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DISEASES AND PESTS OF CARNATION

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CONTENTS

DISEASES AND PESTS OF CARNATION

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PATHOGEN-INDUCED DISEASES

Carnation Rust

Rust, caused by the fungus *Uromyces caryophyllinus* (= *U. dianthi*) is the most common foliar disease of carnation in Hawaii. The first symptoms on leaves, stems, or flower buds are small, slightly raised blisters that eventually rupture, forming pustules filled with powdery reddish-brown spores (Fig. 1). A yellow margin surrounds the pustules and, when infections are severe, entire leaves turn yellow and die. Stems may be girdled when several pustules develop around the shoot, resulting in decreased flower production and quality. Plants may be attacked at any stage of development. Spores of this fungus are disseminated by wind, splashing water, or infected cuttings (*12*). Disease is favored by cool nights alternating with warm humid days. This induces dew at night and the formation of a film of water on the leaf surface. Because rust spores require free water for nine to 12 hours on the plant surfaces to germinate and infect, this disease is most severe in open air culture and in plastic film greenhouses, where dew formation is common (*1*).

Alternaria Blight

Initial leaf symptoms of alternaria blight of carnation, caused by the fungus *Alternaria dianthi*, are tiny purple dots (1/16 to 1/8 inch). When moist weather prevails, the spots enlarge, developing into large lesions with a purple margin and a yellow-green border surrounding a gray-brown center covered with black spores (Fig. 2). Several lesions may expand and coalesce to form large, irregular necrotic areas that eventually kill the entire leaf. The branches are most frequently infected at the nodes and branch base. These infection centers enlarge to form cankers, which eventually girdle the stem, causing the branch to wilt and the girdled portion to turn yellow and die (*12*). Spores of this fungus are disseminated by wind, rain, and infected cuttings. The pathogen needs free water to germinate and infect the leaves and stem (*3*, *12*).

Flower Blight

Alternaria flower blight caused by the fungus *Alternaria dianthicola* is without doubt the most serious blossom disease of outdoor carnations in Hawaii. Symptoms of this disease appear as tan to dark brown lesions on sepals and petals (Fig. 3). These lesions are covered with dark brown powdery spores that are disseminated by wind and rain (*11*, *14*). Because flower parts must be wet for at least eight hours before infections can occur, extended wet periods with light night rains favor outbreaks of this disease.

Botrytis Flower Blight

Botrytis flower blight is caused by the fungus *Botrytis cinerea*. This fungal disease appears as tan to light brown soft rots on the petals of flower buds and opened flowers. Affected petals soon become covered with the grayish growth of the fungus filaments, which later are covered by a powdery mass of grayish spores (Fig. 4). The disease usually occurs when the environment is cool and damp at night, and warm with high relative humidity in the daytime (*12*).

Septoria Leaf Spot

Septoria leaf spot is caused by the fungus *Septoria dianthi*. Symptoms on leaves and stems appear as light brown spots with purple margins. Small black specks are present at the center of the spots. These are the spore-producing structures of the fungus. Individual lesions may enlarge and coalesce with adjacent lesions to cause death of the leaf. Dissemination of the fungus is by windblown rain and splashing water. High relative humidity favors the development of the disease and production of spores (*6*).

Rhizoctonia Stem Rot

Rhizoctonia stem rot is caused by the soil-borne fungus *Rhizoctonia solani*. The symptom on rooted cuttings is a moist grayish-black rot at the soil line, which causes the top of the plant to wilt and die (Fig. 5). On older plants the rot may extend a couple of inches above the soil line, inducing bark decay, which is easily rubbed off. Occasionally brown mycelial strands may be seen on the surface of diseased tissue. The fungus causing this disease in Kula, Maui, has been found to belong to a genetically distinct stock, known as anastomosis grouping AG2-2 (*15*). This pathogen apparently has been introduced in infected cuttings from the continental United States (*16*).

Phythophthora Blight

Phytophthora blight is caused by the soilborne fungus *Phytophthora parasitica*. On carnations, symptom expression depends on infection site. Infections occurring on the basal portion of the stem cause a typical wilting and collapse of the stem or plant. The fungus may also invade the stem at any point on the plant, causing stem collapse and eventual death of the branch. If the infection is on the upper leaves and stem, blighting occurs. The most common symptom of this disease, however, is a wilting, collapse, and bleaching of the tips of healthy shoots (Fig. 6), which resembles bromide toxicity symptoms (*8*). This is a common disease of carnations grown in areas where soil temperatures rise above 25°C in the daytime.

