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research bulletin

CONTROL OF *PYTHIUM* ROOT ROT ON CARNATIONS. PART II.[1]

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***Pythium* root rot, at high levels of infestation, will significantly delay peak production and decrease yield while lower levels may only slightly affect yield. Prevention of the disease is recommended through the use of Truban® to better obtain maximum return from a carnation crop. The effects of *Trichoderma Harzianum* on carnation growth were not clear.**

Introduction

Six experiments were carried out at the CSU Lake Street Greenhouses on carnations. Four of these dealt with the effects of *Trichoderma,* Truban® and *Pythium* on the development of flowering carnations. The remaining two dealt with photoperiodism and timing in carnations, based upon work by W.E. Healy at Minnesota. The majority of the experiments were negative, largely due to the fact that the root rot organism, *Pythium,* was not present at sufficient levels to significantly affect carnation flowering and the consideration of suitable conditions for maximum response to *Trichoderma* was secondary. The results show (CGGA Bul. 425) that if *Pythium* reinfests steam pasteurized soil at sufficiently high levels, peak production will be delayed and yield will be reduced. Experiment One was discussed in Part I of this report, leaving the remaining five experiments yet to be considered.

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THIRD ANNUAL COLORADO FLOWER CROP EXPO

Department of Horticulture
Colorado State University
Fort Collins, CO 80523

FEBRUARY 18, 1986

PLACE: Room 228 - Lory Student Center

8:30 a.m.
Registration: $10.50, lunch included

9:00 a.m.
Flower bulb crops for the world market in Colorado. Tom Thornton, General Sales Manager, Melridge Inc., Arcata, California

Growing new crops is easy — can you market them? Seward Besemer, Farm Advisor, University of California Coop. Extension, San Diego County

12:00 a.m.
Lunch, Cherokee Park Room

1:30-4:00 p.m.
Tour of W.D. Holley Plant Environmental Research Center (PERC) Greenhouses

- Cuts of Alstroemeria, gerbera, Euphorpia fulgens, Bouvardia, Eustoma, roses, anemones, etc.
- Pots of lilies, carnations and new varieties, etc.
- New bedding plants including pansies, primula, etc.
- Greenhouse covers
- The latest in greenhouse computer control and monitoring
- Rockwool growing medium

Tour of Bay Farm Greenhouses — A 6000 ft^2, hands-on, teaching greenhouse. Infrared and forced air heating.

- Spray and standard carnations, mums, alstroemeria, roses, asters, snaps, anemone and other cuts.
- Assorted pot materials

Reservations are encouraged. A complete program and reservation form will be mailed in January.

New plant materials can be included in the expo by contacting:

Dr. K.L. Goldsberry
Department of Horticulture
Colorado State University
Fort Collins, CO 80523
(303) 491-7118

Remember: *"Anything they can grow, we can grow better."*

Methods and results

Experiment Two

Experiment two was begun June 16, 1983, when 1200 'White Sim' #1 cuttings were rooted. One third of these cuttings were rooted in an isolated portion of the propagation bench in which *Trichoderma,* strain T-95, was added to bring the population level to 1×10^7 cfu* g^{-1}.

Rooted cuttings were then planted into four benches which were divided into six plots each, with a buffer zone at each end. Each of the plots measured approximately 41 × 67 in. and were planted with 54 cuttings in a 7 × 7 in. spacing giving nine rows of six plants each.

Six treatments were used in this experiment, each bench representing a block. Treatments were assigned to each of the plots within a block at random. The six treatments included:
1. T-95 in propagation bench.
2. T-95 in growing bench.
3. Truban® in growing bench.
4. T-95 in growing bench plus Truban®.
5. T-95 in propagation bench plus Truban®.
6. Control.

Two treatments had T-95 added to the growing bench. This was done in the same manner as described in the addition of T-95 to the propagation bench resulting in a similar population level.

No indication was given of benefit to be gained from the use of *Trichoderma* in this experiment. No statistically significant differences were seen between production in any of the six treatments in either timing or in production in the four quality grades **(Table 1 and Fig. 1).** It will be noted, however, that plants treated with T-95 in the propagation bench had the highest total yield per sq. ft.

