Some Effects of Pallidosis Disease on Strawberry Growth Under Greenhouse Conditions

R. H. CONVERSE, Plant Pathologist, U.S. Department of Agriculture, Agricultural Research Service, Horticultural Crops Research Unit, 3420 N.W. Orchard Ave., Corvallis, OR 97330-5098, and Department of Botany and Plant Pathology, Oregon State University, and E. VOLK, Research Assistant, Department of Botany and Plant Pathology, Oregon State University, Corvallis 97331

ABSTRACT

Converse, R. H., and Volk, E. 1990. Some effects of pallidosis disease on strawberry growth under greenhouse conditions. Plant Dis. 74:814-816.

Various vegetative measurements were made in the greenhouse on potted plants of *Fragaria virginiana* cv. UC-10 and *F.* × *ananassa* cv. Northwest, uninoculated and inoculated with a severe strain of strawberry pallidosis agent (PA). Two months after inoculation with PA, dry weights of tops and roots of UC-10 plants (an indicator showing foliar chlorosis, distortion, and dwarfing when inoculated with PA) were half those of control plants. Seven months after PA inoculation, Northwest plants, though free of visible foliar symptoms, had root and runner plant systems that were reduced in number and weight by 15–20% in comparison with controls ($P = 0.01$–0.10). Foliar measurements of PA-inoculated Northwest plants did not differ significantly from uninoculated controls.

Pallidosis disease (PD) is one of the least understood graft-transmissible diseases of strawberry. It was described in 1969 by Frazier and Stubbs (6) as being indigenous to North America and has since been reported in California (9), Arkansas (8), and North Carolina (5) in the USA, and in Nova Scotia (2) and Ontario (10) in Canada. Pallidosis disease is suspected to be caused by a vector-borne virus, but no corroborated evidence of this has been reported. We shall refer to the incitant as pallidosis agent (PA) and to the disease as pallidosis disease (PD). The literature on PD was reviewed recently (7).

Cooperative investigations between USDA ARS and Oregon Agricultural Experiment Station, technical publication 9106 of the latter.

Accepted for publication 27 March 1990 (submitted for electronic processing).

PD has been reported to cause severe symptoms of dwarfing, chlorosis, and distortion on certain *Fragaria virginiana* L. cultivars like UC-10, UC-11, and UC-12 (3), which are used for detection of PD by leaf grafting (4). After graft inoculation, PD is latent in most strawberry cultivars, but mild symptoms have been reported to occur on a few (6). No significant differences occurred in fruit yield between PA-infected and uninfected plots of the strawberry cultivars Redcoat and Midway in field tests in Nova Scotia, Canada (2). The study reported here was designed to measure some effects of PD on vegetative growth of graft-inoculated UC-10 and the strawberry cultivar Northwest in greenhouse tests.

MATERIALS AND METHODS

F. virginiana UC-10 (3) and *F.* × *ananassa* Duch. 'Northwest' plants free from known viruses, as determined by standard leaflet graft-indexing procedures (1), were increased by standard runner propagation methods in a screened, insecticide-treated greenhouse. A severe strain of PA (isolate Rip 157), supplied by N. W. Frazier, was used to inoculate young, vigorous UC-10 and Northwest plants by petiole insert leaf grafting (one and two leaves per grafted plant, respectively) (4). In polyacrylamide gel electrophoresis, PA isolate Rip 157 exhibited a major double-stranded RNA band at M_r 4.6×10^6 (10). PA-infected UC-10 plants were selected on the basis of characteristic PD symptom production, and uninoculated UC-10 plants of the same age were used as control plants for growth comparison studies. Because PA is symptomless in the cultivar Northwest, the PA-inoculated Northwest plants used for this study were selected on the basis of positive PD symptom development in UC-10 plants graft-inoculated from them. Uninoculated Northwest plants of the same age were selected as control plants for growth comparison studies. For UC-10 and Northwest, each control plant was grafted with one or two of its own leaves, respectively, and the rest of the leaves were pruned off (4), just as for the PA-inoculated plants (and at the same time).

