An Unusual Mottle Produced in Some *Prunus besseyi* x *Prunus salicina* Hybrids[1]

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ABSTRACT

An unusual mottle and necrotic spotting occurs in the tip leaves of some *Prunus besseyi* x *Prunus salicina* hybrids but not in hybrids of these two species that include other species. The cause of the syndrome is seed transmitted and completely systemic. The severest mottles are produced at 26C. Experiments to demonstrate transmissibility and cure by thermotherapy failed indicating that the condition is probably genetic in origin.

Necrotic spots that resemble symptoms of virus infection occur frequently in leaves of many plum cultivars and species. In most cultivars the spots are more striking on yearling nursery whips where they appear in the basal leaves but rarely if ever in tip leaves. The necrotic spots are usually angular in outline, but some may be small and round. Sometimes the necrotic areas fall out causing a shot hole effect. If the spots are large when they fall out a severe tatter leaf syndrome may develop. These types of spots are generally considered to be genetic in origin (10).

A different type of necrotic spotting occurs in some plum cultivars that have *Prunus besseyi* Bailey X *Prunus salicina* Lindl. ancestry. In these cultivars the new shoots may grow normally in early spring, but with the onset of warmer weather, large yellow spots appear in the developing tip leaves. These spots eventually become necrotic and drop out causing a tatter leaf syndrome (Figure 1). If the spots are numerous and large, the new leaves may shred until little more than the veins remain.

There is little recorded information about these symptoms in *P. besseyi* hybrids, probably because of the low economic value of the cultivars involved. Fink (4) in Iowa apparently made the first written comments about them after they interfered with his Prunus ring spot inoculation trials. Later Fridlund (5) noticed the problem in Minnesota nurseries and photographically recorded the symptoms. Pine and Welsh (10) also described and pictured the symptoms. They concluded in the absence of published experimentation that the cause was probably genetic in origin and was similar to other kinds of noninfectious plum shot hole.

In Minnesota a nursery row survey of 5287 trees of eight cultivars showed symptoms occurring in 100% of the Sapa and Sapalta trees, very mild symptoms expressed as mottle in 69% each of Oka and Opata trees, and no symptoms in trees of Compass and the *P. besseyi* cultivars, Sioux, Black Beauty and Brooks (5). Inoculations of *Prunus tomentosa* Thunb. and *Prunus persica* (L.) Batsch did not cause symptoms, and a mild hot water treatment of budwood (50c for 5 min), as used for the control of some pathogens, did not prevent symptoms in trees arising from the treated buds. No definite conclusions could be drawn regarding the cause of the condition from these negative results.

Because some of these symptom-expressing cultivars are maintained in the IR-2 Virus-free Deciduous Fruit Tree Repository at Prosser, WA, and because practically no research has been done on the cause of the condition, research was needed to deter-

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Fig. 1. Plum shoots that were bud propagated and forced in a greenhouse at 26C. Left, Sapa with mottle and tatterleaf.

mine if the symptoms were genetically induced or caused by a pathogen that is not detected by the standard IR-2 virus indicators. None of the symptom-expressing cultivars already in the repository had induced symptoms in any of the IR-2 index hosts which collectively detect most known viruses that infect *Prunus* (7). These index hosts are: *Prunus serrulata* Lindl. cv. Shirofugen and Kwanzan; *Prunus avium* L. cv. Bing and Sam; *P. persica* cv. Elberta; *Prunus armeniaca* L. cv. Tilton; *Prunus hybrid* cv. Shiro plum; and *P. tomentosa* seedlings.

MATERIALS AND METHODS

All experiments were made in a greenhouse with propagation and inoculation materials from cultivars that had reacted negatively on the standard IR-2 virus indicators. Propagations and inoculations were made with "chip buds" budded on potted *P. persica* (peach) or *Prunus cerasifera* Elrh. (myrobalan) seedlings.

Temperature effects on symptoms were evaluated in greenhouse sections having ±1C variations.

