

**Fertility Affects Susceptibility of Chrysanthemum
to Cotton Aphids (*Aphis gossypii*):
Influence on Plant Growth and Physiology**

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Nature of Work: This research details the influence of fertility on plant growth, photosynthesis, ethylene evolution, and herbivore abundance of chrysanthemum (*Dendranthema grandiflora* Tzvelev var. Charm) inoculated with cotton aphids (*Aphis gossypii* Glover). We tested five fertilization treatments that consisted of 0%, 5%, 10%, 20%, and 100% (375 ppm N) of recommended nitrogen levels. After five weeks, plants were inoculated at five aphids per 6-in. pot containing four rooted cuttings. Plants were grown in growth chambers.

The cotton or melon aphid (*Aphis gossypii* Glover) is a serious economic pest of greenhouse crops such as chrysanthemum (*Dendranthema grandiflora* Tzvelev var. Charm) (2). High densities of cotton aphids can occur throughout the chrysanthemum production cycle because of favorable greenhouse growing environments and the prolific reproduction of aphids. Chrysanthemum cultivars differ in susceptibility to aphids (1). The greenhouse environment and cultural conditions contribute to host-plant resistance or susceptibility (6).

Fertilizers used in nursery - greenhouse industries are an important source of essential elements for both chrysanthemums and aphids. High nitrogen fertility can increase insect populations and decrease secondary metabolites, such as phenolics, reducing the chemical resistance of host plants to aphids. During commercial production, chrysanthemums are fertilized at high fertility (i.e., 375 ppm N for pulse feeding). However, unlike agronomic or other field crops, there is near zero tolerance for any aphids during greenhouse crop production of chrysanthemum. In short, strategies for optimizing greenhouse chrysanthemum nitrogen fertilization while simultaneously controlling aphid population development have led to mixed results (1).

Hence this study tested the hypothesis that moderate levels of nitrogen would better control cotton aphids on chrysanthemum. While aphids are known to reduce plant quality, there have been few comprehensive studies on plant response to aphid population dynamics.

Results and Discussion: This is one of the first reports on the susceptibility of chrysanthemum to cotton aphids (*Aphis gossypii*) -- detailing the influence of fertility on plant growth, photosynthesis and ethylene evolution, and herbivore

abundance. The greatest relative reduction of plant performance was at highest fertility levels of 375 ppm N (Tables 1 & 2).

Plant Growth. Aphids significantly influenced carbohydrate partitioning of chrysanthemum. While aphids did not alter total plant biomass, they did reduce reproductive growth (lower flower bud number and dry mass [dm]) and decreased leaf biomass. Aphids triggered morphological changes in leaf development by increasing the specific leaf area (SLA [$\text{cm}^2 \text{g}^{-1}$]) (i.e., thinner leaves) and increased the leaf area. A higher SLA indicates that fewer leaf mesophyll cells develop and that biomass is reduced per unit leaf area (4). Aphids are phloem feeders and cause minimal tissue damage, relative to leaf miners which attack leaf mesophyll tissue or thrips which target individual cells. As such, plants perceive aphids as pathogens and activate the salicylic acid-dependent and jasmonic acid/ethylene dependent signalling pathways (5). These aphid-triggered physiological responses may cause changes in leaf SLA.

Chlorophyll & Net Photosynthesis. While aphid inoculated (AI) plants did not have statistically different levels of leaf chlorophyll, there was a reduction in net photosynthesis (P_n) at high fertility (375 ppm N) in AI young leaves, but not physiologically mature or older leaves. Lower N in AI plants may have indirectly reduced P_n . The reduced P_n in young leaves of AI plants may also be due to physical stress of phloem-feeding aphids (i.e., causing higher production of ethylene or other signalling compounds).

Ethylene Production. Aphids caused greater ethylene production in reproductive buds and young leaves of high fertility plants, but had no effect on physiologically mature or older leaves. Ethylene is a phytohormone that can occur with plant injury (e.g., aphid stylets penetrating leaf mesophyll cells to locate phloem tissue). Phloem-feeding aphids (and whiteflies) produce marginal injury to plant foliage, but instead are perceived as pathogens that can activate ethylene-dependent signaling pathways (5). The activation of ethylene pathways may in part explain the higher ethylene in flower buds and young leaves of AI plants. Ethylene can adversely affect plant growth, and in combination with other plant hormones, controls such important physiological processes as senescence and abscission of leaves and flowers.

Nitrogen and Aphid Populations. While low to moderate N fertility greatly reduced aphid populations in our study (Fig. 1), the chrysanthemums were not of marketable quality. Dietary nitrogen, principally in the form of amino acids in the phloem, is an important factor influencing aphid development (1). Hence, aphid consumption of soluble nitrogen via amino acids is likely contributing to the decline in total plant N. Aphids are known to concentrate more on newly developing leaves than older leaves, in part because of greater amino acid concentration in the phloem of the former (3).

