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Induced resistance of sweetpotato to Fusarium root rot by UV-C hormesis

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Abstract

'Jewel' sweetpotato storage roots previously treated with a low hormetic dose of ultraviolet light-C (UV-C) were stored for 30 days before inoculated artificially with *Fusarium solani*. Storage roots showed an increase in resistance to Fusarium root rot, as indicated by a reduction in lesion diameter, depth and weight of rotted tissue following UV-C treatment. The rate of decay development around *F. solani* inoculum plugs on UV-C treated sweetpotato storage roots progressed slowly, and about 55% failed to develop lesions on wounded UV-C treated, compared to 11% of untreated sweetpotato storage roots, 10 days after inoculation. There was a polynomial curvilinear regression relationship between percent incidence of Fusarium root rot and hormetic UV-C doses. The hormetic dose of UV-C which suppressed decay to the greatest degree was 3.6 kJ m^{-2}. Exposure of sweetpotato storage roots to doses of UV-C promoted phenylalanine ammonia-lyase (PAL) production with the maximum PAL activity occurred to the greatest degree at a UV-C dose of 3.6 kJ m^{-2}. Similarly, a relationship between PAL activity and the incidence of Fusarium root rot was established. Crude extracts from UV-C treated sweetpotato storage roots reduced germination, germ tube elongation, and growth of *F. solani* compared to extracts obtained from untreated storage roots.

Keywords: Radiation; Ultraviolet light-C; Induced resistance; Hormesis; Sweetpotato; Fusarium root rot

1. Introduction

Hormesis is a beneficial plant response resulting from a low or sublethal dose of a stressor, and hormetin is the agent that is stimulatory in sublethal dose(s) (Luckey, 1980). One of the hormetic stressors often discussed by Luckey (1980) is ultraviolet light-C (UV-C). Recent studies showed that the use of a low dose(s) of hormetic UV-C light (254 nm) resulted in the reduction of storage rots of vegetables and fruits (Lu et al., 1987; Liu et al., 1993; Nigro et al., 1998; Stevens et al., 1990,1996a,b; Wilson et al., 1994). The reduction of natural infection of Fusarium root rot (caused by *Fusarium solani* (Sacc) Mart. Emend. Synd. and Hans) on storage roots from sweetpotato (*Ipomoea batatas* (Lam) L.) cultivars 'Jewel', 'Carver', and 'Georgia Jet' occurred following the treatment with UV-C light (Stevens et al., 1990).

There are at least two possible explanations by which storage rot decay of fruits and vegetables could be reduced following treatment with UV-C light: (1) the germicidal effect on pathogens found on the surface of the host and (2) induced resistance in fruits and vegetables (Stevens et al., 1998). Two lines of evidence have indicated that treating sweet potato storage roots with low doses of UV-C induced host resistance response in the control of Fusarium root rot. First, if the low dose effect was germicidal, a negative correlation between UV-C dosages and storage rot development would be expected following treatment. In a recent study with sweetpotatoes, no negative correlation was observed between UV-C dosage and storage rots, instead a UV-C hormetic dose response relationship was observed. This was

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characterized by a V-shaped dose response curve of UV-C doses vs storage rot development with an optimum UV-C dose occurring at an intermediate level (Stevens et al., 1990,1996a; Wilson et al., 1994). In recent studies of tomatoes and peaches, the second and third degree polynomial regression analysis of the data from dose response plots were shown to be curvilinear and statistically significant (Liu et al., 1993; Stevens et al., 1996a, 1998). Since UV-C is a non-ionizing radiation, and does not penetrate deeply into the plant tissue as ionizing radiation, such as gamma rays (Luckey, 1980), this suggests that incipient infection deep in the storage roots, cannot directly be affected by low doses of UV-C light but could induce host resistance in storage roots (Stevens et al., 1996a,1998).

To test the hypothesis that resistance against Fusarium root rot in sweetpotatoes is induced by low hormetic doses of UV-C, several studies were conducted: (1) sweetpotatoes were exposed to UV-C treatment and then artificially inoculated with *F. solani*. The rate of disease development and the dry weight of storage roots were compared, and (2) assay for phenylalanine ammonia-lyase (PAL) activity in UV-C irradiated sweetpotato storage roots and to correlate PAL activity with the rate of disease development. There is evidence in the literature of enzymes in the host, namely PAL, peroxidase and antifungal-hydrolases, which have been suggested to play some role in UV-C mediated induction of defensive responses in plants. Several studies showed that the onset of induced resistance by UV-C, coincided with the induction of PAL activity where PAL is a key enzyme in the phenylpropanoid pathway. (Hadwiger and Schwochau, 1971; Chalutz et al., 1993; Stevens et al., 1996a,1998; Wilson et al., 1994). Finally, the inhibitory activity of extracts taken from UV-C and non-treated sweetpotato tissues were used to observe conidial germination (Chalutz et al., 1993; Stevens et al., 1998).