Fusarium Stem Rot

Fusarium stem rot is caused by the soilborne fungus *Fusarium roseum* f. sp. *graminearum*. The fungus may attack the plant at all stages of development and does the most damage to cuttings during propagation and to young plants at transplanting (*6, 7, 12*). Symptoms on rooted cuttings range from wilted cuttings with a severely reddish-brown crown rot to apparently healthy cuttings with small internal, amber-colored crown lesions (Fig. 7). The latter diseased cuttings can not be detected visually and when planted in the fumigated fields serve as initial sources of inoculum. Young plants with basal stem rot become ash green, wilt, and die (Fig. 8). Upon closer inspection of diseased cuttings, reddish-brown lesions with pink or orange spore masses are found in association with the disease. *Fusarium roseum* is most virulent when carnation plants are injured or when conditions are unfavorable for growth of the plant (*9*). Wounds produced during harvest, or when pinching or pruning buds and branches, are ideal ports of entry for the fungus. The fungus grows down the stump, eventually invading the main stem or side branches (Fig. 9) and causing them to wilt, turn yellow, and die (*9, 12, 14*).

Bacterial Leaf Spot

Bacterial leaf spot is caused by the bacterium *Pseudomonas syringae* pv. *woodsii*. Symptoms appear as sunken necrotic spots more or less oval in shape and greasy in appearance. In transmitted light, the center of the lesion is pale brown with purplish concentric zones, while the outer zone is water-soaked and yellow (Fig. 10). Under high humidity the bacterium may ooze out in small drops on the surface of the lesions. With numerous lesions on the leaf the spots will tend to coalesce. Several spots will cause the death of the leaf. These symptoms usually occur on the older leaves first and gradually spread upward on the plant (*5, 6*).

Root Knot

Root galls on carnation are caused by parasitic root nematodes, *Meloidogyne* spp. The most characteristic symptom of this disease is the profuse root swellings that assume innumerable shapes. The microscopic eel-shaped larvae of the nematode infect roots at the tip, where the tissue is soft and cell division is occurring. When the female nematode attaches her stylet to dividing root cells during feeding, she introduces growth hormones that cause the root cells to divide abnormally, followed by root swelling and development of typical root-knot galls that are several times larger than normal roots (Fig. 11). Symptoms of nematode-infected plants are lack of vigor, stunting, and pale green to yellow leaves that tend to wilt in warm weather (*13*).

NUTRITIONAL DISORDERS

Nitrogen Deficiency and Excess

Nitrogen concentration close to 20 ppm in the soil solution is required for good growth. Nitrogen deficiency symptoms become visible at 10 ppm as a pale, yellowish-green coloration of the entire plant. Leaves become narrow and straight, flowers become small, and dieback of basal leaves is noticeable.

Excess nitrogen in the soil over 25 ppm induces a dark green coloration of the foliage. Leaves become fleshy and curling is excessive. High salt concentration in greenhouse carnation beds due to excessive application of soluble fertilizers can cause symptoms similar to nitrogen deficiency. This can be corrected by heavy watering to dissolve salts and leach them from the beds (*2, 4*).

Phosphorus Deficiency

Phosphorus deficiency is difficult to determine by visual symptoms. The premature death of older leaves that accompanies phosphorus deficiency is common in other nutritional problems such as potassium deficiency (*2, 4*). To confirm the field diagnosis it is recommended that suspected deficiencies be verified by tissue analysis.

Potassium Deficiency

Potassium deficiency causes excessive leaf-tip burning of the older leaves and off-white spotting of the foliage (*4*).

Calcium Deficiency

Calcium deficiency is associated with leaf-tip burning of the young leaves. Incorporation of lime to maintain soil pH between 6 and 7 is recommended for optimal carnation production. When pH falls below 5, calcium deficiency shows up (*2, 4*).

Boron Deficiency

Boron deficiency symptoms on carnation show on the youngest foliage. Leaves are yellow and twisted, and the terminal bud sometimes is dead. Axillary shoot proliferation at upper nodes is common, resembling the witch's broom effect caused by virus infections in other crops. Flower buds are abnormal and die before opening. The new foliage turn pale brown with a reddish-purple band and partial yellowing of the leaf base. Five ppm of boron in the soil is considered normal (*2, 4*).

Magnesium Deficiency

The typical symptom of magnesium deficiency is interveinal discoloration in older carnation leaves. The leaf area between the veins turns pale yellowish-green, while the veins remain deep green. When potassium is applied in excess to some soils, magnesium deficiency may be accentuated (*2, 4*).