The increased aphid populations on younger than older leaves in the high fertility treatment of our study may be due to higher amino acid levels (which we did not measure). Leaf N was higher in younger leaves.

Significance to the Industry: Commercial production of ornamental plants entails a rapid crop cycle where nutrients and water are applied in abundance. A basic tenant of best management practices and integrated pest management (IPM) systems is the reduction of quantities of fertilizers and pesticides through more judicious use and integration of pest control methods. IPM is highly applicable to a single plant-pest system -- hence the potential with the chrysanthemum-aphid system. The morphology and physiological status of chrysanthemum determines its susceptibility to aphids. This paper demonstrates the influence of aphids on increasing ethylene, decreasing Pn , and decreasing carbon allocation to leaves and reproductive structures. Selecting chrysanthemum cultivars with greater resistance to aphids is one approach to IPM. Controlling fertility and irrigation practices to reduce and manage aphids are other options. While growing plants under deficient fertility levels is not a satisfactory strategy for reducing insect pests, more precise chemical practices that reduce fertility and pesticide levels may result in healthier, less stress susceptible plants.

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Table 1. ANOVA P values of growth parameters of chrysanthemum-aphid study.

Individual Flower Bud DM		Flower Bud DM		Leaf DM		Total Top DM		Shoot DM	
Source	P	Source	P	Source	P	Source	P	Source	P
Aphids (A)	<0.0001	Aphids (A)	0.0256	Aphids (A)	NS	Aphids (A)	NS	Aphids (A)	NS
Fert (F)	<0.0001	Fert (F)	<0.0001	Fert (F)	<0.0001	Fert (F)	<0.0001	Fert (F)	<0.0001
A x F	NS ²	A x F	<0.0001	A x F	0.0200	A x F	<0.0001	A x F	NS
Total Plant DM		Plant Height		Leaf Area		Flower Bud No.		Specific Leaf Area	
Source	P	Source	P	Source	P	Source	P	Source	P
Aphids (A)	NS	Aphids (A)	NS	Aphids (A)	0.0025	Aphids (A)	<0.0001	Aphids (A)	0.0020
Fert (F)	<0.0001	Fert (F)	<0.0001	Fert (F)	<0.0001	Fert (F)	<0.0001	Fert (F)	<0.0001
A x F	NS	A x F	NS	A x F	0.0004	A x F	<0.0001	A x F	<0.0001

[YOU NEED TO DEFINE "DM" IN A FOOT NOTE]

²NS = nonsignificant.

Table 2. ANOVA *P* values of Fertility and Aphids on leaf Nitrogen (N) and Phosphorus (P) from physiologically mature leaves of chrysanthemum.

Fert Aphids	N (%)	P (%)
Fert	<0.0001	<0.0001
Aphids	<0.0001	<0.0001
Fert* Aphids	NS ^z	NS

ZNS = nonsignificant.

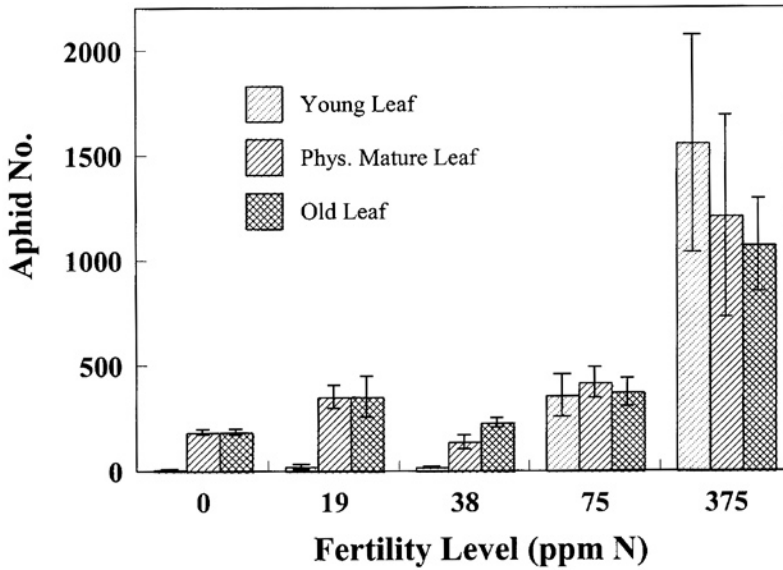


Fig. 1. Effect of fertility and leaf development on aphid populations in chrysanthemum at termination of experiment; n=3; bars indicate the standard error of the mean, when absent it falls under the symbol; treatment effects of fertility (F), leaf position (L) and F X L were highly significant ($P \leq 0.0001$).