2. Materials and methods

2.1. Sweetpotato variety

'Jewel' sweetpotato storage roots were harvested from the George Washington Carver Agricultural Experiment Station, Tuskegee and from a commercial farm in Cullman, Alabama. The roots harvested at Cullman were used in the first experiment. 'Jewel' sweetpotato storage roots were cured by the standard recommended procedure (Clark and Moyer, 1988) by promptly moving them into storage immediately after harvest. The storage house was maintained at 30°C and 85–90% relative humidity for 5–7 days. Afterwards, all roots in wooden crates were held in storage at 16°C until used.

2.2. UV-C irradiation treatment

A low-pressure mercury vapor discharge lamp from General Electric (G E), emitting quasi-monochromatic UV radiation at 254 nm was used. Approximately 95% of the total UV emission of the lamp was at 254 nm, calculated from the data obtained from G E (Harm, 1980). The UV-C field area under the lamp was 30×88 cm.

An UVX digital radiometer (Ultraviolet Products, Inc., San Gabriel, CA) was used to measure the UV-C dose rates. The average dose rate was 1.26 mW cm^{-2}. All storage roots except the non-irradiated control were irradiated with a G E 30 T8 lamp with a normal power output of 30 W and amperage of 0–36. The lamp had a tube diameter of 2.5 cm and a length of 88 cm. The exposure time was calculated from the following equation:

$$\text{exposure time} = \frac{\text{Dose } (D)}{\text{Dose rate}} = \frac{X \text{ mW} \times \text{s/cm}^{-2}}{1.26 \text{ mW/cm}^{-2}}.$$

Using the above equation, UV-C irradiation exposure time for a given dose (X) was calculated. The equation shows that the dose is expressed as kJ m^{-2} with a correspondent mW × s/cm^{-2} equivalent e.g., sweetpotatoes exposed to a dose 3.6 kJ m^{-2} (the dose used to induce host resistance to Fusarium root rot) would be 3.6×10^2 mW × s/cm^{-2}. Storage roots were exposed to UV-C doses [(in kJ m^{-2}) and the total time duration of exposure (in min)] of 1.3 kJ m^{-2} for 1.75 min, 2.4 kJ m^{-2} for 3.23 min, 3.6 kJ m^{-2} for 4.83 min, 4.8 kJ m^{-2} for 6.45 min, 7.5 kJ m^{-2} for 10.10 min, and 20 kJ/m^{-2} for 26.90 min (Stevens et al., 1997). About 35–40 storage roots of US No. 1 grade of uniform size were randomly selected from roots kept in the storage house. These roots were placed on a tray approximately 10 cm from the surface of the lamp. Each dose of UV-C treatment was subdivided into four smaller sub-doses and roots were individually rotated four times to expose four separate sides of the same root to the lamp. Exposure time for each rotation of the roots was measured by a timer connected with a UV lamp. Storage roots were also randomly moved to four different positions within the UV-C field.

Each UV-C irradiation experiment was carried out at room temperature of 24–27°C. The UV-emitting lamps were mounted in a fume hood with sliding plexiglass windows, that allowed observation of roots during UV-C treatment, while protecting the operator from UV-C irradiation. The hood was located in a small preparatory laboratory. Storage roots were treated in small lots and placed in paper bags and stored in complete darkness within 30 min after treatment for 7 days, so that any possible photoreactivation processes would be minimized (Stevens et al., 1996a, 1998).

2.3. Artificial inoculation study

After 30 days following UV-C treatment, irradiated and non-irradiated storage roots were removed from storage, washed and sterilized with 5% Clorox (containing active ingredient 5.25% sodium hypochloride) germicidal bleach solution then washed with sterile deionized water.

