsheath (Table 5). The concentration of the virus in Cavendish banana plants showed seasonal fluctuation, and varied with different virus strains (Table 6). The highest virus titer was detected in autumn banana plants, moderately higher in spring and summer plants, and lowest titer in the winter plants. The severe strain of BBTV replicated to higher concentration than those of the intermediate and mild strains. Air temperature affected virus transmission and symptom development. The aphid vector did not transmit the virus if donor plant was grown at 16°C for one month, while the transmission rate was 55% at 20°C, and 100% at 30°C (Table 7).

Table 1. Symptom expression and ELISA index of different BBTV strains.

BBTV strain/ isolate[a]	Symptom type: vein clearing	leaf atrophy	bunchy-top	stunting	ELISA index
S-P-1	+ +	+ +	+ +	+ + +	+ + + +
I-P-3	-/+-	+	+	+-	+ + +
M-P-1	+-	-	-	-	+
M-P-2	-	-	-	-	+ +

[a] Isolate No. of BBTV strains: M = mild strain; I = intermediate strain; S = severe strain.
[b] Disease index: -, no symptom; +-, very mild; +, mild; + +, moderate; + + +, severe; + + + +, very severe symptom.
[c] ELISA index: +-, 0.1 < ELISA value < 0.2; +, 0.3 - 0.5; + +, 0.6-1.0; + + +, 1.1-1.5; + + + +, >1.6.

Table 2. Detection of BBTV in foreign banana plants by McAb-ELISA.

Country	Date	Cultivar	Symptom	Positive rate[a]
Malaysia	July, 1991	Mas	chlorosis, healthy-looking	5/7
		Cavendish	chlorosis	2/4
Thailand	Feb. 1992	Cavendish	healthy-cooking, mild stunt	4/26
		Kluai Hak Muk	healthy-looking, mild chlorosis	2/5
South Africa	Oct. 1992	Cavendish	healthy-looking	1/5
			mild stunt	4/4
			bunchy top-like	5/5
India	Dec. 1992	Cavendish	healthy/mild stunt	3/4
			bunchy top	1/1

[a] ELISA positive rate of ELISA test: number of test samples showing positive reaction/number of test samples.

Table 3. ELISA values (index) of diseased samples collected from different portions of a diseased banana plant, showing relative concentration of BBTV. (Autumn, 1992).

Plant portion		No. of leaf order from outer leaf										
		1	2	3	4	5	6	7	8	9	10	11
Leaf		+ 0.289	+ 0.586	+ + 0.834	+ 0.622	+ 0.257	+ 0.457	+ + 0.636	+ 0.522	+ 0.425	-a -0.029b	
Midrib		+ 0.154	+ + + 1.282	+ + 0.792	+ + + 1.149	+ + 0.659	+ + + + 1.620	+ + + + 1.737	+ + + + 1.746	+ + + + 1.737		
Petiole		- -0.035	- -0.050	- -0.006	- 0.009	+ 0.132	+ + + 1.595	+ + + + 1.754	+ + + + 1.721	+ + + + 1.754		
Pseudostem	(U)	- -0.023	- 0.014	- 0.043	- 0.003	- 0.086	+ + + + 1.697	+ + + + 1.754	+ + + + 1.737	+ + + + 1.729	+ + + 1.075	
	(M)	- 0.012	- 0.016	- 0.005	- 0.031	- 0.090	+ + + + 1.729	+ + + + 1.129	+ + + + 1.731	+ + + + 1.748	+ + + 1.731	+ + 0.809
	(B)	- 0.001	- 0.020	- 0.037	- 0.018	+ 0.045	+ 0.159	+ + 0.235	+ + + + 0.662	+ + + + 1.600	+ + + + 1.723	+ + + + 1.748

a) ELISA index: -, ELISA value < 0.1; +, 0.1-0.5; + +, 0.6-1.0; + + +, 1.1-1.5; + + +, 1.1-1.5; + + + +, > 1.6.
b) The ELISA values in average of 2 duplications, read 60 minutes after incubation at 37° C. Healthy check, showed OD405 = 0.023.

