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# The Genetic Relationship of *Virescent, Yellow-green, Glabrous,* and *Halo* Mutants in Muskmelon[1]

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*Abstract. Virescent* (*v*) is inherited independently of *yellow-green* (*yg*), *glabrous* (*gl*), and *halo* (*h*) seedling mutants in muskmelon (*Cucumis melo* L.). *Virescent, yellow-green* seedlings were virescent with the yellowish chlorophyll change. *Virescent, glabrous* seedlings were virescent without trichomes, and *virescent, halo* seedlings produced no chlorophyll and were lethal. With each pair of mutants the segregation of progenies from test crosses fit the expected ratio for independent assortment of 2 gene pairs located on different chromosomes.

The virescent (*v*) mutant of muskmelon was discovered in 1967 by Andrus (3). In the original population, 80-90% of the *v* plants did not have chlorophyll and died. The surviving seedlings exhibited normal chlorophyll development and grew slowly to maturity. Throughout their growth, apical meristems were yellowish and stems, petioles and tendrils were pale green or white. Petals were cream in color, fading to white with age; the stigmas were orange. The flesh of mature fruit was bright yellow and a few fruit developed salmon-colored streaks through the flesh. After several crosses with normal green types and selection for plants which increased survival and vigor, a virescent line was developed that could be used for genetic, breeding and pollination studies.

About 40 genes have been recorded for muskmelon, with little information on the genetic relationships among them (2,3,6,8). Robinson et al. (7) summarized the 37 genes known by 1975. Bohn and Principe (1) reported on the independence of 7 genes, including *yellow-green* (*yg*) and *glabrous* (*gl*). Zink (9) found linkage between *yellow virescent* (*yv*) and *bush* (*b*). In 1978, I reported the independence of *halo* (*h*), *glabrous* (*gl*), and *yellow-green* (*yg*) (5). McCreight and Bohn (4) reported the independence of *red stem* (*r*) and *pale* (*Pa*) in 1979.

This study was begun in 1972 to provide information on the genetic relationships of genes *v, yg, gl* and *h* mutants in the muskmelon.

Reciprocal crosses were made between homozygous *v* and plants homozygous for either *yg, gl,* or *h*. The $F_1$ plants were self-pollinated and backcrossed to both parents. Seedlings of the $F_2$ and backcross generations were classified 5-20 days after emergence and some plants of all phenotypes were grown to maturity for self-pollinations and backcrosses. A total 3135 seedlings from 13 selfed and backcross populations involving *v* × *yg*, 7913 seedlings from 35 populations involving *v* × *gl* and 18,590 seedlings from 60 populations involving *v* × *h* were studied.

*Virescent* crossed readily with *yg*. The $F_1$ was normal, and the data fit the expected segregation ratios for 2 genes with independent assortment (Table 1). The double recessive (*vv/ygyg*) seedlings looked like *v*, but showed the *yg* chlorophyll change, thus making their identity unmistakeable. I conclude, therefore, that genes *v* and *yg* are independent.

From the cross between *v* and *gl*, a normal $F_1$ was produced and the $F_2$ and backcross populations fit the expected dihybrid ratios, indicating that *v* was independent of *gl* (Table 2). The double recessive phenotype was distinctly virescent and glabrous.

Crosses of *v* × *h* produced a normal $F_1$ and presented no problem until the $F_2$ germinated (Table 3). Classification of the seedlings into 4 expected classes was difficult because the double recessive *virescent halo* (*vvhh*) and some virescent (*vvH*−) seedlings were phenotypically identical. This resulted in half the $F_2$ populations being classified into a 9:3:4 ratio. Because the double recessive produced little or no chlorophyll, it did not survive and the desired backcross (*VvHh* × *Vh*) could not be made in the conventional manner. This problem was overcome by self-pollinating $F_3$ *halo* plants and looking for *halo virescent* seedlings that would survive. One *halo virescent* $F_4$ plant survived long enough to produce 6 staminate flowers with viable pollen and to produce a backcross population which closely fit the expected 1:1:1:1 ratio of 2 independently inherited genes.