INSECT PESTS

Carnation Bud Mite

Carnation bud rot in Hawaii is caused by saprophytic fungi and bacteria associated with the grass mite (*Pediculopsis graminum*). Affected flower buds may appear normal on the outside, but the inner floral parts are discolored light brown and moist in appearance. Interior petal decay occurs when fungi and bacteria associated with the mite invade the tissues damaged during feeding (Fig. 12). With a magnifying glass, it is possible to see the white ellipsoidal bodies of pregnant female mites embedded in the discolored tissue inside the bud (*9, 12*). Young infected buds fail to open or open abnormally, generally in a lopsided way (*10*).

Spider Mites

The red spider mite or carmine mite, *Tetranychus cinnabarinus*, and the two-spotted spider mite, *T. urticae*, are the most important pests of carnations in Hawaii during very dry, warm summers. Leaves of infested plants become pale and stippled, and the lower leaves become purplish to brown and die prematurely (Fig. 13). Harvested lei flowers infested with mites become shriveled and discolored in transit. The adult mite is about 1/60 inch long, oval, and red or green, depending on the species. The two-spotted mite is greenish and has two black spots on its body, visible with a hand lens (*10*).

Thrips

Thrips are damaging to carnation flowers in dry summer months. On colored flowers they cause white flecks, but on white flowers they cause tan to brown specks (Fig. 14). The western flower thrip, *Frankliniella occidentalis*, is the most prevalent thrip in Hawaii-grown carnations. Other species—e.g., *Thrips palmi*, *T. tabaci*, and *T. hawaiiensis*—are also common. The western flower thrip and *T. palmi* are the most difficult to control because they have developed resistance to insecticides (Ronald F. L. Mau, personal communication). Adult western flower thrips are about 1/20 inch long and are tan; the young are yellowish.

Cutworms

Cutworm damage usually occurs in young plants when soil fumigation was not effective. Plants are cut off at the soil line. In older plants the larvae of the moth *Peridroma saucia* climb the stems, cut off shoots, and gouge out the flower buds (Fig. 15). The larvae are ash gray or mottled brown with a distinct yellow dot on each body segment.

MANAGEMENT OF DISEASES AND PESTS

Soil-borne Diseases

An effective control of *Rhizoctonia* stem rot and *Pythium* root rot is soil fumigation with metam-sodium (Vapam) at 100 gal/acre, applied broadcast to the surface of moist soil before manuring, but after crop residues are removed and the soil is tilled. The effectiveness of the treatment is dependent on a water seal, to a depth of 6 to 8 inches, that must be applied by sprinkler irrigation immediately after the chemical application. The fumigation is also effective in reducing *Fusarium* spp. in the soil. We have detected *F. roseum* inoculum at > 5000 colony-forming units per gram of soil in non-fumigated Maui carnation soils. This fumigant, applied at the recommended rate with a water seal to 8 inches, reduced populations of this pathogen to undetectable levels.

To minimize recontamination of fumigated fields with soil-borne pathogens after Vapam fumigation, disease-free carnation cuttings must be planted. This is a step in disease management that is difficult to accomplish, however, because carnation cuttings originating

