whipped against twigs and branches before it separated and fell through the tree.

Types of removal included: (1) plugging, where the button and stem were attached so firmly that they pulled a plug of rind from the fruit; (2) stem remaining attached to fruit after breaking a short distance above the fruit; (3) complete button left on fruit; (4) partial button left on fruit; and (5) complete abscission where the button separated cleanly from the fruit, leaving no tear in the rind. The percentage and type of separation is shown in table 1. Only plugged fruit was unacceptable for the fresh market.

Fruit injury dropped from 27.5% in 1971, to 16.5% in 1972. Most of the reduction in injury was due to the lesser amount of bruised fruit. The bruising consisted mostly of rind deformation caused by the impact on large branches or other fruit. In most cases, rind deformation soon returned to normal with no flesh damage. However, between 1% and 2% of the bruised fruit showed damage to juice vesicles and rupture of membranes which would relegate the fruit to by-products. At the present time there is no way to check on severity of internal damage other than cutting the fruit in half for a visual inspection. The only alternative is to discard all badly bruised fruit.

Punctures and surface scratches which did not penetrate through the rind usually resulted in brown blemishes after fungicidal treatment and waxing. While detracting from visual appearance, interior quality was unharmed. Punctures which penetrated the flesh caused the fruit to be used for by-products.

TABLE 1. GRAPEFRUIT SHAKE-HARVEST TYPE OF REMOVAL

	1971*	1972
	%	%
Plugged	1.3	0.2
Long Stem	15.2	5.8
Complete Button	19.2	5.2
Partial Button	60.5	33.3
Complete Abscission	3.4	55.3

*Fruit treated with a 2,4-D holding spray in December 1970.

TABLE 2. GRAPEFRUIT SHAKE-HARVEST TYPE OF INJURY

	1971*	1972
	%	%
Bruised	14.2	5.6
Rind Puncture	5.9	4.5
Flesh Pucture	1.4	1.3
Surface Scratch	6.0	4.5
Conveyor Damage	—	0.6
	27.5	16.5

* Fruit treated with a 2,4-D holding spray in December 1970.

Types and percentage of injury are shown in table 2. About 10.5% of the fruit had been previously damaged on the tree by wind, sunburn, or insects—to the point of being channeled into second grade or by-product use. Thus, of the 16.5% of the fruit injured by shake harvesting in 1972, only 6% was unsuitable for top quality fresh marketing.

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Grapefruit tree showing deadwood before pruning.

CARNATION

The best treatment of ground beds to control fusarium wilt in these tests was fumigation with methyl bromide. Bromide residues remaining in the soil after fumigation should be removed by leaching with water prior to planting. Where fusarium wilt is severe, as in the test area, annual fumigation is necessary. When large areas are fumigated, there should be less reinvasion from untreated areas.

FUSARIUM WILT caused by the fungus *Fusarium oxysporum f. dianthi* is probably the most serious disease of carnations in California. The principal reason for steam treatment of soil in raised beds is to control fusarium wilt. For many years the causal fungus was spread through infected cuttings, but with the advent of the mother block system using cultured cuttings, this source has been reduced to a very low level. However, once the fungus is introduced into a carnation range, it usually spreads and the grower must either fumigate the soil or go to raised beds and steam treatments. The construction of raised beds is expensive and they also contribute to poor soil water drainage and require more labor than ground beds.

A number of soil fumigants, including SMDC (Vapam, VPM), DMTT (Mylone, Mico-fume), MIT (Vorlex), and chloropicrin - dichloropropene - dichloropropane (Pictel), Terr-o-cide 30-D and 15-D), have been used by growers with varying success. Soil fumigants containing bromide—such as methyl bromide, ethylene dibromide, and DBCP (dibromochloropropane) — have been avoided by growers because of the susceptibility of carnations to bromides left in the soil following degradation of these fumigants.

Field experiments were started to determine which fumigant or combination of fumigants plus fungicidal drenches would give the best control of the fusarium wilt fungus. The experiments were conducted at the Shishida carnation range in Encinitas. The soil was a loamy sand, Elkhorn series. The carnation cultivar Improved White Sim was planted in the trials.

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FUSARIUM WILT

control with soil fumigation and fungicides

In the first experiment Terr-o-gas (98% methylbromide, 2% chloropicrin), Pictel (57% chloropicrin, 43% dichloropropane), and Vorlex (20% methyl isothiocyanate, 80% chlorinated C_3 hydrocarbons) were evaluated. Pictel and Vorlex were injected with a MacLean Fumigun on 12-inch staggered centers. Pictel was injected at a rate of 400 lb/acre, Vorlex at 50 gal/acre and methyl bromide at 1 lb/100 sq ft (436 lb/acre). All fumigants were injected and then covered with 4 mil polyethylene sheets except for methyl bromide, which was introduced after the polyethylene cover was in place. The soil was treated on April 22, 1970, and the polyethylene covers removed a week later on April 29, 1970. Each treatment covered 200 sq ft, which included the walkways between the ground beds, and each was replicated four times. The area was planted July 2, 1970.