Experiment Three

The cuttings utilized in this experiment were handled in much the same manner as in *Experiment Two.* 'Elliot White' was used as the cultivar. One-half of the cuttings were rooted with the addition of T-95 at a rate of 1×10^6 cfu g^{-1}. Only one bench was used in this experiment, divided into eight plots with a buffer zone at each end of the bench. Each plot was approximately 41 × 49 in. and contained 42 plants in seven rows of six plants.

Table 1: Mean yield ft^{-2} of 'Improved White Sim' carnation flowers, planted July 11, 1983, in each of the six treatments in *Experiment Two* in four grade categories during the 70 wk period beginning October 9, 1983.

FLOWER PRODUCTION BY GRADE					
TREATMENT	**FANCY**	**STD.**	**SHT.**	**DESIGN**	**TTL.**
Control	8.8[z]	30.8	31.2	21.2	89.6
Truban®	8.7	30.0	30.8	20.4	90.4
T-95 in bench	8.4	31.2	30.4	19.2	89.2
T-95 in propagation	8.4	30.8	30.8	23.2	93.2
Truban® + T-95 in bench	9.6	31.2	30.9	21.6	89.6
Truban®	8.5	30.4	29.6	21.2	89.6

[z]Values for each of the flower grades and total were not significantly different from each other P = 0.05. Four replicates were used in a randomized complete block design.

