SCLEROTIUM SPP FOR BIOLOGICAL CONTROL OF TALL LARKSPUR (*DELPHINIUM* SPP)

by

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ABSTRACT

The presence of poisonous plants such as tall larkspur (*Delphinium barbeyi* or *Delphinium occidentale)* on mountain rangeland grazing sites creates problems for livestock managers. Methods for controlling cattle losses to larkspur include managing the animals, deferred grazing, or eliminating the poisonous plants. Plant eradication efforts have focused on chemical herbicides with little research on biological control options. The objective of this study was to compare and test two phytopathogenic species from the fungal genus *Sclerotium, S. rolfsii and S. delphinii,* for potential as biocontrol agents. The fungi were tested for optimal temperature growth parameters and comparative virulence on a variety of hosts. Results indicate that the temperature tolerances were very similar and that both species may be pathogenic on many hosts.

INTRODUCTION

The presence of poisonous plants on rangeland grazing sites is a major concern throughout the world (Fowler 1983). Nielsen (1978) estimated that poisonous plants were responsible for a $107 million annual loss to the livestock industry in the 17 western states. On mountain rangelands in the western United States, larkspur (*Delphinium* spp.) poisoning is a significant cause of cattle deaths. In 1986, over 1,000 cattle reportedly died from larkspur poisoning in the Intermountain Forest Service Region (Nielsen and Ralphs 1988).

Current methods of controlling cattle losses to *Delphinium* spp include fencing, managing the livestock, deferred grazing, or plant elimination (Krueger and Sharp 1978, Lane et al. 1990, Merrill and Schuster 1978, Olsen 1984). To date, plant eradication or control efforts have focused on the use of herbicides (Cronin et al. 1974, 1977, 1979, Mickelsen et al. 1990, Ralphs et al. 1990 and Whitson et al. 1992) while little research has been done on biological control options. Two fungi in the genus *Sclerotium* are reported to be phytopathogenic to cultivated *Delphinium* spp. (Farr et al. 1989) but have not been tested as possible biocontrol agents on native *Delphinium* spp. The objective of this study is to compare two species of *Sclerotium*, *S. rolfsii* (Sacc.) and *S. delphinii* (Welch) and determine suitability as biocontrol agents for tall larkspur *Delphinium barbeyi* (Huth) and *Delphinium occidentale* (Watson) on mountain rangelands.

LITERATURE REVIEW

Larkspur Ecology

Tall larkspurs, or those species taller than 91 cm, are hardy, long-lived, herbaceous, perennial plants inhabiting moist microclimates of subalpine rangelands (Kingsbury 1964). In Utah *Delphinium barbeyi* plants were estimated to be over 75 years old (Cronin and Nielsen 1979). They are a dominant component of the forb community and are often found in close association with persistent snowdrifts or at the edge of wet meadows (Cronin et al. 1972). The genus *Delphinium* is native to every continent in the northern hemisphere (Cronin and Nielsen 1979). All species are considered poisonous to livestock, but those in the western United States are more toxic than eastern or European species. All but four species are found west of the Mississippi River, with most found in California and the Rocky Mountains (Cronin and Nielsen 1979). *Delphinium occidentale*, or duncecap larkspur is commonly found in the regions north from central Utah , while *Delphinium barbeyi* is found primarily in the southern subalpine regions of the Rocky Mountains. Personal observation of these larkspur species at sites in Montana and Colorado indicates a difference in their growth habits. In Montana, *Delphinium occidentale* usually grows in clumps or patches, while in the subalpine regions of Colorado, *Delphinium barbeyi* is ubiquitous, occurring under Aspen trees as well as in open meadows. Other plants often found in association with larkspur include such common subalpine forbs as columbine (*Aquilegia spp.*), sticky geranium (*Geranium viscosissimum)*, perennial lupine (*Lupinus perennis*) and yarrow (*Achillea millefolium*).

At a clearcut site in Colorado, false hellebore (*Veratrum californicum*), an invasive species on disturbed sites was as prevalent as *Delphinium barbeyi*.

Larkspurs produce abundant seed but successful seed germination requires 13-14 weeks in direct contact with moist, unfrozen soil under snow cover. When conditions are optimal, 70-80% of the seed will germinate within the first year but dormant seeds are not long lived (Williams and Cronin 1968). Seedlings are slow to establish as most of the energy reserves are used in root development. Duncecap larkspur does not produce true leaves until the second year of growth and is probably not reproductively mature for eight to ten years (Cronin et al. 1988). Vegetative regeneration may be an important aspect of survival, as the plant crowns will produce multiple shoots even after several years of apparent dormancy. Mature larkspur is dormant for a short time in the fall but resumes growth under snow cover (Cronin and Nielsen 1979).

Tall larkspurs are palatable and nutritious to livestock. However, they contain toxic diterpenoid alkaloids which attack the nervous system often resulting in death (James and Johnson 1976). Cattle are particularly susceptible to the alkaloids, while sheep are four to six times more tolerant (Ralphs 1988). Alkaloid concentrations are highest in the rapidly growing and reproductive structures of the plants (Olsen and Manners 1989). Thus, toxicity is high early in the growing season, declining as the plant matures, but increasing again during the seed stage. Most cattle losses are associated with large, dense patches of larkspur whereas losses decrease as the plants disperse and browse diversity increases (Cronin 1971).

Control of Losses

Several management methods to reduce losses to larkspur poisoning have been suggested. One strategy is to delay access to a larkspur infested site until after flowering; however; this is not always the best use of the plant resource. Wise and efficient management of many rangelands dictates a variation in the timing and longevity of use. Prolonged use of a specific site during the same season each year will lead to a deterioration of plant community diversity. This deterioration of the range increases the risk of poisoning by limiting plant selection (Fowler 1983). Maintaining plant community diversity is difficult if a livestock manager must wait to graze until late in the season every year. Aversion training may be another management tool for rangeland cattle, but it is easily reversed if the trained cows graze with untrained animals (Lane et al. 1990).

Herbicides may be used effectively to manage larkspur plants, but they are often economically and environmentally costly, or they are no longer available. Until 1984, 2,4,5-T and silvex were commonly used (Torrel and Higgins 1963, Cronin et al. 1977) but the EPA withdrew their registrations. Recently many studies are being conducted on the efficacy of picloram, dicamba, clopyralid, glyphosate and metsulfuron (Mickelsen et al. 1990, Ralphs et al. 1992, Whitson et al. 1992). However, herbicides are often non-selective and may have a detrimental effect on the surrounding forb communities. Also, since larkspur is often found in drainages and watersheds potential chemical contamination becomes an important consideration. Increased public awareness, stricter water quality parameters and environmental concerns may continue to limit the type and applicability of chemical herbicides on native plants on public lands or reclaimed areas.

Biological Control

Biological control is "the planned use of living organisms to reduce the vigor, reproductive capacity, or effect of weeds" (Quimby and Birdsall 1994). A naturally occurring biocontrol organism would provide an ecologically attractive alternative to chemical control of tall larkspurs, especially in environmentally sensitive sites. Biocontrol agents may include insects and plant pathogens. These organisms can be either native (extant) or introduced species. One concept of biocontrol is the augmentative approach which uses naturally available organisms and augments their populations. This method temporarily supercharges the system to toxic levels to control the undesired plant species. As the host plant populations decrease then the augmented biocontrol agent also decreases. The biocontrol organism also has a high level of host specificity and site adaptability to limit its spread. Established communities of native *Delphinium* typically have naturally occurring enemies to monitor plant populations in undisturbed sites. Problems in developing these agents for use in biological control include locating and culturing these native organisms.