Exposure temperatures during thermotherapy varied ±1C for both the hot water and hot air methods. The hot water method consisted of soaking dormant budsticks for 20 min at 50C. In the hot air method single dormant buds were chip budded on healthy peach seedlings growing in clay pots 15 cm in diameter. Seven days after budding the seedlings were placed in a heat chamber at 37.5C where they were kept for 21 days. After treatment the seedling rootstocks were cut back to force the treated plum buds to grow while being maintained at 26C.

Seed transmission tests were made with open-pollinated seeds harvested from two trees of the compatible cultivars Dura and Sapalta that were growing 1.5 m apart. No other potential pollenizer was nearby except a dark colored purpleleaf plum, *Prunus pissardi* Carr., located about 30 m from the seed-producing trees. After harvest the seeds were stratified at 3C in wet sand in a greenhouse flat. Four months later the flats were removed to a greenhouse maintained at 26C where the seeds were allowed to germinate and grow into trees.

The ancestries of the cultivars used were determined from several published descriptions (1, 2, 3, 8, 9).

RESULTS

Temperature effects on symptoms. A series of Alace and Sapa trees were bud-propagated on potted myrobalan seedlings and forced at constant 18, 22, 26 and 30C in the greenhouse to determine the optimal temperature for maximum symptom development. This information was needed before further meaningful experiments could be made. The forced propagations were maintained at each constant temperature until foliage symptom severities could be determined (Table 1).

The most severe symptoms occurred at 26C with a declining order of severity at 30C and 22C. For practical purposes no symptoms occurred at 18C.

Symptom production among plum cultivars. Four trees of all plum cultivars in the IR-2 Repository Project inventory, except cultivars of *Prunus domestica* L. and *Prunus institia* L., were propagated on potted myrobalan seedlings using two buds per seedling. The seedlings were maintained at 26C while the buds were forced.

Typical symptoms occurred in the foliage of only six cultivars (St. Anthony, Sapa, Dura, Manor, Sapalta and Alace), all of which have *P. besseyi* and *P. salicina* in their parentage (Table 2). Opata, Oka and Winered

Table 1. Temperature effects on chlorotic and necrotic spot symptom production in leaves of two *P. besseyi* X *P. salicina* hybrids.

Variety	Temperature (C)	Number of trees	Symptom intensities: None	Mild	Moderate	Severe
Alace	18	11	11			
Alace	22	10	5	4	1	
Alace	26	8				8
Sapa	18	11	10	1		
Sapa	22	11	1	3	7	
Sapa	26	12				12
Sapa	30	12	1	4	4	3

Table 2. Occurrence of chlorotic and necrotic leaf spotting in *P. besseyi* hybrid plum cultivars.

Cultivars	Ancestry
	With symptoms
Alace	Opata x open pollinated
Dura	Sapa x open pollinated
Manor	Sapa x open pollinated
St. Anthony	*P. besseyi* x *P. salicina* cv. Satsuma
Sapa	*P. besseyi* x *P. salicina* cv. Sultan
Sapalta	Sapa x open pollinated
	Without symptoms
Cistena	*P. besseyi* x *P. Pissardi*
Compass	*P. besseyi* x *P. hortulana* Mineri
Convoy	Seedling of a *P. besseyi* hybrid
Mansan	*P. besseyi* x *P. hortulana*
Oka	[*P. besseyi* cv. Sioux x open pollinated] cv. Champa x open pollinated
Opata	*P. besseyi* x [*P. munsoniana* cv. Robinson x *P. salicina* cv. Abundance] cv. Golden
Winered	*P. Salicina* x *P. besseyi* hybrid
Yuksa	*P. besseyi* x *P. armeniaca* (?)
	***P. besseyi* cultivars without symptoms**
Black Beauty	
Brooks	
Seedling Selection (IR878-1)	
Sioux	
Weta	

which also have *P. besseyi* and *P. salicina* in their ancesteries remained symptomless. Also symptomless were Mansan, Compass, Yuksa, and Cistena whose ancestries includes *P. besseyi* hybridized with species other than *P. salicina.* None of the five pure *P. besseyi* cultivars tested developed symptoms. Thirty other cultivars that are pure species or hybrid combinations of *P. salicina, Prunus americana* Marsh., *P. cerasifera, Prunus hortulana* Bailey, *Prunus niger* Ait., *Prunus* simoni Carr., and *Prunus munsoniana* Wight and Hedr. remained symptomless.