A group of 10 PA-infected, potted UC-10 plants were grown on the greenhouse bench. A second group of 10 healthy UC-10 plants were grown next to them. Twenty potted, PA-infected Northwest plants were paired with 20 healthy Northwest plants on a greenhouse bench. The growth comparison experiments began February 26, 1988. All mother plants were kept deflowered but were allowed to runner freely. All mother

plants received the same greenhouse management with respect to watering, fertilizing, and pest and disease control. Each pair of PA-inoculated and uninoculated Northwest mother plants with their runner systems was moved as a unit in the greenhouse to a new bench location weekly to reduce plant crowding and position effects on growth.

For UC-10, the number of leaves per mother plant and the petiole lengths were determined 67 days after inoculation. Dry weight of plant tops (leaves and runners) and dry weight of crowns and roots (dried to a constant weight in an oven at 30 C in each case) were determined 67 days after inoculation. The data were analyzed by the unpaired t test.

Runners were cut at 157 days from the Northwest mother plants; the number, length, and fresh weight of runners per mother plant and the number of daughter plants per mother plant were determined. Runners were again cut 218 days after initial graft inoculation. Mother plants, runners, and daughter plants were all harvested at that time. Fresh and dry weights of mother plant whole leaves, petioles, roots, runners, and daughter plants and numbers of crowns, roots, runners, and daughter plants per mother plant were determined. Mean differences between PA-inoculated and uninoculated control Northwest plants were analyzed by the paired t test.

RESULTS

PA-infected UC-10 plants were easy to distinguish from uninoculated UC-10 plants throughout the experiment by their chlorotic and twisted leaves. Data on vegetative measurements of PA-infected and healthy UC-10 plants are presented in Table 1. At 67 days, dry weights of leaves and runners and dry weights of roots and crowns of PA-infected plants were decreased below controls by 41 and 50%, respectively ($P < 0.01$). Differences between the two treatments in petiole length and in the number of leaves per plant 67 days after grafting were not significant.

Throughout the observation period, no obvious differences were visible between PA-infected and healthy Northwest plants. From runner systems harvested 157 days after inoculation, the number of daughter plants per mother plant decreased 14% ($P < 0.05$) below that of comparable uninoculated control plants. The fresh weight of PD-infected runners per mother plant decreased 11% below controls ($P < 0.10$%). Mean runner length and the number of runners per mother plant did not differ significantly between the two treatments (Table 2).

At the close of the experiment at 218 days, the only differences that were significant at $P < 0.01$ or $P < 0.05$ occurred in the root systems (Table 2). The number of primary roots decreased 18% in PA-infected plants ($P < 0.05$), root fresh weight decreased 19% ($P < 0.01$), and root dry weight decreased 19% ($P < 0.02$). Some differences in runner plant systems between the two treatments were significant at $P < 0.20$–0.10. The number of runners per PA-infected plant decreased 16% below controls ($P < 0.10$), and their fresh and dry weights decreased by 13% ($P < 0.20$) and 16% ($P < 0.10$), respectively, as did the number of daughter plants per mother plant (17%; $P < 0.10$). The number of crowns per PA-infected mother plant increased by 24% over comparable healthy controls ($P < 0.20$).

Table 1. Effects of strawberry pallidosis agent, isolate Rip 157, on some vegetative measurements of *Fragaria virginiana* cv. UC-10, 67 days after leaf-graft inoculation[a] in the greenhouse

Mean vegetative measurements per mother plant	Inoculated	Uninoculated	P[b]	Percent change below (−) uninoculated UC-10
Number of leaves	7.0	7.2	>0.50	−3
Petiole length (mm)	91.0	96.0	>0.50	−5
Dry weight of leaves and runner system (gm)	3.0	5.1	<0.01	−41
Dry weight of crown and roots (gm)	0.8	1.6	<0.01	−50

[a] One leaf per mother plant, 10 mother plants per treatment.
[b] Probabilities (P) were assigned from unpaired t tests.

Table 2. Effects of strawberry pallidosis agent, isolate Rip 157, on some vegetative measurements of leaf-graft inoculated[a] strawberry cultivar Northwest in the greenhouse