There are several steps required in the research and development of extant plant pathogens as biocontrol agents. The initial step is to locate and identify infectious pathogens on the target plant. This process involves sampling and searching for diseased plants in the field. Diseased plants or samples are returned to the laboratory to isolate the causal agent. Identification of the unknown pathogen is determined following the methods of Koch's Postulates (Agrios 1988). When a pathogen is isolated, it is then transferred repeatedly to sterile media until a pure culture is achieved. The pure cultures are used to

inoculate healthy plants of the same species and produce the same disease. Then the pathogen must be isolated in pure culture again. Once the pathogen is identified and is growing successfully, further studies are conducted to ascertain its virulence and optimal growth parameters. Another step in the process is to assess the susceptibility of closely associated non target plants, known as host range pathogenicity testing.

Sclerotium spp.

In the summer of 1992, Dr. Tony Caesar, a research plant pathologist with the Agricultural Research Service, collected sclerotia from diseased crowns of *Delphinium barbeyi* plants near Yampa, Colorado. The native fungus was identified as a member of the genus *Sclerotium,* but it has not been definitely characterized to the species level. Two members of the genus *Sclerotium* have been reported as pathogens on *Delphinium, S. rolfsii* (Sacc.) and *S. Delphinii* (Welch) (Farr et al. 1989). Species identification of *Sclerotium* can be difficult as identification is based primarily on the morphological characteristics of the sclerotia. Sclerotia characteristics may vary due to differences in type of growth medium, light, and maturity (Aycock 1966, Lyle 1953).

Sclerotium rolfsii is generally found in southern, western and southeastern regions, preferring a warm, humid climate. The sclerotia do not survive below 0°C, which limits distribution (Punja and Rahe 1992). *Sclerotium delphinii* is more often found in northern regions due to greater cold tolerance, but both species are widely distributed. More research has been conducted on *Sclerotium rolfsii*, due to the greater economic significance

of the diseases it causes. The lesser researched, *Sclerotium delphinii*, was first described in 1924 (Welch 1924). There is debate and taxonomic confusion regarding the placement of *Sclerotium delphinii*, with some references referring to it as *Sclerotium rolfsii* Sacc. var. *delphinii*, and others questioning whether *S. delphinii* should be a separate classification (Lyle 1953, Harlton et al. 1995, Stevens 1931). For purposes of this project, we will assume a separate species classification.

Sclerotia are small (0.05-6.0 mm in diameter), globose masses of hyphae covered with a melanized rind (Aycock 1966, Punja and Rahe 1992). They are produced on either infected plant material or saprophytically on plant debris. Sclerotia are the primary means of overwintering and spread of the fungus (Aycock 1966). Germination is stimulated by host plant exudates or available nutrients combined with ample moisture and warm temperatures. The sclerotia may remain dormant in or on the soil for a brief time, but are sensitive to repeated cycles of wetting and drying (Smith 1972).

The sclerotia collected in Colorado were brought back to the laboratory in Bozeman, Montana and stored dry, in sterile Petri dishes at 10°C until research could begin. Repeated efforts to grow and culture the native sclerotia were unsuccessful. Several different methods were used to stimulate germination. The methods included: soaking the sclerotia in a 0.5% sodium hypochlorite (NaOCl) solution for five, ten and fifteen minutes as described by Linderman and Gilbert (1972); plating the sclerotia on a specialized delphinium extract nutrient agar; and scarifying the sclerotial rind. However, none of the methods induced germination. Another trip to Colorado was made in July of 1994 to the site of initial collections to gather additional sclerotia. Similar efforts to

stimulate the sclerotia also proved unsuccessful. It appears that germination parameters for the Colorado sclerotia may be as specific as those of the larkspur seed. Further research to induce germination of the sclerotia should include freezing for various lengths of time followed by the aforementioned treatments. Since the native sclerotia were collected from diseased plants in the mountains of northern Colorado it is most likely *S. delphinii,* due to exposure to cold temperature extremes. Since we were unable to germinate the native sclerotia the focus of this research will include both of the known pathogens, *S. rolfsii* and *S. delphinii* to determine if either would be suited for biocontrol of native *Delphinium* species.

MATERIALS AND METHODS

Known isolates of *S .rolfsii* and *S. delphinii* were received from the American Type Culture Collection (ATCC). The isolates were grown at room temperature on sterile Petri dishes (87mm diameter) containing Acidified Potato Dextrose Agar (APDA) medium (pH 3.5). Early research done by Abeygunawardena and Wood (1957) indicated that optimal growth of *Sclerotium rolfsii* occurred between pH 2.1 and 4.2. Acidified media also limits the amount of bacterial contamination on the cultures.

The research project was separated into two phases. The first aspect of the study was to compare the temperature tolerances and optimal growth ranges for each of the two ATCC fungal species. This was to verify if either species would be better suited to the subalpine climate. The second phase was to compare the potential host range of both *Sclerotium* spp. Previous studies (Aycock 1966 and Obee 1937) of host plants that were susceptible to *Sclerotium* spp. had focused on horticultural or cultivated plants rather than on native species or wildflowers. Thus, the emphasis for this study was to compare the potential host range of both *Sclerotium* species on subalpine native plants that may be found in the associated *Delphinium* plant community.

Thermogradient Analysis

The thermogradient unit consists of four aluminum bars (one meter long) that are simultaneously heated and cooled at opposite ends. The temperature gradient is achieved by circulating either chilled or heated water at the opposing ends, and ranges from 8.6° C to 35.8° C. Each aluminum bar had enough room for eleven petri dishes, allowing

growth at eleven different temperature ranges. The temperatures were averaged for comparison of the data, but the petri dish location was identical for each trial. The bars were covered with a plexi-glass hood to help maintain the temperatures and reduce the influence of external factors from the laboratory.

When the ATCC isolates were actively growing, a 2 mm mycelial plug was extracted and placed on a sterile Petri dish containing APDA. The inoculated petri dishes were placed directly on the bar with the mycelial plug toward the cool end of each position. The linear mycelial growth (mm), or hyphal elongation across the media was measured with digital calipers every 24 hours for nine days. The experiment was replicated four times. The daily growth results were averaged for the four experiments for each isolate at each temperature (Appendix A).

Host Range Tests

Thirty-five different herbaceous species were tested for susceptibility to both fungi in the greenhouse. In selecting the plants for the host study, emphasis was placed on native genera, although some of the species were closely related garden varieties (Table 1). Often native plant seeds were unavailable or germination was too erratic to produce enough viable plants for testing. Consideration was also given to species that have been previously tested (Aycock 1966) and have known susceptibility. Seeds of *Delphinium barbeyi* were site collected in Colorado and subjected to cold, moist stratification in the greenhouse, but germination and survivabilty of the seedlings was too low to include them in the host range test. Additionally, the seedlings were very tender and only beginning to

produce leaves when the pathogenicity testing initiated. *Delphinium occidentale* seeds were not available. Therefore, a faster growing, cultivated, perennial *Delphinium, D. elatum* was substituted for the native species.