cfu = colony forming units

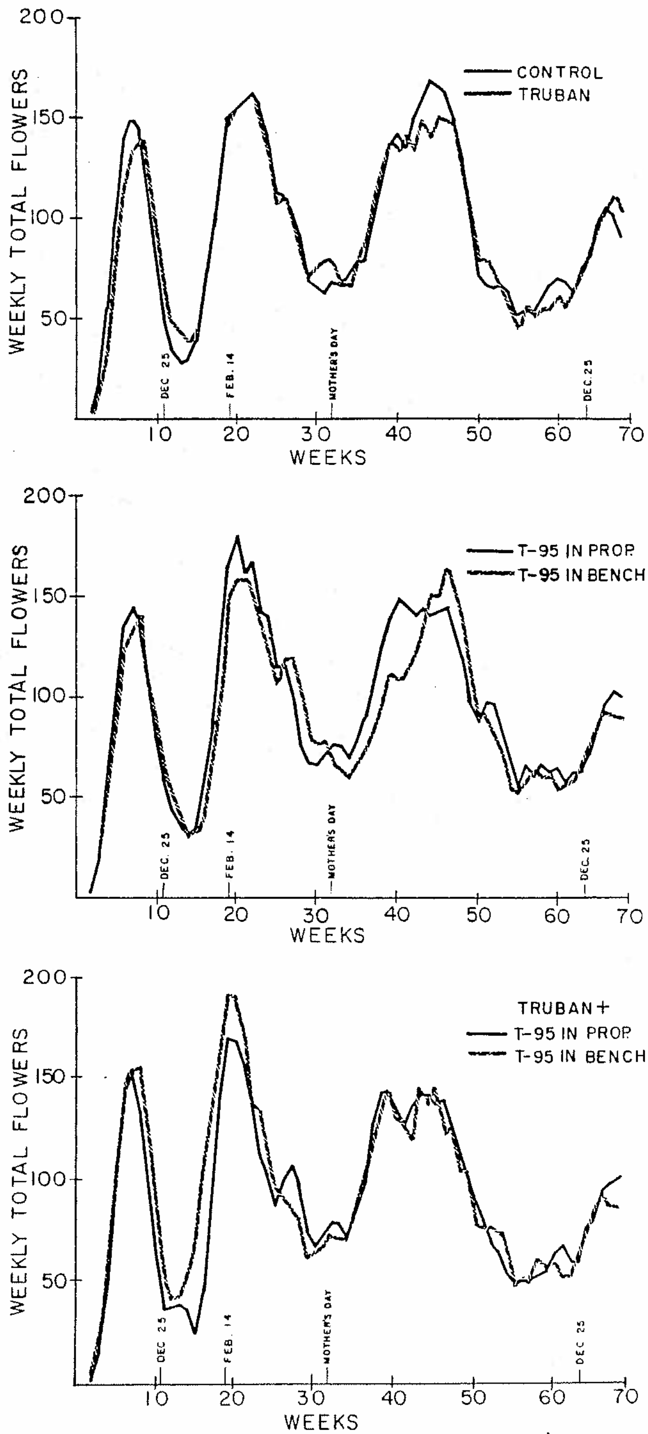

Fig. 1: Average production per plot per week of each of six treatments over the course of *Experiment Two.* Values plotted weekly are the total production of 'Improved White Sim' carnation flowers, planted July 11, 1983, for that week. Data was transformed using a three-week floating mean to remove some of the variation in production from week-to-week.

Four treatments, replicated twice, were used in this experiment in a randomized complete block design including:

1. T-95 in propagation bench.
2. Truban®.
3. T-95 in propagation bench plus Truban®.
4. Control.

Rooted cuttings were planted June 6, 1984, and pinched two weeks later. At this time the Truban® was applied to the plots which required it, as well as approximately 6×10^4 cfu plot^{-1} *Pythium ultimum* inoculum to all treatments and thoroughly watered in. This was done to simulate the reinfestation of a steamed bench with *Pythium* after planting.

As in the previous experiment, no statistically significant differences were observed between the four treatments in either timing or production in either of the four quality grades of flowers or in total production **(Table 2 and Fig. 2).**

Table 2: Mean yield ft^{-2} of 'Elliot White' carnation flowers, planted June 6, 1984, in each of the four treatments in *Experiment Three* in four grade categories during the nine week period beginning September 9, 1984.

FLOWER PRODUCTION BY GRADE					
TREATMENT	**FANCY**	**STD.**	**SHT.**	**DESIGN**	**TTL.**
Control	0.1^z	2.8	6.6	3.3	13.0
Truban®	0.1	2.2	5.9	4.6	12.7
T-95 in propagation	0.1	3.3	6.6	3.1	13.0
T-95 in prop. + Truban®	0.1	3.2	8.2	3.1	12.6

^{z}Values for each of the flower grades and total were not significantly different from each other. P = 0.05. Two replicates were used in a randomized complete block design.

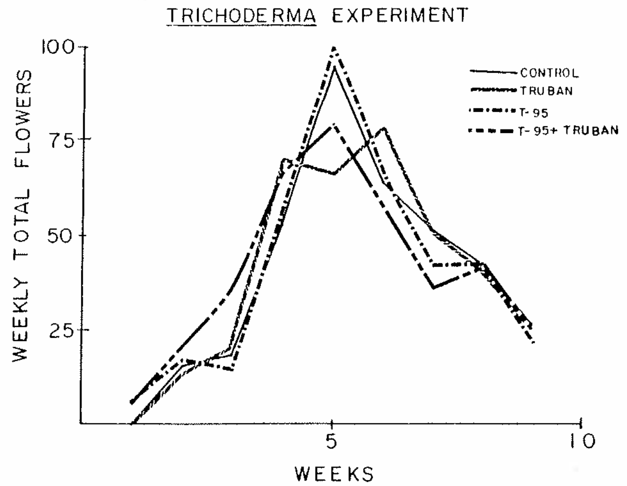

Fig. 2: Total weekly 'Elliot White' carnation flower production of each of the four treatments in *Experiment Three,* planted June 6, 1984, for the nine week period beginning September 9, 1984. Although there appear to be differences between the flowers produced at the peak of production, at about week five, they were not significantly different. Only one crop was harvested from this experiment.

Experiment Four

The main objective of this experiment was to determine the effect of *Trichoderma* on rooting of carnations. T-12, another strain of *Trichoderma,* was used in this experiment at two different population levels, 1×10^6 and 5×10^7 cfu g^{-1} as well as a control. A six inch azalea pot containing 10 cuttings was used for each treatment, all treatments were replicated five times. Each pot was filled with the same peat:perlite media and was either untreated or at either of the two T-12 population levels.