Non-irradiated and UV-C irradiated whole storage roots in the first and third experiments, were inoculated by removing the periderm from a spot on the storage root, and placing a *F. solani* culture plug (mycelium down) on the wound. A cork borer with a 10 mm diameter was used to cut the culture plugs from the culture agar plates. An Alabama isolate of *F. solani* was obtained from Dr. C.A. Clark, Louisiana Agriculture Experiment Station, Louisiana State University Center, Baton Rouge, and was maintained on potato dextrose agar (PDA) in petri dishes at 28°C for 7–14 days before transferring cultures in vitro. A culture plugs for inoculation studies were obtained from a 7 day old culture maintained on PDA. These storage roots were incubated at 24°C for 3 days in plastic bags containing moistened paper towels, and then transferred to paper bags for four to eight weeks at room temperature (25–27°C). The storage root lesion diameter, weight, (were taken in the second experiment only see (Table 2)) percent wounds with developing lesions and lesion depth in the first experiment (see Table 1) were determined after artificial inoculation following UV-C treatment (Tables 1 and 2). The rotted lesion tissues were removed with a scalpel and weighed.

The dry weight determination were made from 5 roots taken from each replication (3 replicas) from all dosages of the UV-C and nontreated storage roots from the first and second experiment. Storage root tissues were removed with a 20 mm diameter cork borer up to a depth of 20 mm, and weighed to about 25 g, then oven dried at 70°C for 72 h; cooled in a dessicator and reweighed.

In the third experiment (see Table 3), roots irradiated with UV-C 30 days following treatment were peeled and sliced. Slices were removed midway between the proximal and distal ends of the storage roots. These slices were then placed in Petri dishes containing a sterile moist filter paper and artificially inoculated with *F. solani*. Culture agar plugs from actively growing *F. solani* plugs were inverted, and placed on the center of each slice, and incubated for 5–7 days at 27°C in an incubator. The lesion diameter was first measured at 10 days, and then the lesion diameter, depth and weight of the rotted tissues from root slices were measured 20 days after inoculation.

Table 1
Average lesion depth and weight of UV-C irradiated Jewel sweetpotato storage roots after artificial inoculation with *Fusarium solani*

UV-C dosage (kJ/m^{-2})	Lesion depth (mm)[a]	Lesion weight (g) at 58 day[b]
0.0	7.6	1.93
1.30	12.5	13.10
2.40	2.4	0.27
3.60	2.3	0.37
4.80	2.4	0.49
7.50	5.2	4.60
20.00	10.9	8.40

[a]Cubic regression equation of UV-C doses (X) on lesion depth of *Fusaruim* surface rot on Jewel sweetpotato storage roots (Y) was: $Y = 10.11 + 3.21(X) + 0.42(X^2) + 0.01(X^3), r^2 = 0.6$.

[b]Quartic regression equation of UV-C doses (X) on lesion weight of *Fusaruim* surface rot on Jewel sweetpotato storage roots (Y) was: $Y = 3.41 + 7.26(X) - 3.78(X^2) + 0.50(X^3) - 0.01(X^4), r^2 = 0.53$. Regression coefficients were significant equations when $r^2 \leqslant 0.7$. Regression coefficient were significant at $P \leqslant 0.05$ for all equations.

Table 2
Mean lesion diameter and weight of UV-C irradiated Jewel sweetpotato storage root slices after inoculation with *Fusarium solani*

UV-C dosage (kJ/m^{-2})	Lesion diameter (mm)[a]	Lesion weight (g)[b]
0.0	32	3.0
1.3	21	2.1
3.6	16	1.0
7.5	18	1.4
20.0	23	1.4

[a]Quadratic regression equation of UV-C doses (X) on lesion diameter of *Fusarium* surface rot on Jewel sweetpotato storage roots (Y) was: $Y = 30.9 - 5.8(X) + 0.27(X^2), r^2 = 0.97$.

[b]Cubic regression equation of UV-C doses (X) on lesion weight of *Fusarium* surface rot on Jewel sweetpotato storage roots was: $Y = -147.99(X) + 276(Y) - 149.139(X^2) + 24(X^3), r^2 = 0.7$. Regression coefficient were significant at $P \leqslant 0.05$ for all equations.