Table 1: Scientific and common names of plants used in host range study.

Scientific Name	Common Name	Family
Achillea millefolium	Yarrow	Compositae
Antirrhinum majus	Snapdragon	Scrophulariaceae
Aquilegia coerulea	Columbine	Ranunculaceae
Aster spp.	Michaelmas daisy	Compositae
Aubretia deltondea	Rockcress	Cruciferae
Calendula officinalis	Calendula	Compositae
Campanula medium	Canterbury bells	Campanulaceae
Cheiranthus linifolius	Wallflower	Cruciferae
Chrysanthemum coccineum	Oxeye daisy	Compositae
Clarkia unguiculata	Clarkia	Onagraceae
Consolida orientalis	Larkspur	Ranunculaceae
Delphinium elatum	Delphinium	Ranunculaceae
Dianthus deltoides	Swiss mtn dianthus	Carophyllaceae
Echinacea purpurea	Purple coneflower	Compositae
Erigeron speciosus	Aspen daisy	Compositae
Gaillardia aristata	Blanketflower	Compositae
Geranium viscosissimum	Sticky geranium	Geraniaceae
Gilia aggergata	Scarlet gilia	Polemoniaceae
Gypsophila paniculata	Baby's breath	Caryophyllaceae
Hesperis matronalis	Dame's rocket	Cruciferae
Liatris spicata	Gayfeather	Compositae
Linum perenne	Blue flax	Linaceae

Lobularia maritima	Alyssum	Cruciferae
Lychnis coronaria	Rose campion	Caryophyllaceae
Lupinus perennis	Perennial lupine	Leguminosae
Myosotis sylvatica	Forget-me-not	Boraginaceae
Oenothera biennis	Evening primrose	Onagraceae
Papaver nudicaule	Iceland poppy	Papaveraceae
Papaver rhoeas	Shirley poppy	Papaveraceae
Penstemon strictus	Rocky Mtn penstemon	Scrophulariceae
Rudbeckia hirta	Blackeyed susan	Compositae
Salvia farinacea	Blue bedder salvia	Labiatae
Schizanthus pinnatus	Butterfly flower	Solanaceae
Tagetes patula	Marigold	Compositae

(USDA 1982)

Seedlings were started in plug trays, transplanted to 5 cm pots and finally to individual 10 cm pots prior to inoculation. The objective was to have stable, well established plants and to inoculate them prior to reproductive maturity. The two ATCC cultures of *Sclerotium* species were grown on APDA for two weeks. When mature they were gently scraped from the agar plates and dried overnight in a laminar air-flow hood. Due to the variation in sclerotial size, 0.04 grams of sclerotia were weighed and carefully placed at the base of each plant for inoculation. The plants were placed in a random block design per species on the greenhouse bench. The bench was covered with a plastic dome which contained a timed mist unit at each end. The units emitted water for one minute every ten minutes to achieve 100% humidity without inundating the plants or saturating the soil. The temperature was ± 24° C in the greenhouse, with a 12 hour photoperiod

under high intensity discharge lamps.

Two separate trials were run. The first trial was divided into two categories, with four replications of each plant species placed either in the mist chamber or on an open bench in the greenhouse. The humidity in the mist chamber was 100%, while it ranged from 41% to 72% (following watering) on the open bench. The fungus did not germinate or infect on the open bench. Therefore in the second trial all eight of the replicates were placed in the mist chamber to provide optimal disease inducing humidity. Due to space constraints and germination variability, not each species was tested in each trial. Some of the species tested in trial one were not available for trial two, and some new species were added for trial two. Due to the variable sample size, a chi square distribution using the Fisher's exact test was used to determine the significance probability value at a 95% confidence level for susceptibility comparison in the two trials (Appendix B). Plants were rated as either infected or healthy.

RESULTS AND DISCUSSION

Thermogradient Analysis

Figures 1-11 provide a visual comparison of the mean growth of the four replications for each fungus at each temperature. Based on these comparisons there were virtually no differences between the two fungal isolates at each temperature. Their growth habits were similar in that neither species grew rapidly nor was predictable at the colder temperature ranges. It took several days (up to five or seven) for germination or growth initiation at 8.6°C and 10.8°C (Figures 2 and 3). Even then, growth was slow and erratic. At 13.9° C (Figure 4), germination was slow, but once initiated, both isolates continued to grow. At 16.9°C (Figure 5), germination and growth were slow to initiate, but by day five the growth was well established. The optimum temperature range for rapid growth for both species lies between 19.4°C and 32.7°C (Figures 6-10). Between 19.4°C and 32.7°C germination occurred within the first couple of days and was followed by a flush of growth that quickly covered the plates. Previous research, as reported by Punja (1985), indicated that maximum growth and sclerotial production for *Sclerotium rolfsii* occurs at 27-30°C. The extreme temperature of 35.8°C (Figure 11) allowed for rapid germination, but then limited or stopped the growth of the fungi.

