THE CONTROL OF PLANT DEVELOPMENT WITH MALEIC HYDRAZIDE

Many species of plants, commonly handled as nursery stock, are likely to develop undesirable soft shoots when exposed to high temperatures following a long period in cold storage. Such development, as well as the cost of cold storage facilities, might be avoided if nursery stock could be kept dormant by spraying nursery plants in fall or early spring. Our preliminary experiments have indicated that maleic hydrazide, which is effective as a low temperature spray on dormant nursery stock, may be a useful material for this purpose.

The effect of maleic hydrazide was first described by Schoene and Hoffman (5) in 1949. Dilute solutions of maleic hydrazide were found to inhibit growth of tomatoes and various grasses. Growth was inhibited for a few days to several months depending upon the concentration of the chemical. Knott (2) found that growth in a Pyracantha hedge could be controlled by spraying with a 0.2 to 0.5 percent solution. White and Kennard (6) used a 0.045 percent solution which delayed flowering in raspberries without any deleterious effect on subsequent fruit set. Plants sprayed on April twenty-seventh, when leaflets had expanded about one-half inch, set fruit from sixteen to twenty-three days later than untreated plants. Vegetative growth was temporarily inhibited but both treated and untreated plants had attained a similar development by midsummer. The crop was equally good in both instances. Miller and Erskine (8) have prevented fruit set in Ginkgo biloba by spraying blooming trees with 0.1 percent maleic hydrazide. Naylor (4) sprayed corn plants thirty to forty inches high with 0.025 percent solution, thus producing male sterile plants with normal ears. Currier and Crafts (1) have found that a 0.2 percent spray killed young plants of Johnson and water grasses, but did not affect cotton plants sixteen inches high.

Maleic hydrazide was sent to us for experimental purposes by Dr. John W. Zukel, Naugatuck Chemical Division, United States Rubber Company, Naugatuck,
Connecticut, as a solution containing 30 percent of the active ingredient in the form of the diethanolamine salt. The percentages of the dilute solutions are based upon the actual weight of the active ingredient dissolved in 1 liter of distilled water. Thus the 0.6 percent solution was prepared by adding 20 grams of the formulation, containing 6 grams of the active ingredient, to one liter of distilled water. Since the formulation has a specific gravity of 1.2, a substantially similar solution may be prepared by dissolving 16.6 milliliters of the formulation in one liter of distilled water.

The material may be applied as a spray or by immersing the stems in the solution. The effectiveness of the spray treatments is increased by adding a wetting agent. Maleic hydrazide should be handled with the customary precautions which apply to all new chemicals. Treated food crops should not be eaten until a complete toxicological evaluation is available.

**Experimental Results**

On January twenty-third, field grown, dormant plants of several rose varieties were sprayed out-of-doors at a temperature of about 43° F. and at high relative humidity. At the same time corresponding plants were selected as controls. About five hours after spraying, suitable branches were removed from these plants and made up into seven-inch cuttings. These cuttings were then planted in sand and placed in a warm greenhouse. The results with *Rosa dilecta* "Talisman," sprayed with 0.3 percent solution, are illustrated in Plate IX. Treated cuttings of this variety were effectively inhibited for twenty-eight days following treatment. At this time several dead cuttings had appeared in both treated and control lots and the cuttings were subsequently discarded. "Paul's Scarlet" climber was inhibited by spraying with 0.15 percent solution, but eleven weeks later the treated cuttings had only produced abnormally elongated leaves and the material was discarded. "Dorothy Perkins" climber, however, which received the same treatment, was effectively inhibited for about six weeks and after eleven weeks, the treated cuttings had resumed apparently normal growth, including good roots and vigorous, leafy shoots. Similar results were obtained with cuttings of *Rosa multiflora* "thornless" sprayed with 0.15 and 0.075 percent solutions. There were no apparent differences between the two concentrations.

Both dormant and actively growing plants of *Rosa multiflora* "thornless" were seriously injured by a 0.6 percent spray treatment. Some of these dormant plants were packaged with moist moss and stored either in a warm greenhouse or in cold storage at 40° F. None of the plants treated with 0.6 percent have resumed normal growth and many of them were killed by the treatment. The treatment, however, is effective at temperatures of 40° F. and it is entirely possible that a suitable concentration would be very useful in preventing premature bud development in stored rose bushes.