These studies confirmed previous reports on the independence of *gl, yg* and *h* mutants and demonstrated the independence of these seedling mutants to *v*. They also showed that *vyg, vhl,* and *vh* are double recessive to normal green seedlings. Three of these 4 mutant genes affected chlorophyll production in one or more parts of the muskmelon plant. Apparently, *v* and *h* inhibited

**Table 1. Segregation of muskmelon crosses involving *virescent* (*v*) "$P_1$" and *yellow-green* (yg) "$P_2$".**

| Generation | Phenotype of parent | Segregation | | | | Expected ratio | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|
| | | normal | *yg* | *v* | *ygv* | | | |
| $P_1$ | *v* | 0 | 0 | 352 | 0 | All *v* | 0.00 | 1.00 |
| $P_2$ | *yg* | 0 | 521 | 0 | 0 | All *yg* | 0.00 | 1.00 |
| $F_1$ | *yg* × *v* | 187 | 0 | 0 | 0 | All normal | 0.00 | 1.00 |
| $F_1$ | *v* × *yg* | 291 | 0 | 0 | 0 | All normal | 0.00 | 1.00 |
| $F_1 \times P_1$ | Normal × *v* | 193 | 0 | 181 | 0 | 1:1 | 0.19 | 0.80–0.90 |
| $F_1 \times P_2$ | Normal × *yg* | 219 | 203 | 0 | 0 | 1:1 | 0.30 | 0.50–0.70 |
| $F_1 \times F_2$ | Normal × *ygv* | 130 | 126 | 132 | 128 | 1:1:1:1 | 0.04 | 0.98–0.99 |
| $F_2$ | Normal | 140 | 44 | 51 | 13 | 9:3:3:1 | 0.14 | 0.90–0.95 |
| $F_3$ | *ygv* | 0 | 0 | 0 | 224 | All *ygv* | 0.00 | 1.00 |

**Table 2. Segregation of muskmelon crosses involving *virescent* (*v*) "$P_1$" and *glabrous* (*gl*) "$P_2$."**

| Generation | Phenotype of parent | Segregation | | | | Expected ratios | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|
| | | Normal | *gl* | *v* | *glv* | | | |
| $P_1$ | *v* | 0 | 0 | 964 | 0 | All *v* | 0.00 | 1.00 |
| $P_2$ | *gl* | 0 | 725 | 0 | 0 | All *gl* | 0.00 | 1.00 |
| $F_1$ | *v* × *gl* | 581 | 0 | 0 | 0 | All normal | 0.00 | 1.00 |
| $F_1$ | *gl* × *v* | 703 | 0 | 0 | 0 | All normal | 0.00 | 1.00 |
| $F_1 \times P_1$ | Normal × *v* | 127 | 0 | 119 | 0 | 1:1 | 0.13 | 0.70–0.80 |
| $F_1 \times P_2$ | Normal × *gl* | 79 | 83 | 0 | 0 | 1:1 | 0.05 | 0.80–0.90 |
| $F_1 \times F_2$ | Normal × *glv* | 462 | 485 | 520 | 492 | 1:1:1:1 | 0.87 | 0.80–0.90 |
| $F_2 \times F_1$ | *glv* × Normal | 398 | 378 | 395 | 374 | 1:1:1:1:1 | 0.28 | 0.95–0.98 |
| $F_2$ | Normal | 389 | 133 | 133 | 52 | 9:3:3:1 | 0.19 | 0.95–0.98 |
| $F_3$ | *glv* | 0 | 0 | 0 | 321 | All *glv* | 0.00 | 1.00 |

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Table 3. Segregation of muskmelon crosses involving *virescent* (*v*) "$P_1$" and *halo* (*h*) "$P_2$".

| Generation | Phenotype of parent | Segregation | | | | Expected ratio | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|
| | | Normal | *h* | *v* | *hv* | | | |
| $P_1$ | *v* | 0 | 0 | 372 | 0 | All *v* | 0.00 | 1.00 |
| $P_2$ | *h* | 0 | 326 | 0 | 0 | All *h* | 0.00 | 1.00 |
| $F_1$ | *v* × *h* | 392 | 0 | 0 | 0 | All normal | 0.00 | 1.00 |
| $F_1$ | *h* × *v* | 429 | 0 | 0 | 0 | All normal | 0.00 | 1.00 |
| $F_1 \times P_1$ | Normal × *v* | 99 | 0 | 96 | 0 | 1:1 | 0.05 | 0.80–0.90 |
| $F_1 \times P_2$ | Normal × *h* | 163 | 167 | 0 | 0 | 1:1 | 0.05 | 0.80–0.90 |
| $F_1 \times F_4$[z] | Normal × *hv* | 99 | 114 | 102 | 100 | 1:1:1:1 | 1.39 | 0.70–0.80 |
| $F_2$ | Normal | 1926 | 654 | 832 | – | 9:3:4 | 0.20 | 0.90–0.95 |
| $F_2$ | Normal | 1428 | 473 | 471 | 148 | 9:3:3:1 | 0.08 | 0.99 |
| $F_3$ | *v* | 0 | 0 | 2433 | 838 | 3:1 | 0.25 | 0.50–0.70 |
| $F_3$ | *v* | 0 | 0 | 1173 | 0 | All *v* | 0.00 | 1.00 |
| $F_3$[z] | *h* | 0 | 1805 | 0 | 580 | 3:1 | 0.22 | 0.50–0.70 |
| $F_3$ | *h* | 0 | 3370 | 0 | 0 | All *h* | 0.00 | 1.00 |

[z]The plant used in $F_1 \times F_4$ backcross was one of the 580 $F_4$ *hv* seedlings from $F_3$ *hhVv* plants.

chlorophyll production by 2 different mechanisms, resulting in no chlorophyll synthesis. These genes should be useful for biochemical studies of the genetic control of chlorophyll synthesis.