Table 4. ELISA value (index) of diseased samples collected from different portions of a infected *Hedychium coronarium*, showing relative concentration of BBTV. (Summer, 1990)

	No. of leaf order from outer leaf						
	1	2	3	4	5	6	7
Leaf	- under 0.164	+ 0.241	+ 0.214	+ + 0.733	+ 0.341	+ + • 0.821 b	
Sheath	- under 0.025	- under	- under	- under	- under	- under	
Stem	- under -0.035	- under	- under	- under	- -0.049	- under	

• ELISA index: -, ELISA value <0.1; +, 0.1-0.5; + +, 0.6-1.0.
b The ELISA values in average of 2 duplications, read 60 min. after incubation at 37°C. Healthy check, OD405 = -0.033.

Table 5. ELISA values (index) of diseased samples collected from different portions of an infected *Canna indica* Linn. plant,showing relative concentration of BBTV. (Autumn, 1992).

	No. of leaf order from outer leaf						
	1	2	3	4	5	6	7
Leaf	+ 0.239	+ 0.261	+ 0.307	+ 0.401	+ 0.401	+ 0.492	+ + • 0.605 b
Midrib	+ 0.357	+ 0.174	+ 0.111	+ 0.131	+ 0.125	+ + 0.627	+ 0.465
Sheath	+ 0.175	+ 0.100	- 0.087	+ 0.105	+ 0.129	+ 0.137	+ 0.117
Stem	- -0.027	- 0.004	- -0.006	- 0.109	+ 0.030	- 0.177	

• ELISA index: -, ELISA value <0.1; +, 0.1-0.5; + +, 0.6-1.0.
b The ELISA values in average of 2 duplications, read 60 minutes after incubation at 37°C. Healthy check, OD405 = 0.003.

Table 6. Seasonal dynamic of virus titer of BBTV strains in Cavendish banana plants.

BBTV strain/ isolate[a]	Season (month)			
	Autumn (Nov.)	Winter (Jan.)	Spring (May)	Summer (Aug.)
S-P-1	+ + + +	+ + +	+ + + +	+ + +[b]
I-P-3	+ + + +	+	+-	+
M-P-1	+ + + +	+-	+-	+
M-P-2	+ + + +	+	+	+ + +

[a] Isolate No. of BBTV strains: M = mild strain; I = intermediate strain; S = severe strain.

[b] ELISA index: -, ELISA value <0.1; +-, 0.1-0.2; +, 0.3-0.5; + +, 0.6-1.0; + + +, 1.1-1.5; + + + +, >1.6.

Table 7. Temperatures affecting BBTV transmission by *Pentalonia nigronervosa* Coq. during pre-inoculation period.

Temperature	Incubation period (month)	No. of inoculated plantlet	No. of diseased plantlet	Transmission rate (%)
16°C	1	14[a]	0	0
20°C	1	20	11	55
27°C	1	17	17	100

[a] All of the inoculated one-month-old plantlets were inoculated by 5 aphids, then kept in 30°C controlled greenhouse.

Disease incubation periods of 2-month-old plantlets inoculated with the virus was 26 days at 30°C, while no symptom developed in the inoculated plantlets kept at 16°C, 75 days after incubation. Symptom development was affected by plant age and plant height. The younger banana TC-plantlets with height less than 20cm developed symptom within one and half months, however, the older TC-plantlets or suckers, taller than 50cm did not produce symptom within its whole lifespan. Heat therapy of diseased seedlings at 40/30°C of 16/8 hr. day cycle, could not eliminate the virus in the plant but reduced the virus concentration. Tissue culture of BBTV-infected banana tissue grown at 35°C, regenerated some healthy plantlets.

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