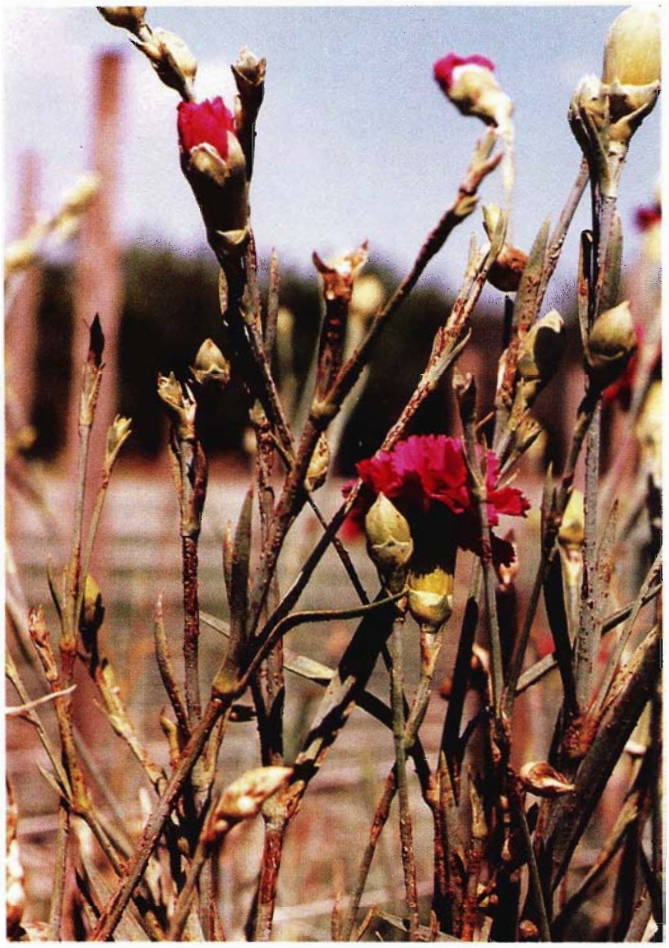

Figure 1. Carnation var. Peterson Red Sim showing orange rust pustules caused by the fungus *Uromyces caryophyllinus*.

Figure 2. Blossom blight caused by the fungus *Alternaria dianthi*.

Figure 3. Flower blight caused by the fungus *Alternaria dianthicola*.

Figure 4. Blossom blight caused by the fungus *Botrytis cinerea*.

Figure 5. Stem rot of cuttings caused by the fungus *Rhizoctonia solani* AG2-2.

Figure 6. Phytophthora blight caused by the fungus *Phytophthora parasitica*.

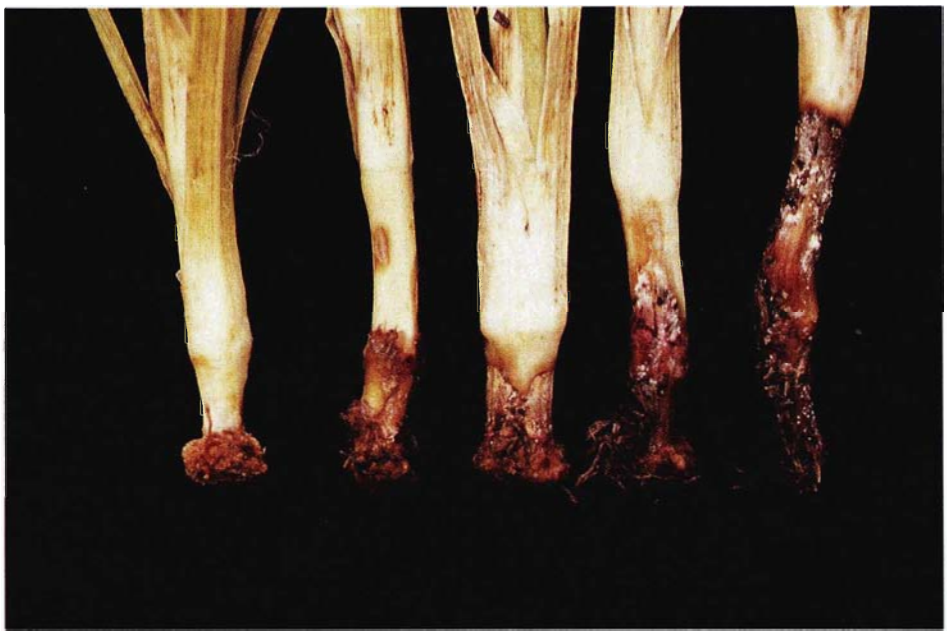

Figure 7. Diseased cuttings received in a December 1988 shipment of rooted cuttings from California. Fewer than 1 percent of the cuttings had various degrees of *Fusarium roseum* f. sp. *graminearum* crown rot.

Figure 8. Wilted, yellowing plant in center of photograph has fusarium stem rot caused by the fungus *Fusarium roseum* f. sp. *graminearum*.

Figure 9. Stem dieback caused by the fungus *Fusarium roseum* f. sp. *graminearum*. Notice black specks at top of branch; these are sexual fructifications of the pathogen, which produce ascospores when they are moistened by rain or dew.

Figure 10. Plant showing symptoms of bacterial blight caused by the bacterium *Pseudomonas syringae* pv. *woodsii*.

Figure 11. Root system heavily affected by root-knot nematodes, *Meloidogyne* spp.

Figure 12. Damage to blossom caused by saprophytic fungi and bacteria carried by the blossom-feeding mite *Pediculopsis graminum*.

Figure 13. Purpling and drying of foliage caused by feeding damage of the two-spotted spider mite, *Tetranychus* spp.