The pots were randomized in complete blocks on top of the medium in the mist bed. After seven days, and each five days later, one pot of each treatment was selected from each replicate. The cuttings were then examined and rated for callus and root development. Dry weights of the cuttings were also determined at the time of each harvest. The pots were initially placed on top of the propagation medium, but later sunk into the medium to provide higher rooting temperature.

As in the previous experiments, root development differences were not significantly increased by the addition of T-12 to the rooting media **(Table 3).** However, rooting medium temperature was too low for best response either to *Trichoderma* or for rooting.

Table 3: Mean root development ratings for 'CSU Red' carnation cuttings in each of the treatments used in *Experiment Four,* at each of the five harvests, 7, 12, 17, 22 and 27 days after being stuck in the mist bed on February 14, 1985. Development was rated on a scale of 0 to 9:

0. No callus development.
1. Slight callus development.
2. Well developed callus.
3. Root initials present.
4. Roots 5 mm in length.
5. Roots 1 cm in length.
6. Roots 2 cm in length.
7. Roots 3 cm in length.
8. Roots 4 cm in length.
9. Roots 5 cm + in length.

ROOT DEVELOPMENT			
	ROOT DEVELOPMENT AT EACH T-12 LEVEL		
DAYS	**CONTROL**	**1.0×10^6 cfu g^{-1}**	**5.0×10^7 cfu g^{-1}**
7	1.0^z b	1.1 ab	1.2 a
12	2.5 a	2.4 a	2.3 a
17	4.0 ab	4.4 a	3.5 b
22	5.0 a	5.4 a	4.7 a
27	6.4 a	7.3 a	5.7 a

^{z}Means not followed by the same letter differed significantly. P = 0.05. Five replicates were used in a randomized complete block design.

Experiment Five

Rooted cuttings, of the variety 'CSU Red', were planted into each of 16 plots measuring 49 × 41 in. in two benches. Each bench consisted of two replicates of four treatments assigned at random. Each treatment plot included a buffer row at each end and all plants were at 7 × 7 in. spacing.

On July 2, 1984, three weeks of natural days after planting, all plants were pinched to four nodes. By July 19, plants had developed sufficiently to be approaching the period of growth when the meristematic regions of the shoots would become responsive to photoperiod. At this time, the four short day photoperiods were commenced. Treatment consisted of:

1. Control; natural photoperiod.
2. Thirty short days.
3. Forty-five short days.
4. Sixty short days.

Short days were provided through the application of black sateen shade cloth over the plots on a conduit framework from 1800 to 0800 h.

At the conclusion of each of the 30, 45 or 60 short day periods, the long day treatment was started. This was produced with a single 60-watt incandescent light bulb, equipped with a reflector, placed approximately 10 in. above the center of each treatment plot. Lights were operated from 2200 to 0200 h each night for a 45 day period following the period of short days which each treatment received. Each plot was isolated from the others by the use of cardboard and black polyethylene.

Due to bench location within the greenhouse, results showed insignificant differences between the four treatments **(Table 4 and Fig. 3).** Higher radiation levels and temperatures caused the treatment plots in one bench, located along the south wall of the greenhouse, to come into production more rapidly than the plots located in a bench with a more interior greenhouse location. Because of this difference, treatment differences were lost although short day treated plants did produce one more flower per sq. ft.

Experiment Six

This experiment was to determine the response of an older crop of carnations to a long day photoperiod. Sixty-watt light bulbs were suspended above the center of two of the four benches used for *Experiment Two.* Each bulb was equipped with a reflector and positioned approximately 59 in. apart. Lighting was from dusk-to-dawn for the period September 20 to October 20, 1984.

