

New Virus Complex of Chrysanthemums

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The most commonly recognized symptoms of chrysanthemum stunt include dwarfing, bushiness, and early flowering (Dimock, 1947). Brierley and Smith, in 1949, reported that the disease is caused by a virus. They showed that stunt was readily transmitted by grafting and by leaf rubbing but that symptoms were seldom expressed at the first flowering, three to four months after infection. However, diagnosis was possible after seven to ten months during the second flowering. Olson (1949) reported that continual roguing and selection of foundation stock effectively eliminated stunt. A system of graft-indexing, using specific chrysanthemum varieties as indicators, was employed in the selection program and the results were checked against flower indexing of the same varieties. Olson's work also showed that the stunt virus could be spread to healthy plants by contaminated hands or knives.

A presumably distinct virus disease of chrysanthemums called stunt-mottle was reported from British Columbia by Welsh (1948). The symptoms described agree in certain respects with some of those observed in the present study, but as yet plants infected with this virus have not been cross-indexed to determine the relationship of the causal virus.

In cross-graft experiments conducted at Cornell in January 1949, numerous small white flecks were found associated with the new leaves of stunt-infected plants of the varieties Vibrant and Sea Gull. Since then, this characteristic has proved to be consistent

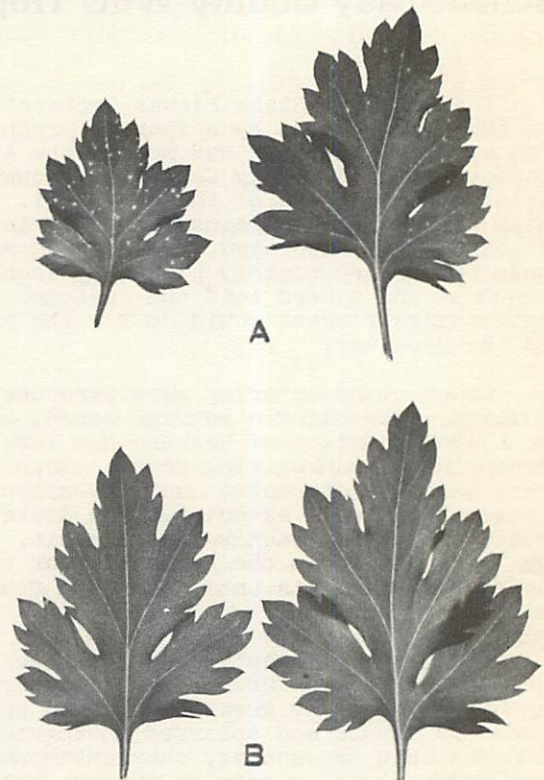


Fig. 1. Leaves of the variety Sea Gull:
A. From stunt infected plant showing flecks.
B. From a healthy plant.

TABLE I. Length of time required for stunt symptom expression in cross-grafted plants.

Type of grafts	Date of Inoculation	Number Grafts	First reading		Final reading	
			Number Plants Showing Stunt	Days After Inoculation	Number Plants Showing Stunt	Days After Inoculation
1. Grafts of Vibrant						
a. Healthy on healthy	Dec. 30, 1948	4	0	-	0	-
b. Stunt on healthy	Dec. 30, 1948	9	4	36	9	42
c. Healthy on stunt	Dec. 30, 1948	10	10	36	10	42
2. Reciprocal grafts of Vibrant, Sea Gull and Mistletoe						
a. Healthy on healthy	Apr. 11, 1950	16	0	-	0	-
b. Stunt on healthy	Apr. 11, 1950	26	14	27	26	37
c. Healthy on stunt	Apr. 11, 1950	29	29	27	29	37

TABLE II. Length of time for stunt symptom expression following juice inoculation.

Source of virus	Variety Inoculated	Date of Inoculation	Number Plants Inoculated	First reading		Final reading	
				Number Plants Showing Stunt	Days After Inoculation	Number Plants Showing Stunt	Days After Inoculation
healthy Sea Gull	healthy Sea Gull	Dec. 6, 1948	10	0	-	0	-
stunted Sea Gull	healthy Sea Gull	Dec. 6, 1948	10	4	85	10	130
stunted Vibrant	healthy Sea Gull	Feb. 6, 1950	2	1	54	1	156
stunted Vibrant	healthy Vibrant	Feb. 6, 1950	2	1	128	2	156
stunted Vibrant	healthy Sea Gull	Feb. 15, 1950	4	1	128	2	144
stunted Vibrant	healthy Sea Gull	Mar. 1, 1950	4	2	115	4	135

on these varieties under the conditions here, although the intensity of the symptom varies. This previously unreported symptom has proved extremely valuable as a uniform standard for the diagnosis of stunt. Infected plants can be found in a much shorter time than when diagnosis is by the flowering method. Under the conditions of this investigation, the dwarfing symptom alone was not fully reliable, due apparently to confounding factors such as differences in nutrient level, light intensity, etc.