Table 3
Average lesion diameter, depth and weight of UV-C irradiated ($3.6\ kJ/m^{-2}$) Jewel sweetpotato storage roots after inoculation with *Fusarium solani*

Treatment	Lesion diameter (mm) after		Lesion[a] depth (mm)	Lesion weight (g)
	10 days	20 days		
Control	4.0[a]	19.0[a]	5.1[a]	1.5[a]
UV-C	1.3[b]	8.4[b]	2.4[b]	0.7[b]

[a]The lesion depth and weight were measured 20 days after inoculation. The UV-C radiation dose was $3.6\ kJ/m^{-2}$ for Jewel sweetpotato. Means of each treatment followed by the same letter in each column do not differ significantly ($P \leqslant 0.05$) as determined by Duncan's Multiple Range Test.

2.4. Phenylalanine ammonia-lyase assay

The phenylalanine ammonia-lyase (PAL) assay was conducted by using the procedure of Koukol and Conn (1961). Assay for PAL activity was conducted 30 days after UV-C treatment of storage roots at the following dose levels: 0, 1.5, 2.4, 4.8, 7.5, and 20 kJm^{-2}. Storage roots were punched with a sterile cork borer to a depth of 10 mm where disks of 1 g were removed at random, and homogenized in 10 ml of cold solution of 0.05 M sodium borate buffer with a pH of 8.5. The homogenate was filtered through three layers of cheese cloth and centrifuged at $14\,500 \times g$ for 30 min. The crude extract was assayed immediately after homogenization. The assay of PAL activity was based on determining the amount of cinnamic acid formed (μg per gram tissue dry weight). The reaction mixture consisted of: 1 ml of 60 μmol L-phenylalanine solution, 1 ml of 200 μmol sodium borate buffer, pH 8.8; 1 ml of crude enzyme (extracted from 1 g sample with 3 ml of 0.05 moles sodium borate buffer, pH 8.5) and 2 ml of distilled water in a total volume of 5 ml. The mixture was incubated at 37°C for 2 h then acidified with 0.1 ml of 5 M HCl. The acidified mixture was boiled in a water bath for 10 min and extracted with ethyl ether, then the residue was dissolved in 20 ml of 0.05 moles sodium hydroxide. The absorbance was recorded at 268 mn. The PAL test was determined from storage roots treated in the first experiment and repeated twice.

2.5. Germination study

Bioassays of antifungal activity were assessed by determining conidial germination, measuring the germ tube length, and hyphal growth, in tissue extracts from UV-C treated and non-treated 'Jewel' sweetpotato storage roots. The tissues were removed from roots in the first and second experiments over a 2 yr period. Thirty days after UV-C treatment of harvested sweetpotato, tissue extracts were prepared from tissues taken as disks 10 mm in diameter from the upper surface of roots (5.5 mm deep) in each treatment. A sample of approximately 1.4 g was added to 8 ml of sterile distilled water and homogenized in a sterile mortar with a pestle. The resulting suspension was filtered through three layers of cheese cloth. An aliquot of 0.2 ml suspension of non-germinated conidia from 7–10 days old cultures of *F. solani* (5.6×10^5 conidia/ml), was added to 0.8 ml of extract and incubated at 27°C for 8 h. A small aliquot of the conidia extract mixture was transferred to a glass slide and covered with a cover slide where the percent germination, germ tube length, and hyphal growth were determined at $400\times$ magnification and germ tube at $1000\times$ magnification by light microscopy.

2.6. Statistical analysis

Storage roots were arranged in a completely randomized block design. There were four replications with five roots per replication, for a total of 20 roots for each treatment in all experiments. The first and second experiments, were repeated two times and the third experiment three times. In the germination assay, about 25–50 germinating conidia were observed at random over the glass slide replicated four times and assays were repeated twice. Actual percentage data are reported, but the values were transformed using values from a standardized arcsin percentage transformation table to stabilize variance before analysis. Analysis of variance (ANOVA) using the Duncan Multiple Range Test and F test were used. The F test was conducted with orthogonal contrast made for one experiment and the data was compared at a probability (P) of a significant value. The dose-response data were subjected to second (quadratic), third (cubic) and fourth (quartic) degree polynomial regression analysis. Quadratic (x^2), cubic (x^3), and quartic (x^4) effects were examined to determine the appropriate terms in the regression model. Polynomial regression analysis was then used to derive the significant quadratic, and cubic and quartic terms in models describing the effects of low dose UV-C on the disease development of Fusarium root rot (SAS Institute, 1995).