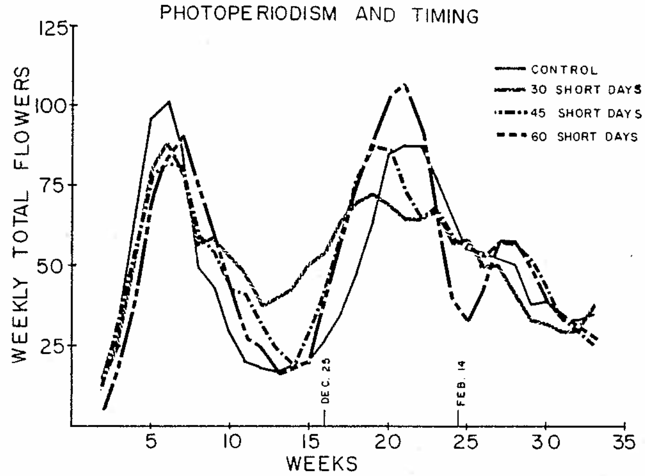

Fig. 3: Mean weekly production of each of the treatments used in *Experiment Five*. Weekly values plotted were totals of four replicates which have been transformed using a three week floating mean. This procedure helps to smooth the data.

Only two replicates were used in this experiment, so production differences were not as clear as had been hoped. However, production was increased in all quality grades of flowers, as well as total flowers produced. In looking at the data, peak production occurred approximately 11 weeks after the termination of the 30 long days. A rapid production decline occurred after the crop peaked **(Table 5 and Fig. 4).**

Summary

The effect of *Trichoderma* was not, given the experimental designs and conditions, clear-cut. A grower might say that

Table 4: Mean number of 'CSU Red' carnation flowers harvested ft^{-2} over the 35 week period of production beginning September 2, 1984, for *Experiment Five* for each of the four treatments, and each of the four replicates showing total production in each of the four quality grades. Plants were planted July 11, 1984.

FLOWER PRODUCTION BY GRADE					
TREATMENT	**FANCY**	**STD.**	**SHT.**	**DESIGN**	**TTL.**
Control	0.8[y]	9.3	14.8	6.5	31.0
30 Short Days	0.8	7.8	16.3	8.0	32.3
45 Short Days	0.5	7.5	16.0	8.0	32.0
60 Short Days	0.5	7.0	16.0	7.8	32.8

FLOWER PRODUCTION BY GRADE					
REPLICATE	**FANCY**	**STD.**	**SHT.**	**DESIGN**	**TTL.**
1	0.3[z]	6.5	14.3	7.3	28.3
2	0.5	6.5	13.8	5.8	26.5
3	0.8	9.3	16.8	8.0	34.8
HSD .05	0.5	2.3	3.4	2.3	6.3

[y]Values for each of the flower grades and total were not significantly different from each other $\underline{P} = 0.05$.
[z]Replicate differences differed significantly. The HSD value is given for each of these. $\underline{P} = 0.05$.

Table 5: Mean number of 'Improved White Sim' carnation flowers ft^{-2} produced over each period for the two treatments in each of the quality grades and total in *Experiment Six* for the overall period of the experiment beginning November 4, 1984, weeks 1 to 25, and two smaller periods during the experiment, weeks 5 to 15 and weeks 15 to 25. Plants were planted July 11, 1983.

			WEEKS 1 TO 25		
TREATMENT	**FANCY**	**STD.**	**SHT.**	**DESIGN**	**TTL.**
Lighted	0.8[z]	6.2	8.3	6.4	21.7
Control	0.5	6.2	10.8	7.1	24.6
HSD $_{.05}$	NS	NS	1.5	NS	NS
			WEEKS 5 TO 15		
Lighted	0.1	2.4	4.6	3.9	11.0
Control	0.1	1.8	4.2	2.8	9.0
HSD $_{.05}$	NS	NS	NS	0.6	NS
			WEEKS 15 TO 25		
Lighted	0.6	2.4	2.2	1.4	6.6
Control	0.3	3.2	4.6	3.1	11.2
HSD $_{.05}$	NS	0.8	0.8	0.6	2.0

[z]When values listed were significantly different from each other, the HSD value is given, or "NS" if not significant. $\underline{P} = 0.05$.

