Correcting Boron Deficiency In Carnations

BY C. A. JACKSON, J. B. GARTNER AND T. F. CANNON,
NORTH CAROLINA STATE COLLEGE, RALEIGH, N. C.

Boron deficient carnations were first recognized at the Waltham field station of the University of Massachusetts late in 1954 and were reported by Mastalerz *et al.* (3). They reported that the first apparent symptom of boron deficiency in carnation flowers was a decrease in the normal petal number, with the decrease being directly related to the severity of the deficiency. At a particular stage in calyx development, some of the cells were injured, causing an epinastic curve of the bud as a result of boron deficiency. With severe boron deficiency, the immature buds died, became straw-brown in color, and papery in texture. Following the abortion of the flower or terminal bud, vegetative growth of the axillary shoots developed normally and usually vigorously until their own terminal buds died. Occasionally a proliferation of axillary shoot growth occurred below an aborted bud, representing the typical witch's broom effect. A greater number of splits was recorded for boron deficient plants as compared to plants receiving adequate amounts of boron. This observation was confirmed by Campbell (1). The appearance of a ring in the waxy bloom on the calyx usually occurred with the increased rate of calyx splitting. The development of a purple leaf tip was determined by Mastalerz (3) to be a characteristic foliar symptom of boron deficiency in carnations.

Symptoms similar to those described were observed in several carnation plantings in North Carolina at about the same time. It was thought at first that the witch's broom effect and other symptoms in the carnations were caused by virus or some other disease. Since none of the symptoms were confirmed to be pathological, it was then thought that a mineral deficiency was the cause of the abnormalities which occurred in the carnations.

In order to determine the specific deficiency symptoms of several elements, rooted carnation cuttings of the variety Sidney Littlefield were potted in washed quartz sand in plastic containers and fertilized with one of six nutrient solutions. The solutions used were a complete nutrient solution (Hoagland Solution) and solutions deficient in either calcium, iron, magnesium, sulfur, or boron. Demineralized water was applied to a check. Daily observations and comparisons were made of the plants. Production records included the number of flowers produced, stem length, flower diameter and stem quality (Table 1).

The plants began to show differences in rate of growth and appearance within a few weeks after they were subjected to the various treatments. The first group of plants to show deficiency symptoms was the one which was fertilized with a solution deficient in calcium. These plants developed a chlorotic appearance along the margins of the leaf and small necrotic spots occurred near the leaf tips. The growing points of the plants died, and the necrotic leaf spots enlarged until the entire leaf tip became a straw-brown color. The margins of the leaves became irregular and the tips curled backward. The symptoms continued to become more severe until the entire plant was killed. These plants produced no flowers.

The plants which were fertilized with a solution deficient in iron became chlorotic and growth was stunted appreciably. The leaf tips and young leaves showed more severe chlorosis than older leaves. As the deficiency became more severe, the leaf tips began to die. Flower production was low in this treatment.

The deficiency of magnesium also caused severe chlorosis of the plants subjected to that treatment. Growth was severely stunted, and the plants became very weak. As the deficiency became more severe, the leaf tips turned purple and finally began to die. The flowers produced on these plants were small and of very poor quality. The stems were very small and extremely weak.

The absence of sulfur in the nutrient solution caused the plants to show some chlorosis and a reduction in shoot growth. Defoliation was also evident on the lower parts of the plants. Flower production was greatly reduced and the flower and stem quality was very poor.

The plants which were fertilized with a solution deficient in boron developed many of the same symptoms which had been described earlier by Mastalerz *et al.* (3). A splitting of the leaf at the node and the growth of the axillary shoot through and below the leaf was one of the first abnormalities to be observed. Messing, (4) working in England with sand culture experiments, reported this as a symptom of boron deficiency. However, Mastalerz (2) has indicated that this symptom is not a reliable indicator of a boron deficiency, since it does occur in normal plantings. A purpling of the leaf tips was observed, and as the deficiency became more severe the leaf tips began to die. The internodes immediately below the flower bud were shortened, and the leaves were very brittle. Many of the flower buds were curved in an epinastic fashion, causing the flowers to open only on one side. As the deficiency became more severe, many of the immature buds died. Following the abortion of the terminal bud, the axillary shoots developed normally until their own terminal bud died. This proliferation of shoot growth below an aborted bud caused a witch's broom effect to occur. The flowers produced on these plants were of poor quality and had very short stems. The petal number was greatly reduced in many of the flowers, especially as the deficiency became more severe.

The plants in the check plot which received demineralized water only, made no new growth and became very chlorotic.

Table 1. Average number of flowers, stem length, flower diameter, and stem quality for plants cultured in sand which received one of seven nutrient solutions.

Solution	Average Number Flowers per plant	Average Stem Length (in.)	Average Flower Diameter (in.)	Average Stem Quality Rating*
Complete nutrient	3.66	19.50	2.87	7.45
Minus boron	2.66	17.63	2.48	7.06
Minus iron	2.33	15.11	2.82	7.36
Minus magnesium	2.16	19.08	2.44	2.92
Minus sulfur	1.83	17.64	2.70	5.27
Minus calcium	0.0			
Demineralized water	0.0			

* Stem quality was rated on a scale of 1 (very weak) to 10 (very strong).

The results of the sand culture investigation provided very strong evidence that boron deficiency was the cause of the abnormal carnation flowers and reduced production which had been observed in North Carolina. The symptoms observed in the plants which were fertilized with a solution deficient in boron seemed to be very similar to those reported by Mastalerz *et al.* (3).

Since these orginial observations were made, boron-deficient flower of carnations have been collected from almost every greenhouse in North Carolina in which carnations are grown. One grower reported a 60% reduction in production because of boron deficiency.

The deficiency did not occur during the first year following replacement of the greenhouse soil. During the second and third year, however, the severity of the deficiency increased very rapidly. This increase in severity following the first year after a soil replacement has been evident throughout the carnation industry in North Carolina. This may partially be explained by some of the cultural practices which have been adopted by carnation growers. Steam sterilization, liquid fertilization, and increased production per square foot may all be contributing to the severity of the boron deficiency problem. These factors also help to account for the somewhat sudden appearance of boron deficiency in carnations throughout the country.

The modern cultural practices have reduced the cost of production so much that the growers cannot discontinue the use of them. It has become necessary, therefore, to find a source of boron to include in the carnation fertilization program in order to produce good quality flowers.

Borax has been recommended by Mastalerz (2) at the rate of one ounce per one hundred square feet per year to correct boron deficiency after the symptoms have been diagnosed. The recommendations for the use of borax in preventing the problem were to use one third to one half ounce per one hundred square feet three times per year. Borax at these rates has failed to correct the deficiency in North Carolina. Other sources of boron have been found to have potential value in the correction of boron deficiency in carnations. Some of these materials are "fritted" so that the boron supply is slowly available to the plants. The fritted micro-metabolic elements are made from glass which is ground into a fine powder after the elements have been incorporated into the contents of the glass.

In November 1957, an experiment was initiated at North Carolina State College to study the effect of different rates of application of five sources of boron on carnation production. The results of this experiment will be reported in the next issue of the N. C. Flower Grower Bulletin.

REFERENCES

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