Figure 14. Damage to blossom caused by thrips.

Figure 15. Damage to flower buds caused by cutworm larvae of the moth *Peridroma saucia*.

from the mainland have not always been disease free. On many occasions we have isolated *R. solani* AG2-2 and *F. roseum* f. sp. *graminearum* on diseased carnation cuttings originating from California and Florida. These pathogens, when reintroduced into Vapam-fumigated soil, aggressively recontaminate the beds, and the fumigation effect is lost in a short time. Carnation growers must inspect the base of the cuttings carefully before planting. Cuttings with disease symptoms (Fig. 7) must be culled. Cuttings may be dipped in a solution of benomyl (Benlate) at 1 oz/5 gal water before planting, to control *Fusarium*. Rhizoctonia stem rot can be controlled with soil drenches of PCNB (Terraclor) at 2.5 lb/300 gal/1000 sq ft of planting area, two to three weeks after planting (*12*). Other soil-borne diseases such as *Pythium* sp. root rot can be controlled with drenches of metalaxyl (Subdue 2E) at 1/2 to 2 fl oz/100 gal water/800 sq ft. Applications should be repeated at one- to two-month intervals.

Control of root-knot nematodes can be achieved with soil fumigants, e.g., methyl bromide (Brom-o-gas), dichloropropene (Telone), or the insecticide oxamyl (Vydate L) at rates stated on the label. Brom-o-gas bromide residues are phytotoxic to carnation, so fumigated soil must be allowed to aerate for seven to 10 days before planting.

Foliar and Flower Diseases

All above-ground diseases of carnation (rust, alternaria, septoria, botrytis, and fusarium stem rot) can be adequately controlled by preventive fungicidal sprays with mancozeb (Dithane M-45, Manzate 200), at a rate of 1.5 lb/100 gal, + 3 fl oz spreader-sticker (Triton B-1956) every seven to 10 days (Fig. 16). Fungicidal control of blossom diseases of carnation is highly cost effective (Fig. 17). Oxycarboxin (Plantvax), at 1 lb + 3 fl oz Triton B-1956/100 gal water, is an excellent curative for rust (Table 1).

To minimize damage caused by diseases and insects, varieties with known tolerances should be selected for planting. Market acceptance is a consideration for such a decision, however. Many commercial carnation varieties are resistant to rust and mites (Table 2).