Measles and Crinkle

Recently an apparently distinct disorder was noted in the variety Mistletoe, characterized by numerous large white spots on the leaves. These spots varied in size but were usually about one-eighth inch in diameter. The affected plants were severely dwarfed and produced numerous small axillary shoots. It has been extremely difficult to root cuttings from this affected material. The malady has been called the "measles" disease of Mistletoe (Figure 2).

Coincident with the discovery of the "measles" disease a still different disorder was recognized in the variety Blanche and has been known as "crinkle." In the diseased plants a severe leaf distortion and dwarfing is accompanied by intense white streaks and flecks over the entire leaf surface. The streaking appears largely along the veins, whereas the flecks are scattered over the interveinal areas as well (Figure 3).

In December 1949, the writer obtained plants of the variety Mistletoe with "measles," Blazing Gold with stunt, and Blanche with "crinkle," together with supposedly healthy plants of each variety. Healthy and stunt-infected clones of the varieties Vibrant and Sea Gull had previously been obtained. The stunt symptom expression of Blazing Gold is typical of most chrysanthemum varieties infected with the stunt virus; that is, no visible leaf markings are produced but rather a dwarfing of the entire plant.

In April 1950, an extensive cross-graft experiment was set up using the above five varieties. All possible combinations were made between the diseased and healthy clones. Simple cleft grafts were made. They were held firm with insect pins and protected from excessive loss of moisture with grafting wax. The grafted plants were kept in a humid chamber, made of cheesecloth, for three weeks to keep them turgid and were then placed on a greenhouse bench.

The grafts between healthy Mistletoe and stunted Vibrant, Sea Gull, and Blazing

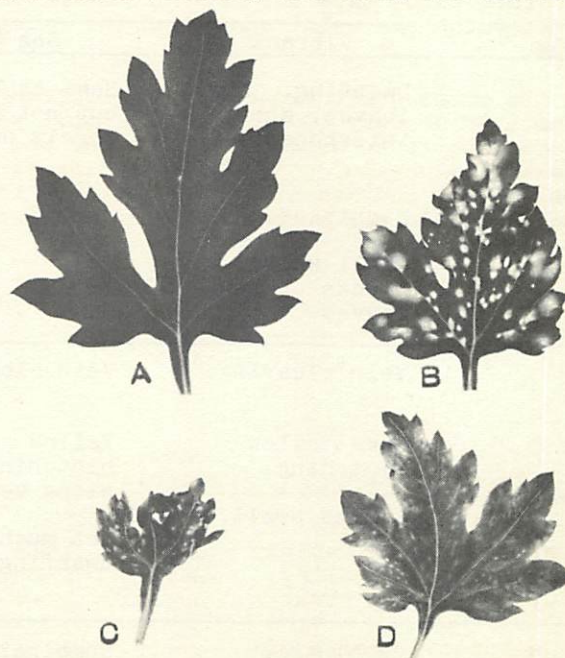


Fig. 2. Leaves of the variety Mistletoe:

- A. Healthy.
- B. Stunt infected ("measles").
- C. Stunt and virus Q.
- D. Virus Q.

Gold resulted in typical "measles" symptoms on Mistletoe. Grafts of healthy Mistletoe scions on stunted Blazing Gold stock resulted in heavy white spotting on Mistletoe leaves whereas the Blazing Gold shoots continued to grow alongside with no leaf markings. When reciprocal grafts were made between Mistletoe plants with "measles" and healthy plants of any of the other three varieties, typical stunt symptoms characteristic of these varieties resulted. The "measles" - stunt relationship has been consistent throughout the graft combinations where Mistletoe and the above three varieties have been used. It is evident, therefore, that Mistletoe "measles" and stunt in Vibrant, Sea Gull, and Blazing Gold are caused by the same virus.

Virus Q

The graft combinations with Blanche produced results not hitherto encountered. When stocks or scions of supposedly healthy Blanche were grafted to healthy Mistletoe severe leaf distortion followed by yellow vein blotching occurred in the new growth of the Mistletoe plants. This was strikingly different from the typical "measles" symptoms noted above. The symptoms were not so severe in Vibrant and Sea Gull when used in similar combinations with Blanche. In these varieties reduction in leaf size, vein clearing, and some vein blotching have been more characteristic. Blazing