Figure 1: Thermogradient Plate Data Temperature 8.6° C

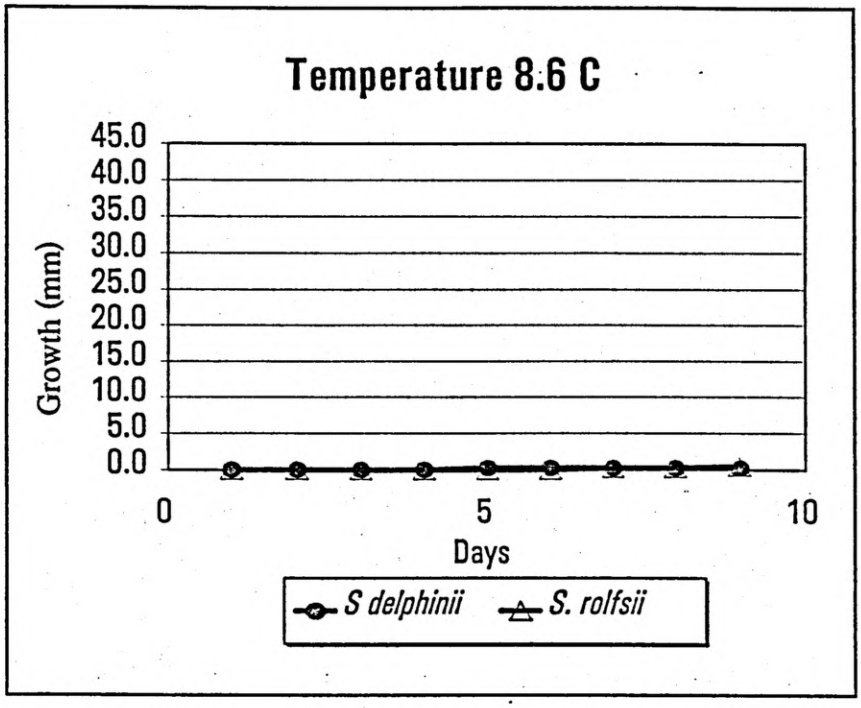


Figure 2: Thermogradient Plate Data Temperature 10.8° C

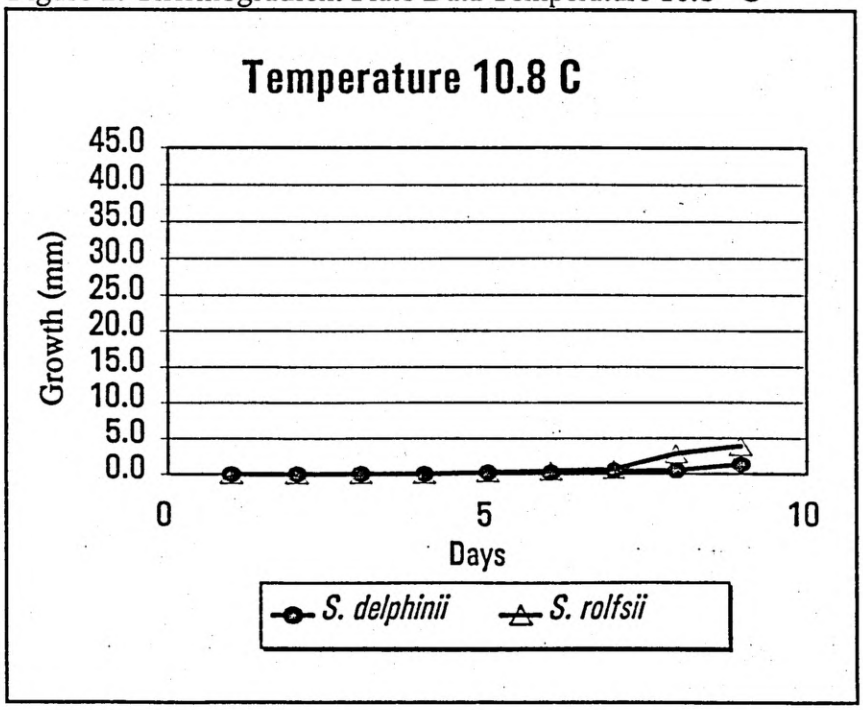


Figure 3: Thermogradient Plate Data Temperature 13.9° C

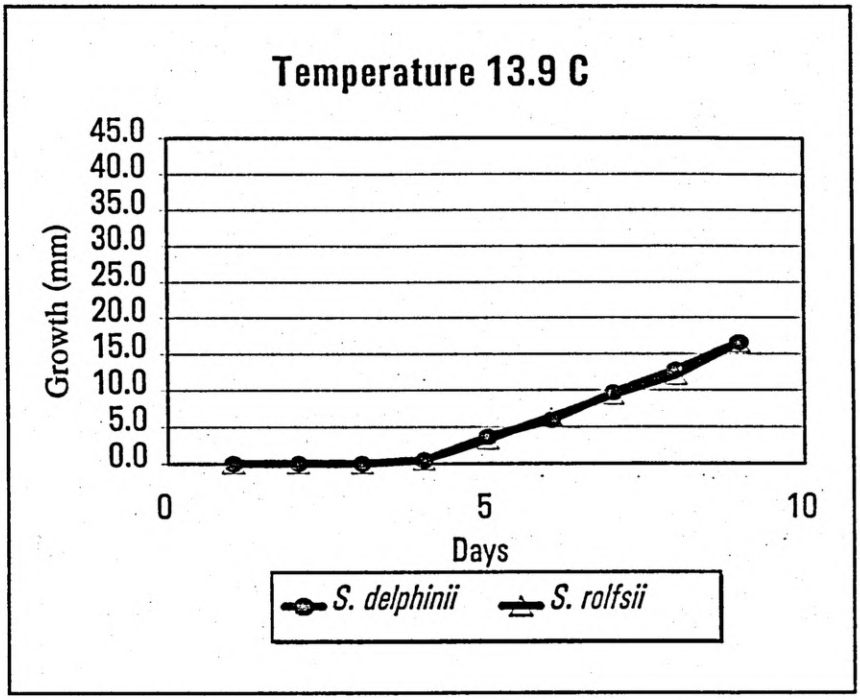


Figure 4: Thermogradient Plate Data Temperature 16.9° C

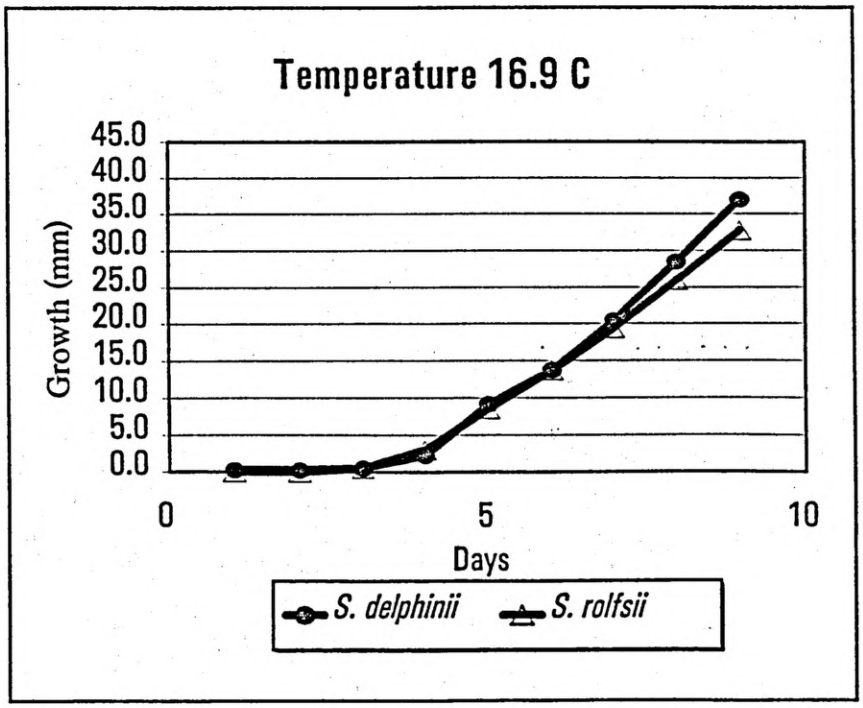


Figure 5: Thermogradient data Temperature 19.4°C

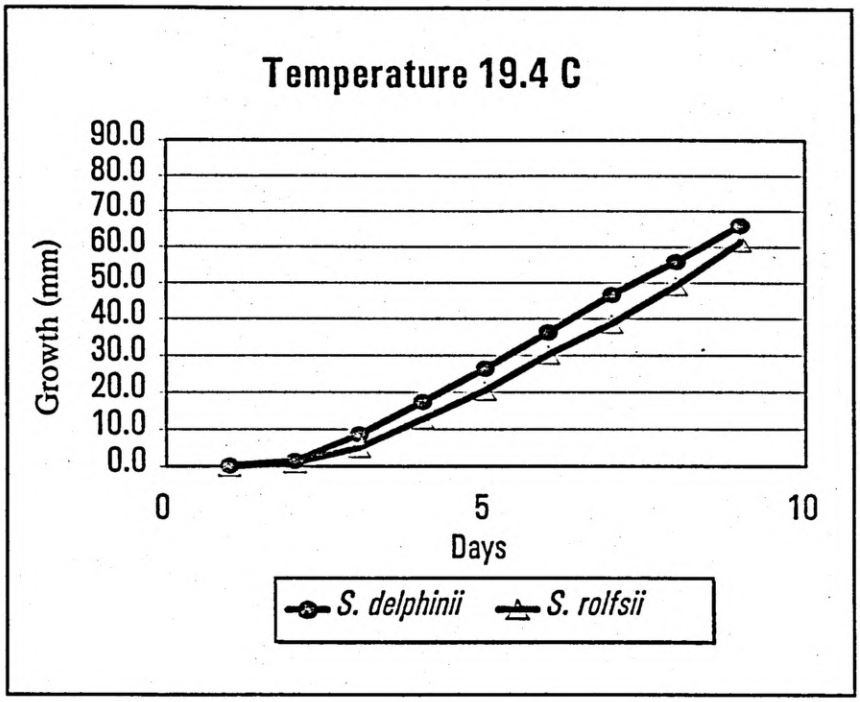


Figure 6: Thermogradient Plate Data Temperature 22.0° C

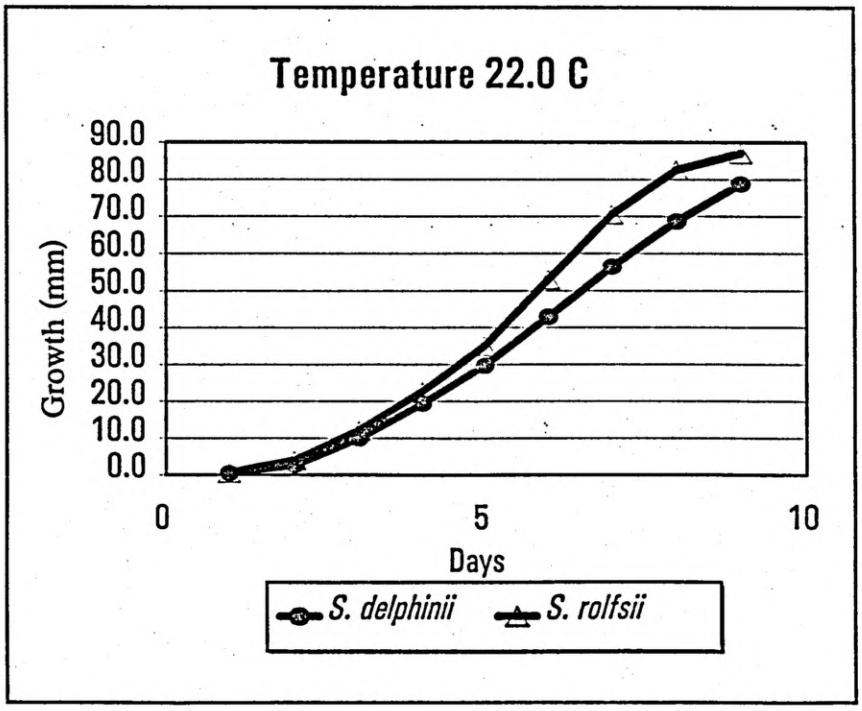