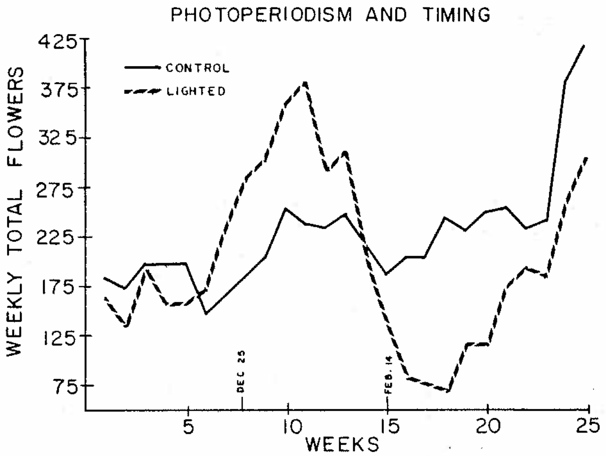

Fig. 4: Mean weekly production for each of the two treatments, control and lighted for 30 days, of *Experiment Six.* Weekly values plotted were total production from two replicates. The lighting treatment was applied for the 30 day period prior to the origin of the graph, beginning on September 20, 1984.

an additional 2 to 3 flowers per sq. ft. (Expt. Two) would be highly desirable. But, we cannot state that the results were valid on a basis of statistical probability. Some of the problems may have resulted from limitation on experimental design in the existing facilities, and also, conditions during the experiments were not suitable for *Trichoderma.* One had two organisms to deal with rather than one (carnations).

Our last lighting experiment (Expt. Six) missed Christmas and Valentine's Day, with very low production for more than one month following Valentine's. This was not a desirable situation.

Lighting on these second-year plants should have been started two weeks earlier to hit Christmas, or four weeks later for Valentine's. In either case, the low production following the peak **(Fig. 4)** would not be good during this period of the winter. Evidently, side break production for future flowers was significantly reduced by the long photoperiod. Combined with low solar energy, carnations returned to production slowly.

FORT COLLINS GREENHOUSE CLIMATOLOGICAL SUMMARY FOR FOUR WEEKS, BEGINNING DECEMBER 1, 1985, AND ENDING DECEMBER 28, 1985. (See Bulletin 426 for details.)

	Week beginning							
	Dec. 1		Dec. 8		Dec. 15		Dec. 22	
	Day	Night	Day	Night	Day	Night	Day	Night
Average outside temperature (°F)	27.7	17.6	16.9	12.0	34.2	26.1	35.4	32.7
Maximum outside temperature (°F)	48.6	41.4	45.5	35.2	49.8	45.7	45.7	54.7
Minimum outside temperature (°F)	-.4	-5.4	-1.1	-9.6	15.8	6.3	18.7	11.8
Degree-days of heating	130.6	165.9	168.4	185.4	107.8	136.2	103.6	113.1
Average hours in the period	8.4	15.7	7.9	16.0	8.4	15.6	8.1	15.9
Accumulated total solar radiation (MJ/sq.m.)	52.4	.8	46.1	.9	50.9	0.7	49.9	0.9
Average relative humidity (%)	62.1	77.2	79.4	87.3	65.6	79.6	55.8	59.5
Maximum relative humidity (%)	85.8	90.9	100.0	100.0	96.0	100.0	82.4	94.0
Minimum relative humidity (%)	32.1	27.4	35.9	63.6	38.7	37.9	38.1	18.4
Average absolute vapor pressure (mb)	3.2	2.6	2.6	2.3	4.4	3.8	3.9	3.7
Average wind speed (mph)	.9	.9	1.3	.9	2.0	0.1	2.9	2.9
Maximum wind speed (mph)	17.2	31.0	9.6	15.4	31.1	18.7	30.4	30.9
Average CO_2 concentration (Pascal)	22.7	—	23.1	—	23.0	—	—[1]	—
Maximum CO_2 concentration (Pascal)	32.0	—	33.1	—	30.9	—	—	—
Accumulated gas consumption (cu.ft./sq.ft.)	5.9	11.8	5.9	13.1	3.0	9.7	3.0	8.3

[1]CO_2 analyzer changed.