3. Results

3.1. Hormetic effect of UV-C on induced resistance of sweetpotato to Fusarium root rot

For the first experiment, results of disease percent incidence, lesion diameter, depth, and fresh weight of sweetpotatoes roots inoculated with *F. solani* after irradiation with different hormetic UV-C dosages are shown in Figs. 1 and 2, and Table 1. Analysis of Fusarium root rot parameters revealed that hormetic UV-C significantly suppressed disease development ($P \leqslant 0.05$). The development of Fusarium root rot was suppressed to the greatest degree when storage roots were treated with 3.6 $kJ\,m^{-2}$ dose of UV-C. A cubic polynomial function best described the decrease in lesion diameter and depth, as the dosages of UV-C increased from 0 to 3.6 $kJ\,m^{-2}$. A quartic function best described the decrease in lesion weight.

In the second experiment, sweetpotato slices which were inoculated in the center from UV-C treated storage roots with *F. solani* showed a marked increase in resistance to decay. Lesion diameter and fresh weight of rotted tissue from sweetpotato slices inoculated with the fungus were reduced when intact storage roots were previously irradiated with 1.3–20 $kJ\,m^{-2}$ UV-C compared to the

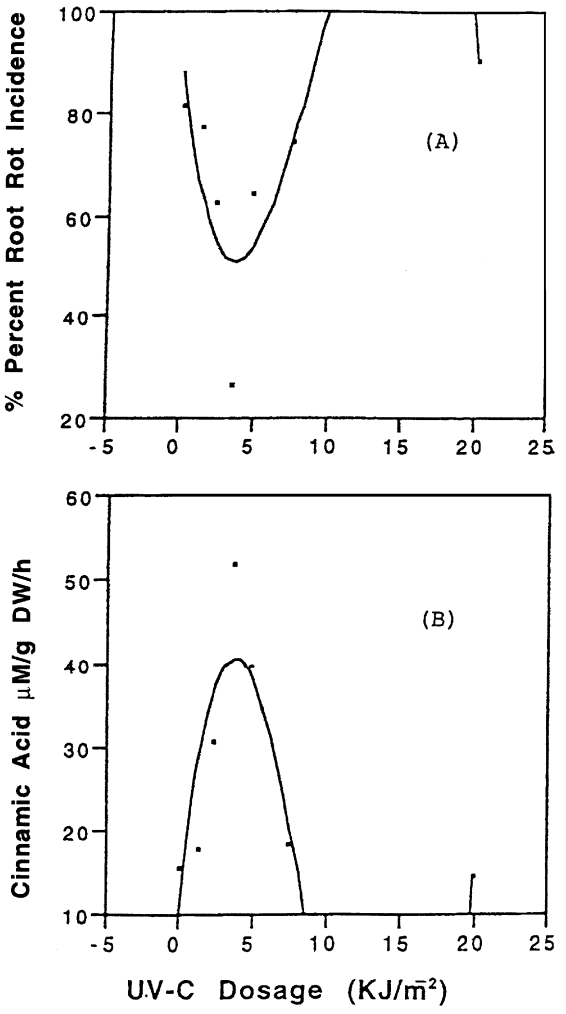

Fig. 1. Relationship between UV-C doses on (A) percent incidence of *Fusarium* root rot artificially inoculated with *Fusarium solani* in 'Jewel' sweetpotatoes; cubic regression of UV-C doses (x) on percent incidence (y) of *Fusarium* root rot was: $y = -88.25 - 21.35(x) + 3.53(x^2) - 0.12(x^3)$, $r^2 = 0.62$ and (B) phenylalanine ammonia-lyase activity (y) in 'Jewel' sweetpotatoes; cubic regression of UV-C doses (x) on phenylalanine ammonia-lyase activity of sweetpotato was: $y = 9.41 - 18.07(x) + 2.98(x^2) - 0.109(x^3)$, $r = 0.74$. The regression coefficients were significant at $P \leqslant 0.05$ for all equations.