Figure 7: Thermogradient Plate Data Temperature 24.0° C

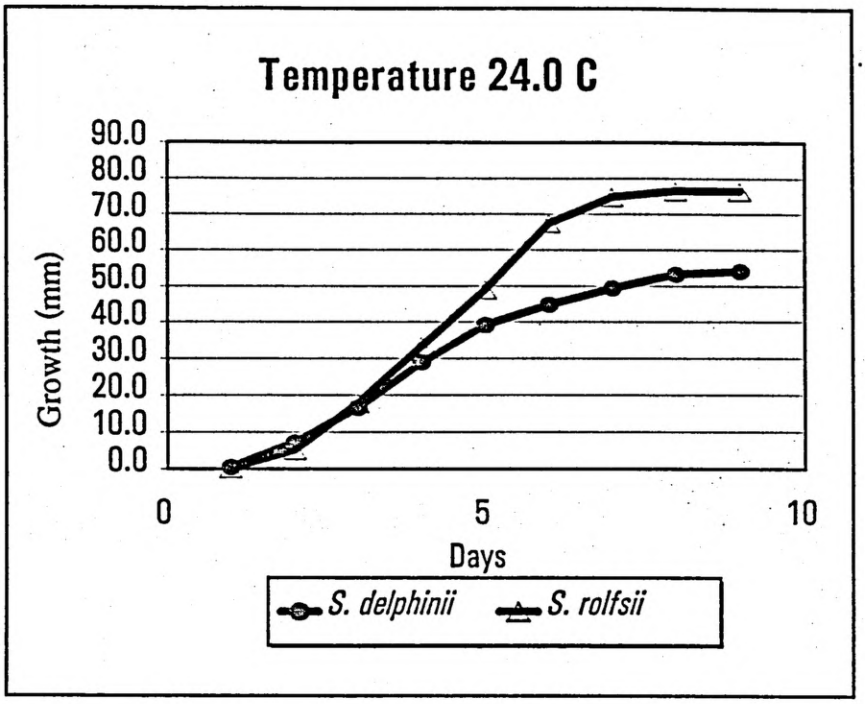


Figure 8: Thermogradient Plate Data Temperature 26.9° C

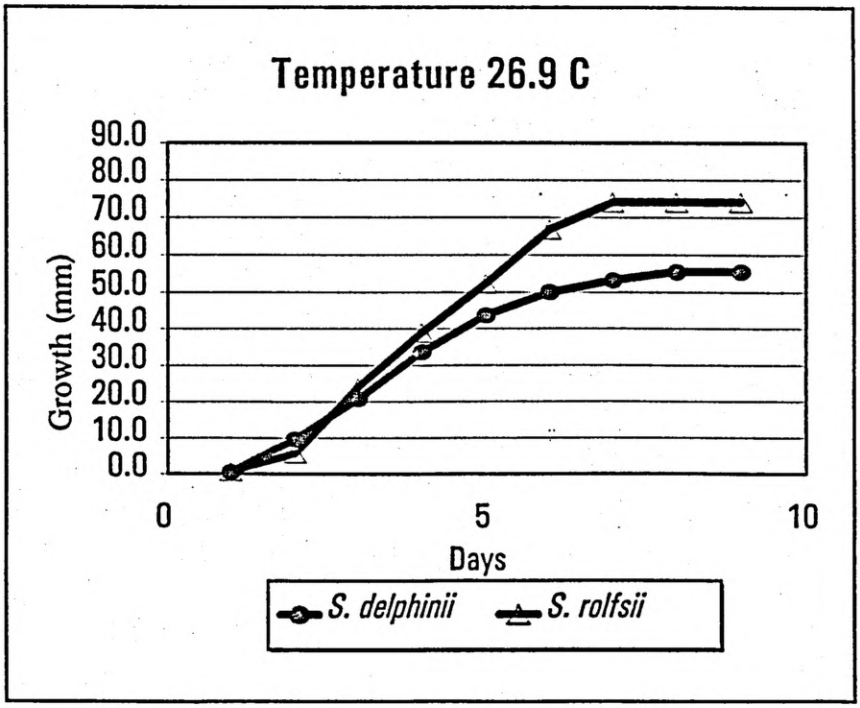


Figure 9: Thermogradient Plate Data Temperature 29.6° C

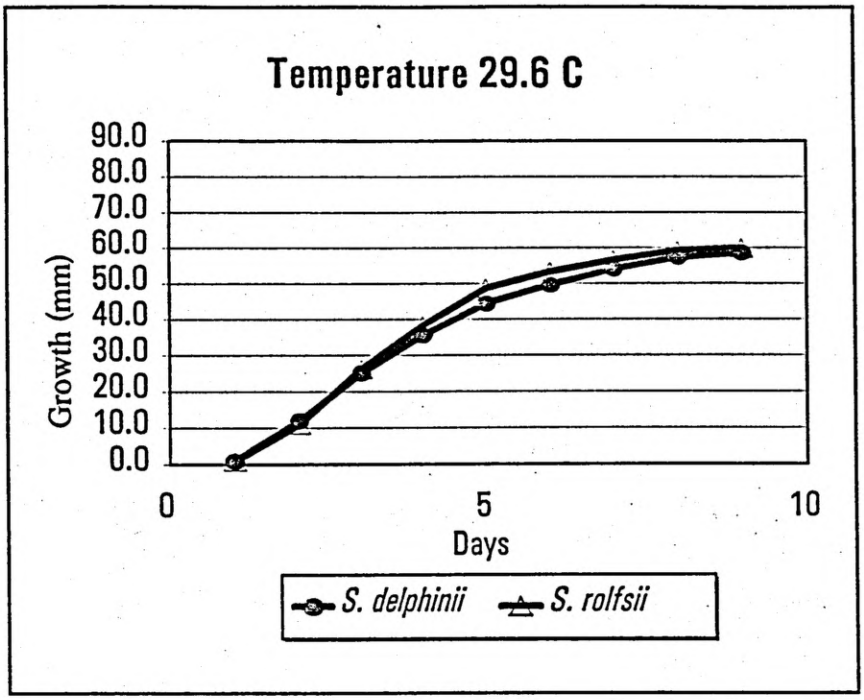


Figure 10: Thermogradient Plate Data Temperature 32.7° C

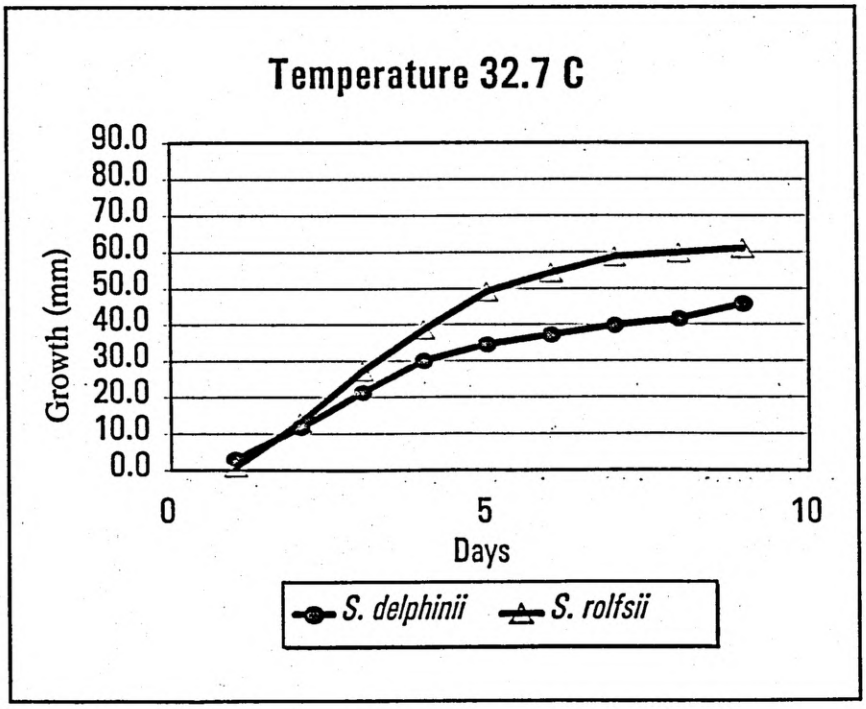


Figure 11: Thermogradient Plate Data Temperature 35.8° C

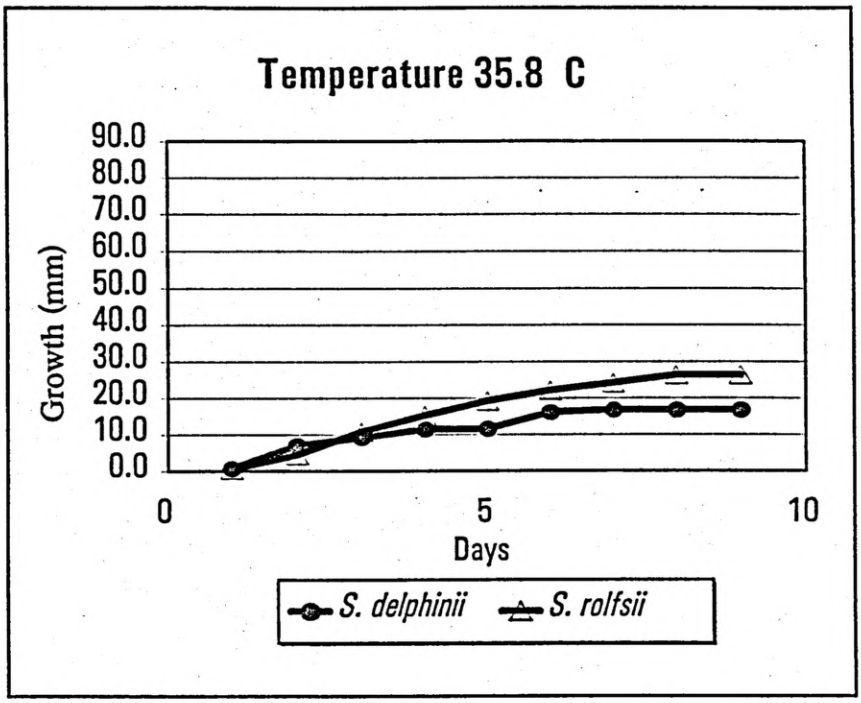


Table 2 : Mean daily growth (mm) of *S. delphinii.*

TEMP	1	2	3	4	5	6	7	8	9
8.6°	0.0	0.0	0.0	0.0	0.25	0.25	0.25	0.25	0.25
10.8°	0.0	0.0	0.0	0.0	0.25	0.25	0.50	0.50	1.33
13.9°	0.0	0.0	0.0	0.50	3.65	5.95	9.68	12.8	16.58
16.9°	0.25	0.25	0.50	2.25	9.18	13.75	20.43	28.45	36.98
19.4°	0.25	1.50	8.63	17.55	26.48	36.45	46.70	55.83	66.05
22.0°	0.50	2.70	10.03	19.55	29.78	42.98	56.55	68.75	78.78
24.0°	0.50	7.18	16.68	29.03	39.23	44.85	49.35	53.23	54.03
26.9°	0.50	9.70	20.93	33.75	43.68	50.0	53.23	55.45	55.45
29.6°	1.00	12.08	25.18	35.63	44.45	49.65	54.03	57.28	58.55
32.7°	3.08	11.78	21.40	30.08	34.48	32.28	39.85	41.58	45.73
35.8°	0.75	7.03	9.33	11.58	11.65	16.23	16.83	16.83	16.83