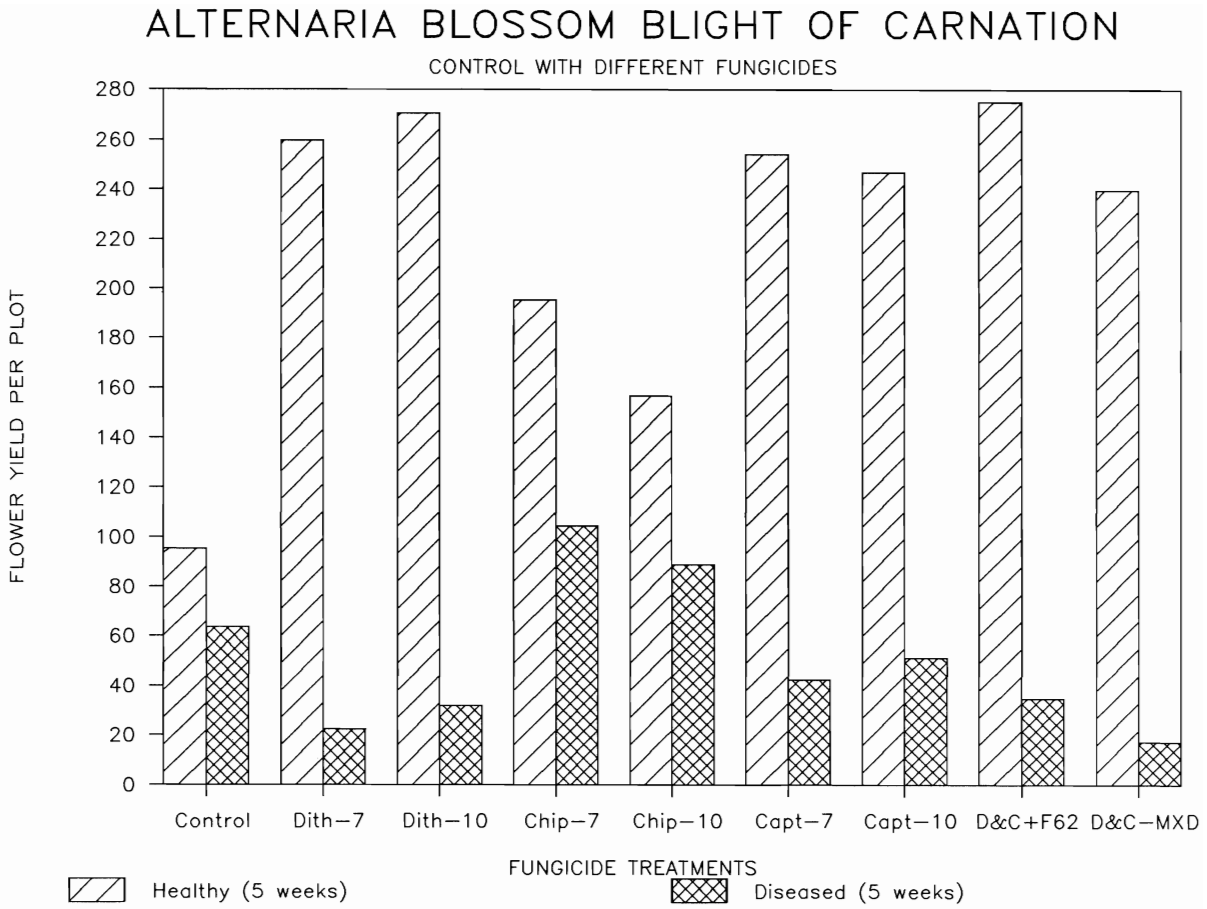

Figure 16. Control of alternaria blossom blight by different fungicides.

1. **Control, sprayed with water every seven days**
2. **Dithane M-45 80WP, 1.5 lb/100 gal every seven days**
3. **Dithane M-45 80WP, 1.5 lb/100 gal every 10 days**
4. **Chipco 26019 50WP, 2.0 lb/100 gal every seven days**
5. **Chipco 26019 50WP, 2.0 lb/100 gal every 10 days**
6. **Captan 50WP, 2.0 lb/100 gal every seven days**
7. **Captan 50WP, 2.0 lb/100 gal every 10 days**
8. **2 and 6 alternated weekly plus 2.0 lb Foliar 62 fertilizer**
9. **2 and 6 at established rates mixed/100 gal water and sprayed every seven days**