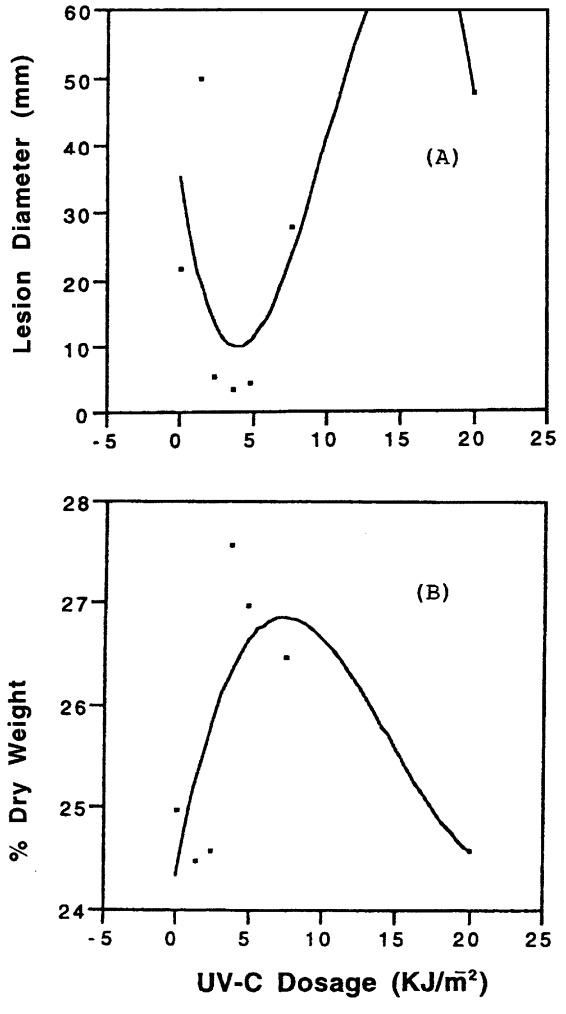

Fig. 2. The comparative effect of UV-C doses on (A) lesion diameter of rotted tissues of *Fusarium* root rot artifically inoculated with *Fusarium solani* in 'Jewel' sweetpotatoes; cubic regression of UV-C doses (x) on lesion diameter (y) of *Fusarium* root rot was: $y = 35.33 - 13.71(x) + 2.15(x^2) - 0.07(x^3)$, $r = 0.5$ and (B) percent dry weight of 'Jewel' sweetpotatoes; cubic regression on UV-C doses (x) on percent dry weight (y) of sweetpotato storage roots was: $y = 24.35 - 0.77(x) + 0.069(x^2) - 0.00(x^3)$, $r = 0.6$. Regression coefficients were significant at $P < 0.05$ for all equations.

non-irradiated storage roots. Effects of UV-C dosages on lesion diameter, and lesion weight of Fusarium root rot were best described by a quadratic and cubic polynomial functions, respectively (Table 2).

Results from the third experiment showed that the lesion diameter, and depth at 10 and 20 days, and weight at 20 days were significantly less in UV irradiated (3.6 kJ m^{-2}) roots compared to the non-irradiated 'Jewel' whole storage roots ($P \leqslant 0.05$) (Table 3). About 55% of the inoculated root wounds on UV-C treated storage roots, failed to develop lesions compared to 11% in the untreated control, 10 days after inoculation (Fig. 4).

3.2. The effect of low dose hormetic UV-C on phenylalanine ammonia-lyase activity change in sweetpotato

Exposure of 'Jewel' sweetpotato storage roots to different UV-C dosages promoted an increase in PAL activity. Maximum PAL activity occurred at 3.6 kJ m^{-2} (Fig. 1). There appeared to be a relationship between PAL and percent incidence of Fusarium root rot (Fig. 1). The effects of UV-C on the increase of PAL activity, and suppression of the disease were best described by a cubic polynomial function (Fig. 1).

Table 4
Germination of *Fusarium solani* conidia in crude extracts from UV-C treated (3.6 kJ/m^{-2}) and non-treated Jewel sweetpotato storage roots

Germination stages	Percent germination at different incubation periods (h)									
	UV-C					Control				
	24	48	72	96	128	24	48	72	96	128
Conidia not germinating	81	74	53	45	19	34	23	14	13	12
Germ tube stage	14	16	14	20	7	42	32	11	13	10
Primary hyphae	2	3	9	2	2	8	9	2	2	0
Secondary hyphae	3	7	23	32	72	15	37	74	72	78
Significance of F test from ANOVA										
UV-C vs control					*					
Incubation period (h)					**					
Fungal stages of growth					**					
Interactions					NS					

3.3. The effect of low dose hormetic UV-C on dry weight of sweetpotato

There was a relationship between the percentage dry weight of storage root tissue, and lesion diameter in the sweetpotato following UV-C treatment. The percentage dry weight was the highest and Fusarium root rot reduced when whole storage roots were treated with UV-C doses from 0 to 3.6 kJ m^{-2} (Fig. 2). Similarly, there was a relationship between PAL activity vs percentage dry weight; as the dosages of UV-C increased from 0 to 3.6 kJ m^{-2}, increases in the PAL and dry weight activities occurred. (Figs. 1 and 2).

