rections of the preferred orientations probably influence the directions of blast fracturing and the stability of mine walls and pillars; they may directionally affect the crushing strength of the salt (*5*).

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5. The cost of the goniometric device was defrayed in part by Geology Department and in part by a grant from Research Institute, University of Texas. I am greatly indebted to Dr. W. R. Muehlberger for extensive assistance and encouragement throughout the project.

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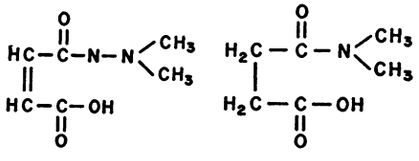
Retardation of Plant Growth by a New Group of Chemicals

Abstract. Sprays of N-dimethylaminomaleamic acid were found to retard the growth of a variety of plants, including legumes, vine crops, potatoes, and ornamentals. It was readily translocated, had a long residual action, was relatively nonphytotoxic, and did not appear to affect adversely root, vegetative, or reproductive development.

N-dimethylaminomaleamic acid (C011) and succinamic acid (B995) retarded the growth of a variety of plants (Table 1) when applied as a spray to the foliage. Their structures are



C011 B995

No activity was noted in the analogous compound derived from phthalic acid. However, chemicals made from tetra- and hexahydrophthalic acids have exhibited a moderate degree of growth regulation. The imides of C011 and B995 were also active but to a lesser degree than the acids.

These chemicals decrease internode growth in a manner similar to the quaternary salts Amo 1618 (*1*), Phosfon (*2*) and "CCC" (*3*). This report describes the biological activity of only one compound, C011.

The free acid of C011 is completely water-soluble at 200,000 ppm (20 percent). Metal and alkanolamine salts are readily formed. The salts also function as growth-retarding chemicals. In the tests described below the free compound was used exclusively.

In foliage spray tests under greenhouse conditions, solutions were made by dissolving C011 in water and adding one drop of Triton X100, a nonionic emulsifier. Seedling plants were sprayed to runoff at a rate of 5000 ppm. Data on height reduction compared to untreated control plants are shown in Table 1. The measurements were taken 1 month (pinto bean, soybean) or 3 months (all other test plants) after chemical treatment. No phytotoxicity effects were noted.

C011 was readily translocated from the primary leaves of pinto bean plants to the growing point when the first trifoliate leaf was beginning to expand. In this experiment only the primary leaves were sprayed to runoff with a 1000-ppm solution of C011. One month later (Fig. 1) when the fourth trifoliate leaf was fully expanded, the average internode length for the treated plants was 1 inch, compared to 2½ inches for the untreated check.

In the field C011 was sprayed on Green Mountain potato foliage at a rate of 8 lb in 40 gal of water per acre. The chemical was applied 20 days after planting. At this time no tuber initials were formed. At harvest the treated foliage was 48 percent shorter than that of the control plants. Tubers were dug,

Table 1. Effect of N-dimethylaminomaleamic acid (C011) on the height of various plants. Seedling plants were sprayed to runoff at a rate of 5000 ppm.

Plant	Reduction in height compared to untreated controls (%)
Alfalfa: *Medicago sativa* (L.)	33
Apple Seedlings: *Malus sylvestris* (Mill.) (McIntosh)	47
Broccoli: *Brassica oleracea* (L.) var. *Italica* (Calabrese)	66
Cosmos: *Cosmos* sp. (Sensation)	53
Marigold: *Tagetes erecta* (L.) (Man-in-the Moon)	52
Morning Glory: *Ipomea purpurea* (Lem.) (Heavenly Blue)	46
Peanuts: *Arachis hypogea* (L.) (Virginia Runner)	50
Petunia: *Petunia hydrida* (Vilm.) (many varieties)	29
Pinto bean: *Phaseolus vulgaris* (L.)	60
Poinsettia: *Euphorbia pulcherrima* Willd.) (Barbara Ecke Supreme)	34
Scabiosa: *Scabiosa pratensis* (Moench.) (Mourning Bride)	50
Soybeans: *Glycine hispida* (Max.) (Harasoy)	36
Squash: *Cucurbita pepo* (L.) (Table Queen)	80
Zinnia: *Zinnia elegans* (Jacq.) (many varieties)	47

Fig. 1. Unsprayed (left) and sprayed (right) pinto bean plants. The spray of C011 was applied to the primary leaves at a rate of 1000 ppm. The leaves of one plant in each treatment were removed to show more clearly the reduced internode length of the C011 treated plants.

stored at 45°F for 5 months, and planted in peat moss. All tubers sprouted within 7 days. One month later the sprouts from tubers harvested from treated plants averaged 8 inches in height, compared to 16 inches for those from untreated plants. All sprouts had approximately the same number of nodes—13.

Numerous observations and some quantitative comparisons on such plants as pinto beans, peanuts, and squash showed that root growth and rate of vegetative development were not altered by the use of C011. Anthesis was sometimes delayed by 1 or 2 days but total flower number was not affected. Plot size and number of replications were not adequate to make exact yield comparisons. However, in the harvesting of many small plots of potatoes, squash, and Tendergreen beans no obvious differences in number or size of tubers, fruit, or seed were noted.

In conclusion, N-dimethylaminomaleamic acid and certain related chemicals appear to be an interesting new group of growth-retarding chemicals. N-dimethylaminomaleamic acid is effective as a spray, it is readily translocated, and it appears to have a long residual action in the plant. This type of growth regulation is particularly interesting because plant height is reduced while rate of development is not affected.

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