Mean vegetative measurements per mother plant	Number of days after inoculation	Inoculated	Uninoculated	P[b]	Percent change above (+) or below (−) uninoculated control
Number of runners	157	5.8	6.1	>0.40	−5
Runner length (cm)	157	125.7	128.2	>0.50	−2
Runner fresh weight (gm)	157	63.6	71.8	<0.10	−11
Number of daughter plants	157	16.0	18.5	<0.05	−14
Number of crowns	218	2.1	1.6	<0.20	+24
Fresh weight of leaves (gm)	218	25.7	23.3	>0.40	+9
Dry weight of leaves (gm)	218	6.7	6.4	>0.50	+4
Petiole fresh weight (gm)	218	7.7	6.7	>0.40	+13
Petiole dry weight (gm)	218	1.42	1.37	>0.50	+4
Number of primary roots	218	24.3	29.5	<0.05	−18
Root fresh weight (gm)	218	17.3	21.4	<0.01	−19
Root dry weight (gm)	218	2.6	3.2	<0.02	−19
Number of runners	218	5.3	6.3	<0.10	−16
Runner fresh weight (gm)	218	63.0	72.1	<0.20	−13
Runner dry weight (gm)	218	11.3	13.4	<0.10	−16
Number of daughter plants	218	10.6	12.7	<0.10	−17

[a] Two leaves per mother plant, 20 mother plants per treatment.
[b] Probabilities (P) were assigned from paired t tests.

DISCUSSION

The amount of loss in vegetative vigor in PA-inoculated UC-10 has not been previously reported but was certainly expected, because of the great distortion and yellowing observed when the severe PA isolate Rip 157 was graft-inoculated to this indicator clone. UC-10 was released particularly because of its ability to detect PA by symptomatology in graft analysis (3,7). UC-10 is also able to detect mild PA strains but cannot reliably detect PA in complex with other viruses because of the lack of diagnostic symptomatology caused by PA in mixed infections.

Although PD did not cause a significant decrease in fresh or dry weight of top growth of Northwest strawberry mother plants, significant decreases ($P < 0.05$) did occur in the number and weight of their primary root systems when compared to uninoculated plants. This may be a main effect of PD on vegetative growth of strawberry

cultivars, at least insofar as the effects of PA isolate Rip 157 grafted into Northwest in the greenhouse may reflect the situation in the field. Although not statistically significant even at $P < 0.10$, it is notable that PD seemed to stimulate crown proliferation ($P < 0.20$) in inoculated Northwest mother plants.

It has long been believed, without critical supporting evidence, that PA interacts synergistically with other common strawberry viruses to produce more severe symptoms on cultivated strawberry (2,9). Now that a dsRNA method has been developed to allow identification of PA in the presence of other viruses in strawberry (10), the tools are at hand for further evaluation of the effects of different PA isolates alone and in combination with other viruses on various strawberry cultivars under field conditions.

ACKNOWLEDGMENT

We thank B. Strik, Department of Horticulture, Oregon State University, for helpful technical advice in experimental design.

LITERATURE CITED

1. Converse, R. H. 1979. Recommended virus indexing procedures for new USDA small fruit and grape cultivars. Plant Dis. Rep. 63:848-851.
2. Craig, D. L. 1981. Strawberry cultivar reaction to pallidosis disease. Can. Plant Dis. Surv. 61:41-42.
3. Frazier, N. W. 1974. Six new strawberry indicator clones evaluated for the detection and diagnosis of twelve graft-transmissible diseases. Plant Dis. Rep. 58:28-31.
4. Frazier, N. W. 1974. Detection of graft-transmissible diseases in strawberry by a modified leaf grafting technique. Plant Dis. Rep. 58:203-207.
5. Frazier, N. W. 1975. Possible transmission of strawberry pallidosis by the leafhopper *Coelidia olitoria*. Plant Dis. Rep. 59:40-41.
6. Frazier, N. W., and Stubbs, L. L. 1969. Pallidosis—A new virus disease of strawberry. Plant Dis. Rep. 53:524-526.
7. Fulton, J. P. 1987. Strawberry pallidosis. Pages 55-56 in: Virus Diseases of Small Fruits. R. H. Converse, ed. U.S. Dep. Agric. Agric. Handb. 631.
8. Fulton, J. P., and Moore, B. J. 1982. Strawberry virus dissemination in Arkansas. Plant Dis. 66:847-848.
9. Mullin, R. H., Frazier, N. W., and Schlegel, D. E. 1975. Meristem culture of *Fragaria chiloensis* infected with pallidosis. Plant Dis. Rep. 59:268.
10. Yoshikawa, N., and Converse, R. H. 1990. Pallidosis disease: Distinctive dsRNA species associated with latent infections in indicators and in diseased strawberry cultivars. Phytopathology. In press.