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# Extending Vase Life of Carnations with Aminooxyacetic Acid, Polyamines, EDU, and CCCP[1]


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*Additional index words.* aminoethoxyvinylglycine, *Dianthus caryophyllus,* preservative solution, postharvest handling, putrescine, spermidine, spermine



*Abstract.* **Aminooxyacetic acid (AOAA) at a concentration of 0.5 mM extended the vase life of carnations (*Dianthus caryophyllus* L. cv. White Sim) to a degree comparable to that shown by 0.1 mM aminoethoxyvinylglycine (AVG) (71 to 94%). Increases in vase life ranging from 22 to 53% were also obtained with N-[2-(2-oxo-1-imidazolidinyl) ethyl]-N′-phenylurea (EDU), carbonylcyanide *m*-chlorophenyl-hydrazone (CCCP), spermidine, putrescine, or spermine. Combinations of AVG and EDU or AOAA and EDU further extended the vase life 134 to 140% over that of the control flowers. These increases were additive to the beneficial effects obtained from the control preservative solution, which contained 2% sucrose and 200 ppm 8-hydroxyquinoline citrate.**


AVG has been demonstrated to be very effective in extending the vase life of carnations (5), snapdragons (12), and irises, daffodils, and chrysanthemums (11). It was shown that AVG increases the longevity of cut flowers by inhibiting ethylene production (5, 10, 12).

Recently, in an *in vitro* study, Yu et al. (13) reported that AOAA was as potent as AVG in inhibiting 1-aminocyclopropanecarboxylate (ACC) synthase, a key enzyme in ethylene biosynthesis. Since AOAA is readily available and relatively inexpensive, we decided to compare its ability to improve the keeping quality of cut flowers with that of AVG. Several polyamines and an anti-ozone protectant, EDU, were also included in this study because of their anti-senescence properties (2, 6-9).

Carnations grown in Colombia were obtained from a wholesale nursery. Uniform flowers were cut to 30 cm and placed in 1-liter glass jars containing 500 ml of solution. Test chemicals included 0.1, 0.5, and 1 mM of AVG, AOAA, spermidine, putrescine, or spermine; 0.05 and 0.1 mM or CCCP; and 0.4, 1, and 2 mM of EDU. In the second experiment, combinations of AVG (0.1 mM) and EDU (1 mM) or AOAA (0.5 mM) and EDU (1 mM) were used. The solutions were made up with deionized water. Each test chemical was added to the preservative solution containing 2% sucrose, 200 ppm 8-hydroxyquinoline citrate, and 0.02 M citric acid buffer adjusted to pH 4.6 with KOH. The jars containing preservative solutions and flowers were placed randomly in a room maintained at 20°C, 50 to 60% relative humidity and under continuous 1.1 klx cool-white fluorescent light. Five flowers were placed in each jar, and the vase life was evaluated individually. Two replicates were used for each treatment.

Among treatments in which only a single test chemical was added to the preservative solution, AVG and AOAA were superior to other chemicals tested (Table 1 and Fig. 1). AVG at concentrations of 0.1 to 1 mM increased vase life of carnations 71 to 91% over that of the control flowers (Tables 1 and 2). At 0.1 mM, AOAA was not as effective as AVG. However, at a concentration of 0.5 mM, AOAA appeared to be comparable in effect to 0.1 mM AVG. When compared to the flowers held in deionized water alone, the flowers in these treatments lasted 3 to 3.5 times longer. Significant but smaller increases in vase life were obtained with spermidine, putrescine, spermine, or CCCP. These increases ranged from 22 to 32%. EDU at the concentration of 1 mM increased vase life 53% of that of the control flowers. At higher concentration, EDU was not as effective, possibly because of a toxic effect on stem tissue. Combinations of AVG and EDU or AOAA and EDU further extended the vase life 134 to 140% over that of the


[1]Received for publication July 2, 1980. Abbreviations: EDU: N-[2-(2-oxo-1-imidazolidinyl)ethyl]-N′-phenylurea; CCCP: carbonylcyanide *m*-chlorophenyl-hydrazone.

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