Several species of *Prunus* were inhibited by maleic hydrazide treatment, both
Plate IX

Rosa 'Talisman', photographed February 9, 1930, after nine days in a warm greenhouse. Lot 1, cuttings collected from a plant sprayed out-of-doors with 0.5 percent maleic hydrazide; Lot 2, cuttings from control plant.
by spraying and by basal immersion of the stems. Dormant nursery seedlings of \textit{Prunus} “Mazzard” have remained alive for eleven weeks following spraying with a 0.6 percent solution, but it seems unlikely that these plants will ever resume normal growth. Twenty-five cuttings, made from a dormant plant of \textit{Prunus persica} “Rutgers Greenleaf,” sprayed out-of-doors with 0.3 percent solution, were definitely inhibited for several weeks. A few cuttings were killed by the treatment, but many resumed normal growth including both roots and shoots. \textit{Prunus sargentii} and \textit{P. yedoensis} seedlings were inhibited by a 0.3 percent spray. Recovery of some individual plants has been fair to good in both instances.

Scions of \textit{Malus pumila} “MacIntosh” were inhibited by spraying with 0.6 percent solution. The treated scions were grafted on roots of untreated apple seedlings. Although the effect of this chemical is systemic rather than localized, it is apparently possible to secure considerable inhibition of buds and yet permit some degree of callus formation. An application of indolebutyric* acid, at the point of graft union, appears to have intensified the inhibiting effect of the maleic hydrazide. Small-scale out-of-door spraying of \textit{Malus pumila} “Delicious,” using 0.075 percent maleic hydrazide, has not resulted in delayed flowering when the treated branches were removed from the tree and forced in a warm greenhouse.

Well-budded branches of \textit{Forsythia} were brought into the greenhouse for forcing in late January. Maleic hydrazide treatment had little effect on the time of flowering, but the duration of flowering was prolonged. In one lot, treated with 0.15 percent solution by soaking the basal part of the stems for sixteen hours, flowers borne on the treated branches remained in good condition for about a week longer than those on the controls. The flowering life of cut roses was also lengthened by using a 0.03 percent solution as an overnight soaking treatment. It is probable that the life of other cut flowers could be prolonged by similar treatments.

Maleic hydrazide, as a 0.3 percent spray on dormant potted plants, has effectively inhibited vegetative growth and has delayed flowering in \textit{Vaccinium corymbosum} “Cabot” and “Pioneer.” One treated plant of the variety “Cabot,” sprayed on February third and subsequently placed in a warm greenhouse, began to flower on April fourth, fourteen days later than the corresponding control. On April fourteenth, this treated plant was in full bloom while only an occasional flower remained on the untreated control. The treated plant still showed evidence of vegetative inhibition, but it had developed numerous apparently normal leafy shoots. Although both treated and control plants produced an abundance of apparently normal flowers, there was practically no fruit set in either lot. This lack of fruit set may be due to poor pollinating conditions in the greenhouse.

Potted plants of \textit{Picea}, \textit{Tsuga}, \textit{Pinus} and \textit{Larix} were sprayed with 0.6 percent maleic hydrazide in greenhouse conditions. Growth was inhibited in all cases,  

*Hormodin 1.
but at the time of writing there has been no resumption of normal growth. *Larix* and *Tsuga* are apparently more tolerant of maleic hydrazide treatment than are *Picea* and *Pinus*.

Actively growing potted plants of *Rhododendron mucronatum* (*Azalea ledifolia alba*) were severely injured by spraying with 0.6 percent solution on January twenty-first. On April fourteenth, however, these plants were forming new roots and there was considerable evidence of renewed bud activity.

*Syringa amurensis japonica, S. vulgaris, Betula papyrifera* and *B. lenta* have not responded markedly to maleic hydrazide treatment in the conditions of these experiments.

**Conclusion**

The control of vegetative and floral development has many applications in horticulture: the delay of flowering in early blooming plants; the destruction of flowers in plants which produce unwanted fruits or pollen; the selective killing of weeds; the prolongation of the life of cut flowers; and the retardation of dormant nursery stock. Although maleic hydrazide has given us some promising results in the control of floral and vegetative development, these results are based on limited trials with relatively small numbers of plants. Definite practical recommendations must await the outcome of further studies.

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