3.4. The effect of tissue extract from UV-C treated and untreated sweetpotato roots on conidial germination of Fusarium solani

To further test the hypothesis that UV-C induced disease resistance is not mainly a germicidal effect, a bioassay of *F. solani* antifungal activity on conidia in extracts taken from UV-C irradiated 'Jewel' sweetpotatoes was determined. Conidia in the UV-C treated extract germinated slowly, compared to the non-irradiated control (Table 4 and Fig. 3). A quartic and cubic polynomial function showed a negative curvilinear relationship when the UV-C dosages increased from 0 to 3.6 kJ m^{-2}, which resulted in the lowest percent conidial germination, and germ tube length reduction, respectively, of *F. solani* in sweetpotato extracts. Furthermore, the bioassay revealed that exposure of sweetpotato storage roots to UV-C, slowed the growth in vitro of the developing secondary hyphae of the germinating conidia (Table 4) (Fig. 3).

4. Discussion

The rate of decay development around *F. solani* plugs on UV-C irradiated sweetpotato storage roots and slices, progressed slower than the non-irradiated storage roots. The inhibitory effect on germinating conidia, germ tube, and hyphae development, and increased PAL activity, suggests that the low dose (3.6 kJ m^{-2}) hormetic UV-C treatment of storage roots, induced host resistance to *F. solani*. Several workers have reported that various types of low dose irradiation increased disease resistance in the vegetative body of plants (Bridge and Klarman, 1973; Grisenko and Mazhara, 1968; Starzyci et al., 1967).

Exposing sweetpotato storage roots to low hormetic UV-C dose stimulated PAL activity. PAL is a key enzyme that leads to the synthesis of phenylprophanoid compounds, that resulted in the accumulation of phytoalexins (Legrand, 1983). It was previously reported that the irradiation of various crops (Langcake and Pryce, 1977; Hardwiger and Schwochau, 1971; Bridge and Klarman, 1973) with UV-C radiation, induced the formation of large quantities of phytoalexins. This stimulation of phytoalexins by UV-C in susceptible soyabean plants, increased their resistance to the pathogen *Phytophthora megasperma* var. *sojae* (Bridge and Klarman, 1973). Recently, induction of disease resistance by UV-C light treatment was reported in the postharvest UV-C treatment of fruits and vegetables. The UV-C induced resistance of some crops was attributed to the induction, and accumulation of phytoalexins such as: 6-methoxymellein in cold-stored carrots and scoparone in lemons and kumquat when inoculated with *Botrytis cinerea* and *Penicillium digitatum*, respectively (Stevens et al., 1996a; Wilson et al., 1994). Further work is needed to determine whether or not the induction of phenolic compounds