Table 3 : Mean daily growth (mm) of *S. rolfsii.*

TEMP	1	2	3	4	5	6	7	8	9
8.6°	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.25	0.50
10.8°	0.0	0.0	0.0	0.0	0.25	0.50	0.75	2.88	3.95
13.9°	0.0	0.0	0.0	0.50	3.35	6.40	9.35	12.05	16.53
16.9°	0.0	0.0	0.50	2.98	8.55	13.78	19.38	25.93	32.73
19.4°	0.0	1.00	5.10	12.90	20.55	30.33	38.75	49.13	61.43
22.0	0.50	4.03	12.10	22.73	32.13	53.05	70.55	82.60	87.00
24.0°	0.25	5.28	17.93	33.30	49.0	67.45	74.88	76.45	76.45
26.9°	0.75	5.68	24.08	39.08	52.35	66.93	74.08	74.08	74.08
29.6°	1.00	11.05	26.28	38.25	48.70	53.28	56.55	59.05	59.78
32.7°	1.00	13.13	27.25	38.70	49.15	54.38	58.80	59.85	61.01
35.8°	0.50	4.50	10.85	15.38	19.33	22.23	24.20	26.45	26.45

In considering the fungi individually, temperature had an effect on the mean daily growth on all days except day one, whereby none of the temperatures induced germination (Tables 2-3). The data are similar to the daily growth at each temperature, but these tables provide another method of observation and comparison of the effect of temperature at daily time intervals. By days five and seven, the growth has stabilized and it is apparent once again that the optimal growth range lies between 19.4° C and 32.7° C. Previous reports by Punja and Rahe (1992) indicate that 30° C is probably the optimum temperature for growth of *Sclerotium rolfsii*, and these data concur with these findings. It is interesting that *S. delphinii* did not grow significantly more than *S. rolfsii* at the colder temperatures since *S. delphinii* is more commonly found in cooler, northern climates.

Host Range

Host range and comparative virulence testing indicated that *S. delphinii* had a broader host range and was generally more virulent than *S. rolfsii*. Significant differences ($P < .05\%$) in virulence were noted on *Calendula*, *Delphinium*, *Gypsophila*, *Salvia*, and *Tagetes* (Table 4). On most of the host plants both fungi produced at least mild levels of disease. *Dianthus deltoides* was the only host tested that was not susceptible to either fungal species. Obee (1937) reported that Dianthus deltoides was susceptible to artificial inoculation of *S. delphinii*, but recovered from the infection.

There are several factors to consider in the interpretation of the data. These plants were tested under conditions optimally conducive to disease development, i.e., greenhouse

temperatures ± 24° C, 100% humidity and with the inoculum touching the plants. An additional consideration may be a host's tolerance range, or its ability to outgrow a mild infection. A plant was rated as infected if the sclerotia germinated, colonized the plant tissue and produced new sclerotia. Generally sclerotia are produced after the fungus has exhausted available nutrients (Punja and Rahe 1992, Townsend 1957). However, the nutrients can be derived from either infected plant tissue or the fungi can colonize already dead plant debris on the soil surface.

Infections of plants that produce thick, basal leaves such as *Erigeron* resulted in the production of copious sclerotia. When the plants were removed from the 100% humidity chamber, disease progress was reduced or arrested. Thus, it appears that high humidity is a critical factor for germination of the sclerotia and disease development of moderately tolerant plants. The objective for testing other plant species was to determine potential hosts for these *Sclerotium* fungi. The data indicate possible susceptibility under optimal disease inducing conditions. Plants grown in the greenhouse are subjected to external stresses that are very different than natural conditions. They are grown in small pots, under artificial lighting, in sterile artificial medium and without the benefit of native microorganisms. In a native setting a plant may have unlimited growing space, naturally occurring organisms (harmful or beneficial), and varying climatic conditions. Since a plant is more susceptible to infection when it is under stress, it is extremely difficult to extrapolate greenhouse data to field conditions. It is possible that if field conditions were as stressful, combined with 100% relative humidity levels similar levels of infection may occur on non-target plants.

Table 4 : Infection of plants in host range test.

Plant Species	Trial (N=) 1	2	*S.delph*	*S. rolfsii*
Achillea millefolium	4	8	91.7%	75.0%
Antirrhinum majus		8	87.5%	50.0%
Aquilegia coerulea	4	8	91.7%	91.7%
Aster sp	4		100.0%	75.0%
Aubretia deltondea		8	87.5%	87.5%
*Calendula officinalis**		8	100.0%	25.0%
Campanula medium		8	100.0%	87.5%
Cheiranthus linifolius		8	50.0%	12.5%
Chrysanthemum coccineum	4		25.0%	0.0%
Clarkia unguiculata		8	87.5%	37.5%
Consolida orientalis		8	100.0%	75.0%
*Delphinium elatum**	4	8	83.3%	33.3%
Dianthus deltoides	4		0.0%	0.0%
Digitalis purpurea	4		100.0%	50.0%
Echinacea purpurea		8	87.5%	62.5%
Erigeron speciosus		8	100.0%	100.0%
Gaillardia aristata		4	75.0%	58.3%
Geranium viscosissimum	4	8	41.7%	8.3%
Gilia aggregata	4		100.0%	75.0%
*Gypsophila paniculata **		8	62.5%	0.0%
Hesperis matronalis	4		75.0%	50.0%
Liatris spicata		8	87.5%	75.0%
Linum perenne	4	8	83.3%	50.0%
Lobularia maritima		8	87.5%	87.5%
Lychnis coronaria	4		50.0%	75.0%
Lupinus perennis		8	75.0%	87.5%

Plant Species	Trial (N=) 1	2	*S.delph*	*S. rolfsii*
Myosotis sylvatica		8	87.5%	75.0%
Oenothera biennis	4		75.0%	0.0%
Papaver nudicaule	4		75.0%	50.0%
Papaver rhoeas		8	100.0%	100.0%
Penstemon strictus	4		50.0%	75.0%
Rudbeckia hirta		8	50.0%	75.0%
*Salvia farinacea**		8	0.0%	62.5%
Schizanthus pinnatus		8	62.5%	75.0%
*Tagetes patula**		8	87.5%	0.0%

* Denotes significant difference between the isolates at the 95% confidence interval.

CONCLUSIONS

An interesting finding of this research was the wide host range of *Sclerotium delphinii*. Several previous studies have emphasized and indicated the broad host range of *Sclerotium rolfsii* (Aycock 1966, Obee 1937, Stevens 1931). The results of this study indicate that the host range of *Sclerotium delphinii* may be at least as broad or broader than *Sclerotium rolfsii*. Further research should include many more hosts and perhaps focus on specific families to study susceptibility trends. These experiments indicated that members of the family *Compositae* were more susceptible to *S. delphinii* than to *S. rolfsii*.

A recent study by Harlton et al. (1995) indicates that there is wide genetic diversity among strains of *S. rolfsii* and *S. delphinii*. A worldwide collection of *Sclerotium* and related species were paired on petri dishes and rated for compatibility. The isolates were then separated into mycelial compatibility groups (MCGs) based on aversion zones among pairings. Compatibility could be correlated to geographic origin, but the MCGs also contained a wide variety of isolates. Host of origin was not correlated with the MCG except in *S. delphinii*. It would be interesting to study an array of hosts and compare virulence of specific MCGs.

It is unfortunate that we have been unable to grow the native fungus isolated from Colorado, as it may be the best suited for the subalpine site. Since it was found growing on larkspur plants, it probably is *S. delphinii* as this research indicates *S. delphinii* is more virulent on *Delphinium*. It is also unlikely that S. rolfsii could survive the extreme temperatures at 3,000 meters in northern Colorado.