Systemic nature of the condition. Attempts were made to obtain buds that would not produce symptom-expressing trees due to having escaped either the genetic abnormality or possible virus infection. Accordingly all buds on two budsticks from each of three cultivars were propagated individually on myrobalan rootstocks. The cultivars and numbers of buds were: Alace, 33 and 34; Sapa, 40 and 22; and Sapalta, 27 and 25. The buds were forced at 26C.

All buds produced symptom-expressing trees indicating that the condition was fully systemic.

Transmission Tests. Inoculations to demonstrate transmissibility were not possible among symptom-expressing cultivars because no symptomless sources of them could be found. Consequently inoculations were made using symptomless near relatives as possible indicators. Accordingly, in two duplicate experiments 12 myrobalan seedlings were double-budded with two buds each of the symptom-expressing cultivar Alace and the possible indicators Compass, Convoy, Mansan, Oka, Opata and Winered. The buds of the possible indicators were forced at 26C.

None of the resulting plum shoots developed symptoms so transmission was not demonstrated.

Seed transmission. Seven of 54 Dura and 4 of 90 Sapalta seedlings expressed symptoms similar to the parent plants when the open-pollinated seeds were germinated and grown in the greenhouse at 26C. As the symptoms were very severe at this temperature, some symptom-expressing seedlings may have died before or shortly after emerging. All symptom-expressing seedlings had green leaves and appeared to germinate slower than normal seedlings. Many of the surviving seedlings had red leaves so the *P. pissardi* tree in the vicinity quite possibly played an important part in the pollenation of the parent Dura and Sapalta trees.

Thermotherapy. Forty-nine of 49 buds of Alace and 39 of 39 buds of St. Anthony that survived hot water thermotherapy grew and produced shoots with symptoms. This treatment did not cure the condition.

In three experiments using the hot air thermotherapy method, 2 of 35 and 40 of 42 Sapa buds and 9 of 22 Alace buds survived and grew. All resulting shoots had symptoms indicating that this treatment was also unsuccessful.

DISCUSSION

The peculiar mottle and necrotic spot syndrome in tip leaves of plum cultivars investigated in these experiments occurred only in apparent *P. besseyi* X *P. salicina* hybrids. When symptoms were absent in hybrids between these species, the cultivars either contained additional species in their parentage or their parentage records were incomplete.

The apparent lack of graft transmission of the syndrome to the IR-2 virus indicators or to possible near relative indicators strongly suggests that either all the indicators remained symptomless to an infectious agent because of their genetic make-up or that there was no infectious agent to be transmitted.

The lack of cure by both the water and air methods of thermotherapy is strong, but not conclusive, evidence that the syndrome is not caused by an infectious agent. An infectious organism should have been eliminataed by both methods (6), and a virus quite possibly by this kind of hot air treatment.

Although Oka and Opata showed mild symptoms in 69% of the young bud-propagated trees in Minnesota nurseries, they remained symptomless in the present tests. Because the symptoms were completely systemic in budsticks from three other symptom-expressing cultivars, it appears probable that the mild mottle in the bud-propagated Minnesota trees resulted from another cause.

The sensitivity of the syndrome to temperature suggests that intensities vary from year to year and location to location. This would account for erratic reports of its occurrence, although temperature is not believed to be involved with the mild mottles in the Oka and Opata trees in Minnesota nurseries.

Conclusions based on negative data are always open to question, but sometimes they must be made. Accordingly the information presented here strongly suggests that the *P. besseyi* X *P. salicina* mottle is genetic in origin and not the result of an infectious agent. Because the syndrome occurs in tip leaves in contrast to the necrotic spotting in older leaves of other plum species, it appears to be a different condition and an interesting problem for further study.

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