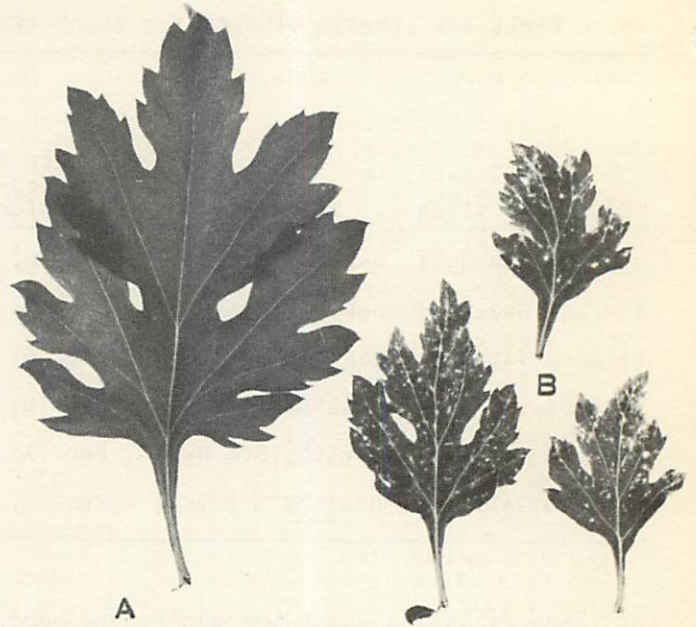


Fig. 3. Leaves of the variety Blanche:
 A. Infected with virus Q.
 B. Distortion due to presence of "crinkle" complex.

TABLE III. Symptom expression of stunt and Q on chrysanthemum varieties.

Virus	Chrysanthemum varieties				
	Vibrant	Sea Gull	Mistletoe	Blazing Gold	Blanche
Dwarfing.	Small leaves, short internodes.	Same as Vibrant but not as severely dwarfed.	Large white spots on the leaves --- "measles."	Dwarfing. No leaf symptoms.	Not yet known.
Stunt	Bushiness.				
	Small white flecks on new leaves.				
Virus Q	Vein clearing. Some yellow blotching. Leaves small.	Vein clearing. Yellow blotching along veins. Not much dwarfing.	Severe leaf distortion. Intense vein clearing and yellow blotching. Very dwarfed.	Intense yellow blotching along leaf veins. Not much dwarfing.	No leaf symptoms. Probably slightly dwarfed.
Stunt + Virus Q	Combination of above symptoms.	Combination of above symptoms.	Combination of above symptoms.	"Crinkle" disease. Leaf distortion. Intense white mottling on leaves.	"Crinkle" disease. Leaf distortion. White spots and streaks over leaf surface.

Gold behaves more like Vibrant and Sea Gull except that the yellow mottling along the veins is more pronounced.

When stunted scions of any of the other four varieties were grafted to supposedly healthy Blanche, the "crinkle" disease resulted in Blanche. This severe symptom also appeared in the Blazing Gold. In the other three varieties the symptoms were more or less of a combination of the characteristics of each virus. The "crinkle" Blanche produces the same additive effect on these varieties when graft combinations are made (Table 3).

The new symptoms have been reproducible and were obtained in all grafts involving supposedly healthy Blanche. Therefore, the Blanche thought to be healthy was actually harboring a masked virus. Plants of Blanche infected with this virus grow very vigorously and maintain dark green foliage. However, when this virus is introduced into certain other varieties, a severe leaf distortion or a yellow mottle pattern results. As noted earlier, varietal differences in response are also observed with the stunt virus. Stunt infected Blazing Gold plants are almost normal in appearance except for dwarfing, while infected Mistletoe plants are severely spotted.

The newly recognized masked virus in Blanche has been tentatively termed "chrysanthemum virus Q." As yet, there has not been sufficient time to determine any of its characteristics. Results to date show that chrysanthemum stunt and virus Q do not protect (both virus symptoms are expressed) against each other when inoculations are made either by juice or by grafting. This indicates that the viruses are not closely related.

Further studies on chrysanthemum stunt

Throughout these studies, vegetative symptoms of stunt have appeared in three to four weeks in previously healthy scions when grafted to diseased stocks (Table 1). This has been consistent with the varieties Vibrant, Sea Gull, and Mistletoe. About a week or two longer is required for symptom expression when scions with stunt are grafted to healthy stocks. This is a striking contrast to the long period of time required for diagnosis on the basis of the flowering technique used by Brierley and Smith (1949). In juice inoculation tests employing the carborundum technique, stunt appears in the new growth three to four months after inoculation (Table 2). A three month period of waiting was also noted by Olson (1949) with the variety Bronze Minuet. This period between inoculation and symptom expression is unusually long for a virus of herbaceous plants and constitutes one of the greatest handicaps in work with this disease.

Consequently, in the fall of 1949, nearly 90 plant species included in 27 families were inoculated in an effort to locate a more suitable test plant for the stunt virus. Unfortunately, not one of the plants gave a good reaction.

Summary

1. The "measles" disease of the chrysanthemum variety Mistletoe is caused by the same virus that produces typical stunt in Vibrant, Sea Gull, and Blazing Gold. Different varieties may vary greatly in response to infection by the same virus.

2. A new masked virus found in apparently healthy Blanche plants causes "crinkle" of Blanche when combined with the stunt virus. This new virus is tentatively called chrysanthemum virus Q.

3. Stunt in the varieties Sea Gull, Vibrant, and Mistletoe can be diagnosed by leaf symptoms in three to four weeks following inoculation by grafting and in three to four months following juice inoculation.

4. Over 90 plant species were tested, without success, in an effort to find a plant which would give a rapid and distinctive reaction to the chrysanthemum stunt virus.

Literature Cited

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