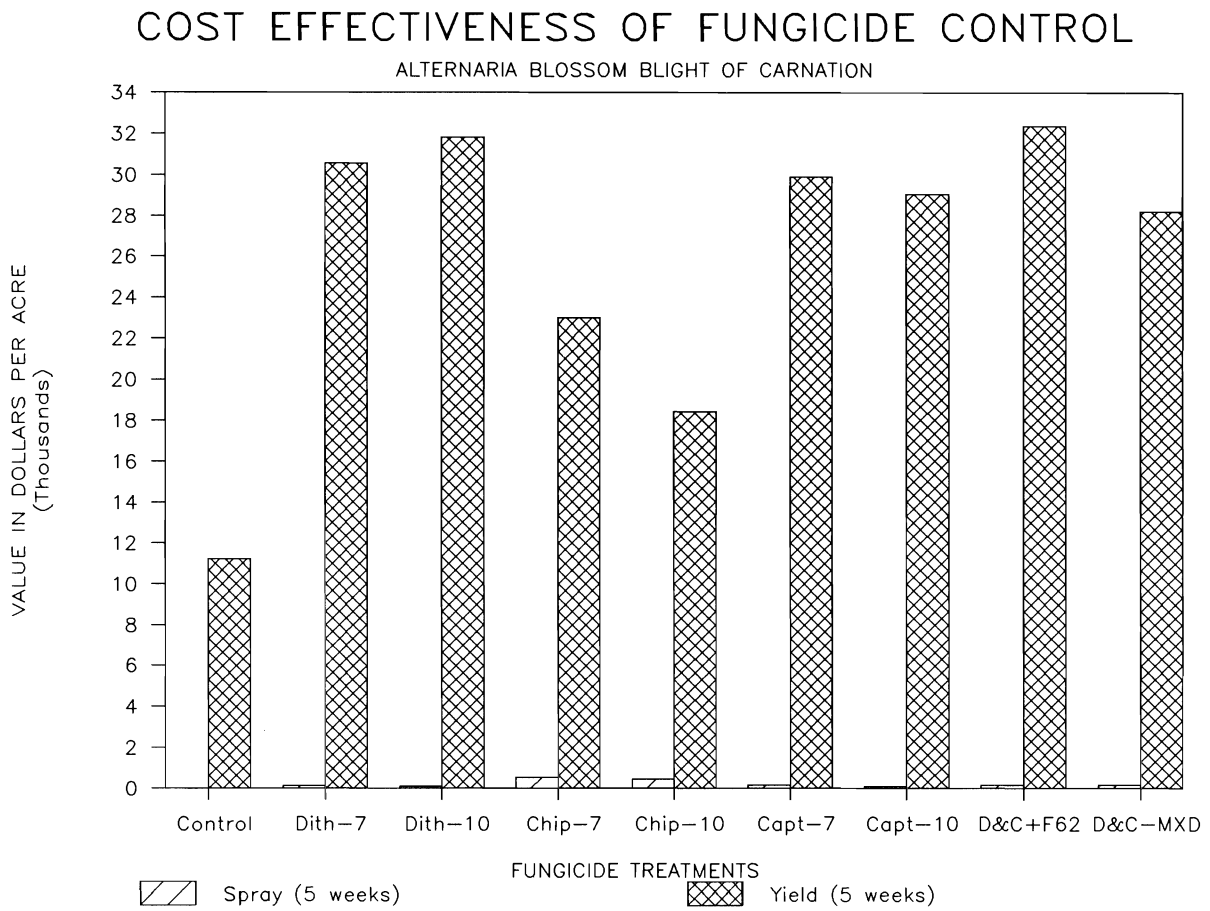

Figure 17. Cost effectiveness of blossom blight control with fungicides (see Fig. 16), value in $1000/acre.

Table 1. Fungicide control of rust on carnation

No.	*Treatment (7/19 to 8/23/88)* Rate	Days	Disease severity rating*
1	Control	—	2.7 a**
2	Dithane M-45 1.5 lb/100 gal	7	2.0 cd
3	Dithane M-45 1.5 lb/100 gal	14	2.6 ab
4	Nustar 1.5 oz/acre	14	2.1 cd (1)
5	Nustar 3.5 oz/acre	14	2.2 bc (1)
6	Tilt 4 fl oz/acre	14	1.8 de (2)
7	Tilt 8 fl oz/acre	14	1.8 d (2)
8	No. 2 alternated weekly with Plantvax-75W 1 lb/100 gal	7	1.4 e

*Disease severity was assessed on the top five nodes of a flowering shoot using a scale of 0 (= no disease) to 4 (= severe damage on 10 shoots).
**Means followed by the same letter are not significantly different (P = 0.05), using Waller-Duncan K-Ratio T Test.
(1), (2) These fungicides are not registered for use on carnation (registration is pending).

Table 2. Rating of carnation varieties for rust tolerance

Variety	Origin	Disease severity rating					Mite incidence		
		0	1	2	3	4	0	1	2
Peterson Red Sim	Yoder				*				*
Improved White Sim	Yoder					*			*
Red Diamond	Yoder					*			*
Barlo II Nora	Yoder					*			*
Lavender Lace	Yoder			*					*
Big Red	Yoder			*					*
Etna	Yoder/Cal-Fla				*				*
Sparkle	Yoder/Cal-Fla				*				*
Maiko	Yoder		*					*	
Lucy Carrier	Yoder				*				*
Red Lena	Cal-Fla					*			*
Kaly	Cal-Fla					*			*
Cal-White	Cal-Fla				*				*
Exquisite Select	Yoder				*				*
Silvery Pink	Cal-Fla			*				*	
Lior	Cal-Fla				*				*
Sharon	Cal-Fla					*			*
Vanessa	Cal-Fla					*			*
Pallas	Cal-Fla				*			*	
Tanga	Cal-Fla				*			*	
Praline	Cal-Fla			*				*	
Raggio Di Sole	Cal-Fla			*			*		
French Can Can	Cal-Fla			*			*		
Day Spring	Cal-Fla					*		*	
Pink Juanita	Cal-Fla	*					*		
Charmin	Cal-Fla			*				*	
Gold Star	Cal-Fla				*			*	
Winsome	Cal-Fla					*			*
Dark Pink Mini Star	Cal-Fla					*			*
Orchid Apache	Cal-Fla				*				*
Emily	Cal-Fla				*				*
Adelfie	Cal-Fla					*			*
May Ling	Cal-Fla				*				*
Calcopia	Cal-Fla				*				*
Barber Rae Pink	Cal-Fla				*				*
Fantasia	Cal-Fla					*			*
Mini Star	Cal-Fla			*				*	
Scarlet Bell (micro)	Cal-Fla				*			*	
Pink Bell (micro)	Cal-Fla			*				*	

Disease severity rating:

0 = no disease
1 = few pustules (only on leaves)
2 = few pustules on leaves and stem
3 = many pustules on leaves and stem
4 = most of plant tissue covered with pustules with yellowing

Mite incidence:

0 = no mites
1 = few mites
2 = many mites

Cultural practices essential to the successful control of foliar and flower diseases are sanitation, pruning, soil preparation, and watering.