In this experiment all fumigated plots and nonfumigated controls were subdivided into four subplots of 50 sq ft, one of which was drenched at one month intervals with Benlate (50% benomyl) 1 lb/1000 sq ft; one was drenched with Mertect 160 (60% thiabendazole) 1 lb/1000 sq ft; and one was drenched with SD-345 (97% allylidene diacetate 1 fl oz/1000 sq ft. All materials were applied at 60 gallons of water per 1000 sq ft. A total of five drenches were applied starting 12 days after planting. The last drench was applied January 13, 1971.

In this experiment an attempt was made to monitor the level of *Fusarium oxysporum* propagules in the soil. The fusarium propagule count presented in table 1 is that of a non-parasitic *fusarium* species. The counts, however, were correlated with disease incidence. The counts reported in table 1 are the averages of four replications.

Methyl bromide was the most effective fumigant in this trial. Table 2 shows the percentage of healthy plants for each treatment four months after planting, and again at 6, 12, and 14 months. The three fumigants used provided economic fusarium control for one year from planting. The marked decrease in healthy plants between 12 and 14 months is a result of warm temperatures in the second summer. It is evident that *Fusarium oxysporum* was not completely eliminated from the treated soil, and that where the disease is severe, fumigation must be on an annual basis. No fusarium control was achieved by the fungicidal drenches.

The *Fusarium* propagule counts were correlated with later disease incidence and gave an early indication of the performance of the fumigants. This approach might be useful in a preliminary screening of fumigants.

Some early plant loss occurred in the methyl bromide treatments as a result of bromine accumulation. In plots that received extra water from overlapping sprinklers in the nontest area, there were no plant losses. The methyl bromide plots received no special treatment; however, it is known and recommended that where methyl bromide is used, the soil should be irrigated to leach the bromides from the soil prior to planting.

In a second experiment, methyl bromide was compared with steam, hot water, and allylidene diacetate at 41.4 gal/acre. The ground beds were steamed by the Thomas method with steam introduced beneath a tarp. Generally only the top 5 to 6 inches reach temperatures effective in killing disease-producing fungi. The hot water at 190°F was injected using a pipe to a depth of 20 inches. The allylidene diacetate (SD-345 and Magmacide D) was applied in water at the rate of 1000 gal/1000 sq ft and covered with a polyethylene sheet for one week. In this trial the methyl bromide was injected beneath polyethylene covers as in the previous trial, but in this trial the methyl bromide plots were watered heavily prior to planting to leach away some of the bromides. The treatments were applied on June 2, 1971, and planted July 12, 1971. The first plant counts were made on February 22, 1972, seven and one-half months after planting. The results are shown in table 3.

Untreated control plots were not included in this trial because of the severity of the disease and heavy losses to the cooperating grower. Recontamination of the plots occurred from the aisles on the uphill side and very little spread occurred between plots which were separated by ridges of soil. Methyl bromide again gave the best control. The poor performance of steam was predictable because of the shallow depth of the treatment. Allylidene diacetate also was not as effective as methyl bromide.

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TABLE 1. FUSARIUM PROPAGULES* PER GRAM OF SOIL FOLLOWING SOIL FUMIGATIONS, EXPERIMENT 1 (AVERAGE OF FOUR REPLICATIONS ON FOUR SAMPLING DATES)

Fumigant	May 6	July 14	Sept 16	Jan
		Propagules per gm		
methyl bromide	250	5,250	11,500	4,
chloropicrin-C_3†	3,120	13,000	12,500	5,
MIT-C_3	11,400	22,600	25,200	4,
Check	20,600	45,500	37,800	20,

* A propagule is a reproductive unit. In **Fusarium oxysporum** other **Fusarium** sp. chlamydospores are the chief resting struc and serve as propagules. Other types of spores (conidia) and of fungus in organic matter might also be recorded as a propa on soil isolation plates.

†C_3 = chlorinated C_3 hydrocarbons including dichloropropane dichloropropene.

TABLE 2. PER CENT HEALTHY CARNATION PLANTS ON VARIOU DATES FOLLOWING SOIL FUMIGATION TREATMENTS, EXPERIMEN (AVERAGE OF FOUR REPLICATIONS)

Treatment	benomyl	thiabendazole	allylidene diacetate	control ave
November 18, 1970—4 months (after 4th drench)				
methyl bromide	100	100	99	95
chloropicrin-C_3	95	95	89	90
MIT-C_3	96	94	95	93
Check	37	44	39	42
January 13, 1971—6 months (prior to 5th drench)				
methyl bromide	99	98	98	93
Chloropicrin-C_3	91	91	85	90
MIT-C_3	94	91	86	88
Check	19	26	18	28
July 6, 1971—12 months (1 year from planting)				
methyl bromide	84	85	76	72
chloropicrin-C_3	64	74	61	64
MIT-C_3	73	68	79	72
Check	9	4	21	18
September 15, 1971—14 months				
methyl bromide	22	16	34	18
chloropicrin-C_3	19	19	22	27
MIT-C_3	19	15	21	23
Check	1	0	1	4

TABLE 3. PER CENT HEALTHY PLANTS FOLLOWING SOIL TREATMENTS, EXPERIMENT 2 (AVERAGE OF FOUR REPLICAT

Treatment	Feb 22	M
	% healthy plant	
steam	56	
hot water	88	
methyl bromide 1 lb/1000 sq ft	97	
methyl bromide ½ lb/1000 sq ft	91	
allylidene diacetate	55	