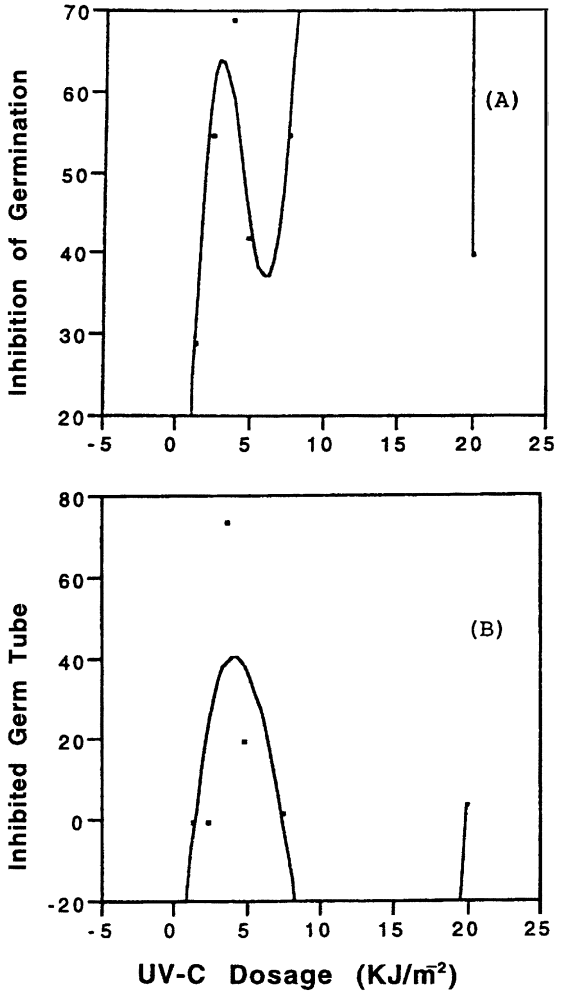

Fig. 3. Effect of crude extracts from tissues treated with UV-C and non-treated 'Jewel' sweetpotato storage roots, on the antifungal activity of *Fusarium solani*. Inhibitory activities were assessed by measuring (A) the percent germinating conidia (% control) (y); quartic regression of UV-C doses (x) on germinating conidia (y) was: $y = -88.22 + 130.93(x) - 37.11(x^2) - 3.81(x^3) - 0.11(x^4)$, $r^2 = 0.87$ and (B) percent inhibited germ tube length (% control) (y); cubic regression of UV-C doses (x) on germinating conidia was: $y = -64.31 + 55.23(x) - 8.41(x^2) - 0.29(x^3) - 0.11(x^4)$, $r^2 = 0.50$. Regression coefficients were significant at $P < 0.05$ for all equations.

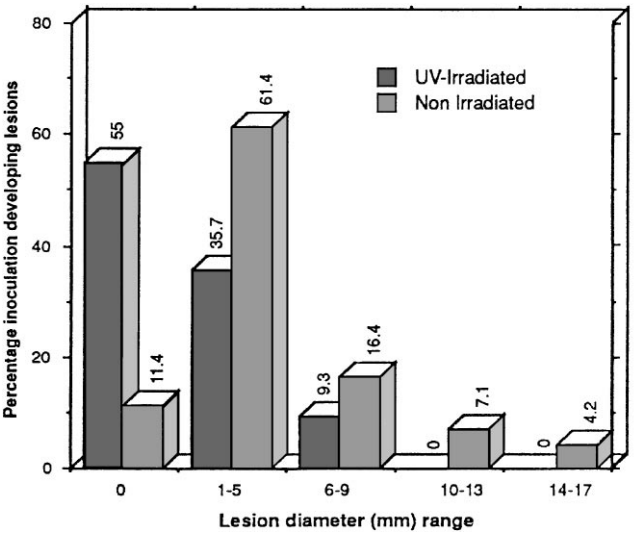

Fig. 4. The effect of low dose hormetic UV-C (3.60 kJ/m^{-2}) on the percentage of *Fusarium solani* inoculations that developed lesions and lesion diameter on 'Jewel' sweetpotato storage roots 10 days after inoculations. The lesion diameter ranges were significant between UV-C vs control as determined by the F test ($P \leqslant 0.01$).

such as phytoalexins and lignification, in root tissue is a response to UV-C hormesis which is involved with the increase resistance of sweetpotato storage roots to Fusarium root rot.

Results from our study with sweetpotato slices that were inoculated in the center of the root slices, showed evidence that UV-C treatment can significantly reduce infection deep in the storage roots. The deep seated infection *In roots* could have resulted from the mother plant, as a result of natural infection (Stevens et al., 1990). There are two reports that showed evidence of reducing deep seated infection following UV-C treatment in postharvested commodities: (1) low dose UV-C was effective in reducing latent infection of brown rot caused by *Monilinia fructicola* within 1 cm of the mesocarp of peaches (Stevens et al., 1998) and (2) UV-C was effective in reducing Alternaria rot found in the septa of tangerines. After harvest, sound healthy citrus remains resistant to invasion until the button becomes moribund, whereupon, the fungus progresses into the fruits (Stevens et al., 1996a).

The results of this study also showed that the percent dry weight was the highest at 3.6 kJ m^{-2} which also induced host resistance of sweetpotatoes to Fusarium root rot. Stevens et al. (1990) reported that UV-C irradiated storage roots of sweetpotatoes had greater starch content than the control. Slower starch degradation is beneficial because it means UV-C treated sweetpotatoes retained more dry matter, and thus extended the shelf life of the storage roots. Wu (1995) showed that UV-C treated sweetpotato storage roots had smaller weight loss and lower alpha and beta amylases and invertase activities, but higher sucrose synthase activity (starch synthesis) compared with the control. The respiration process in UV-C treated commodity would also be reduced resulting in a slower rate of starch degradation (Stevens et al., 1996a). Induced resistance which is an energy-conserving phenomenon, may be especially important in sweetpotato (Wilson et al., 1994).

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