Sanitation. Prompt removal of old plantings and diseased plants is effective in the control of most carnation diseases. Removal of diseased flowers from the field is an excellent way to reduce inoculum and disease incidence, especially in the event of alternaria and botrytis flower blight outbreaks.

Pruning. Sufficient plant trimming to provide adequate air circulation reduces the formation of dew on flowers and foliage, minimizing the outbreak of fungal and bacterial diseases.

Soil preparation. Early ground preparation to accelerate decomposition of crop residues enhances the control of soil-borne pathogens when Vapam fumigation is used.

Watering. Soil moisture is essential for good fumigation results. Watering must be adequate to provide a water seal to a depth of 6 to 8 inches immediately after application of the fumigant. Avoiding water on the foliage helps to control fungal diseases as well as bacterial leaf spot. Absence of water on the leaf surface prevents the germination of rust spores (*6*). *Alternaria* spp. spores also need a water film on the plant surface to germinate and infect. *Botrytis* spores landing on wet flowers are able to release a toxin in the water, which kills the tissues in advance of fungal infection. The bacterium *P. woodsii* is spread by splashing water.

Nutritional Disorders

Optimal plant nutrition is the most important factor in maximizing flower production. Adequate fertilization before planting requires a soil analysis to determine soil pH and fertility. Soil pH range from 6 to 7 is recommended (*4*). For optimal growth, major and minor elements must be provided as required.

Phosphorus is usually incorporated as a preplant application to the field in the amounts determined by soil analysis. Generally, Kula soils require 15 to 25 lb treble superphosphate/1000 sq ft of planting.

Magnesium requirements can be met with dolomitic limestone (20 to 45 percent Mg) or magnesium sulfate (epsom salt, 9.8 percent Mg) as a preplant application of 64 lb Mg/acre. When magnesium has not been incorporated before planting, it can be applied through the irrigation system at a rate of 8 oz/1000 gal of water.

Calcium requirements are met by application of calcium-rich fertilizers such as dolomitic limestone, gypsum, and superphosphate. Calcium is also applied regularly through the irrigation system in the form of calcium nitrate.

Carnations have a high boron requirement. Three applications of 1/3 oz borax (household type)/100 sq ft of planting are needed per year. An alternative is 0.8 ppm boron (1 oz borax/1000 gal water) applied through the irrigation system each watering period (*4*).

A mixture of complete fertilizers including 600 lb/acre of 10–30–10 and 200 lb/acre of 16–16–16, plus 18 lb borax/acre, and 640 lb magnesium sulfate (such as epsom salt or a comparable dolomitic limestone)/acre, applied broadcast before planting, provides adequate nutrition for carnations.

Most growers use a liquid-fertilizer proportioner system of some type, and many rely on recommendations developed for mainland operations. Nitrogen and potassium requirements are met by applications of 200 to 300 ppm of N and K with each watering two to four times a week. When fertilizing through the irrigation system, apply at least 1/2 gal/sq ft of bed area to produce some leaching, which will prevent the build-up of soluble salts.

Insect Pests

A number of insecticides and miticides are registered for use on carnations. Some insecticides used to control chewing insects may cause the mites to increase egg production, resulting in mite population explosions after spraying; carbaryl (Sevin) has this effect on mites.

The following insecticides are registered for use on carnation: acephate (Orthene) is registered for thrip control; diazinon (D.Z.N.) is registered for control of cutworms and carnation bud mites; dienochlor (Pentac Aquaflow), oxamyl (Vydate L), avermectin (Avid), fenbutatin-oxide (Vendex), and fluvalinate (Mavrik) are effective miticides registered for control of two-spotted and red spider mites. Application of miticides should be alternated to avoid developing pesticide-resistant mites.

Current control recommendations are available from your local county agent. Your agent will be able to provide you with information on pesticide formulations, dilution rates, equivalent quantities, and precautions for handling.

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