There is no question that biocontrol would be an ecologically attractive alternative for control of tall larkspur. Further research may indicate a *Sclerotium* spp. that would be appropriate for subalpine conditions. Although the research indicates that both species of *Sclerotium* have a broad host range, it is possible that in the field the non-target plants would not be affected by augmented inoculum. Since sclerotia are usually not wind borne, the inoculum is relatively immobile and spread would be limited to adjacent susceptible plants or carried in infected soil. Given that disease conditions must be optimal for infection, combined with the short longevity of sclerotia, the inoculum would be density dependent on a highly susceptible host. These parameters indicate that *Sclerotium delphinii* would be a good candidate as a biocontrol agent for tall larkspur (*Delphinium* spp.) in regions where other highly susceptible non-target plants are not present.

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APPENDICES

APPENDIX A

Thermogradient Plate Raw Data

Table 5: Thermogradient Plate Data Temperature 8.6° C.

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	0.0	0
1	1	0.0	
1	1	0.0	
1	1	0.0	
1	2	0.0	0
1	2	0.0	
1	2	0.0	
1	2	0.0	
1	3	0.0	0
1	3	0.0	
1	3	0.0	
1	3	0.0	
1	4	0.0	0
1	4	0.0	
1	4	0.0	
1	4	0.0	
1	5	0.0	0.25
1	5	0.0	
1	5	0.0	
1	5	1.0	
1	6	0.0	0.25
1	6	0.0	
1	6	1.0	
1	6	0.0	
1	7	1.0	0.25
1	7	0.0	
1	7	0.0	
1	7	0.0	
1	8	0.0	0.25
1	8	0.0	
1	8	0.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	8	1.0	
1	9	0.0	0.25
1	9	0.0	
1	9	0.0	
1	9	1.0	
2	1	0.0	0
2	1	0.0	
2	1	0.0	
2	1	0.0	
2	2	0.0	0
2	2	0.0	
2	2	0.0	
2	2	0.0	
2	3	0.0	0
2	3	0.0	
2	3	0.0	
2	3	0.0	
2	4	0.0	0
2	4	0.0	
2	4	0.0	
2	4	0.0	
2	5	0.0	0
2	5	0.0	
2	5	0.0	
2	5	0.0	
2	6	0.0	0
2	6	0.0	
2	6	0.0	
2	6	0.0	
2	7	1.0	0.25
2	7	0.0	
2	7	0.0	
2	7	0.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	8	0.0	0.25
2	8	0.0	
2	8	1.0	
2	8	0.0	
2	9	0.0	0.5
2	9	1.0	
2	9	1.0	
2	9	0.0	

Table 6: Thermogradient data Temperature **10.8°C**

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	0.0	0
1	1	0.0	
1	1	0.0	
1	1	0.0	
1	2	0.0	0
1	2	0.0	
1	2	0.0	
1	2	0.0	
1	3	0.0	0
1	3	0.0	
1	3	0.0	
1	3	0.0	
1	4	0.0	0
1	4	0.0	
1	4	0.0	
1	4	0.0	
1	5	1.0	0.25
1	5	0.0	
1	5	0.0	
1	5	0.0	
1	6	0.0	0.25
1	6	0.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	6	0.0	
1	6	1.0	
1	7	0.0	0.5
1	7	1.0	
1	7	0.0	
1	7	1.0	
1	8	1.0	0.5
1	8	0.0	
1	8	1.0	
1	8	0.0	
1	9	1.0	1.325
1	9	4.3	
1	9	0.0	
1	9	0.0	
2	1	0.0	0
2	1	0.0	
2	1	0.0	
2	1	0.0	
2	2	0.0	0
2	2	0.0	
2	2	0.0	
2	2	0.0	
2	3	0.0	0
2	3	0.0	
2	3	0.0	
2	3	0.0	
2	4	0.0	0
2	4	0.0	
2	4	0.0	
2	4	0.0	
2	5	1.0	0.25
2	5	0.0	
2	5	0.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	5	0.0	
2	6	1.0	0.5
2	6	0.0	
2	6	0.0	
2	6	1.0	
2	7	1.0	0.75
2	7	1.0	
2	7	0.0	
2	7	1.0	
2	8	4.9	2.875
2	8	0.0	
2	8	1.0	
2	8	5.6	
2	9	7.5	3.95
2	9	7.3	
2	9	1.0	
2	9	0.0	

Table 7: Thermogradient Plate Data Temperature 13.9° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	0.0	0
1	1	0.0	
1	1	0.0	
1	1	0.0	
1	2	0.0	0
1	2	0.0	
1	2	0.0	
1	2	0.0	
1	3	0.0	0
1	3	0.0	
1	3	0.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	3	0.0	
1	4	1.0	0.5
1	4	1.0	
1	4	0.0	
1	4	0.0	
1	5	8.0	3.65
1	5	5.6	
1	5	0.0	
1	5	1.0	
1	6	10.7	5.95
1	6	0.0	
1	6	1.0	
1	6	12.1	
1	7	6.6	9.675
1	7	15.4	
1	7	1.0	
1	7	15.7	
1	8	19.9	12.8
1	8	1.0	
1	8	19.7	
1	8	10.6	
1	9	25.2	16.575
1	9	25.2	
1	9	1.0	
1	9	14.9	
2	1	0.0	0
2	1	0.0	
2	1	0.0	
2	1	0.0	
2	2	0.0	0
2	2	0.0	
2	2	0.0	
2	2	0.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	3	0.0	0
2	3	0.0	
2	3	0.0	
2	3	0.0	
2	4	0.0	0.5
2	4	0.0	
2	4	1.0	
2	4	1.0	
2	5	8.3	3.35
2	5	1.0	
2	5	1.0	
2	5	3.1	
2	6	10.6	6.4
2	6	1.0	
2	6	6.5	
2	6	7.5	
2	7	11.5	9.35
2	7	13.6	
2	7	1.0	
2	7	11.3	
2	8	16.4	12.05
2	8	2.7	
2	8	13.8	
2	8	15.3	
2	9	20.0	16.525
2	9	20.7	
2	9	17.6	
2	9	7.8	

Table 8: Thermogradient Plate Data Temperature 16.9° C

ISOLATE	DAY	GROWTH (mm)	MEAN
1	1	0.0	0.25

ISOLATE	DAY	GROWTH (mm)	MEAN
1	1	0.0	
1	1	0.0	
1	1	1.0	
1	2	0.0	0.25
1	2	1.0	
1	2	0.0	
1	2	0.0	
1	3	0.0	0.5
1	3	1.0	
1	3	1.0	
1	3	0.0	
1	4	1.0	2.25
1	4	7.0	
1	4	1.0	
1	4	0.0	
1	5	10.0	9.175
1	5	15.0	
1	5	0.0	
1	5	11.7	
1	6	22.6	13.75
1	6	1.0	
1	6	15.5	
1	6	15.9	
1	7	19.8	20.425
1	7	32.6	
1	7	6.6	
1	7	22.7	
1	8	30.8	28.45
1	8	12.0	
1	8	41.8	

ISOLATE	DAY	GROWTH (mm)	MEAN
1	8	29.2	
1	9	40.0	36.975
1	9	52.9	
1	9	18.1	
1	9	36.9	
2	1	0.0	0
2	1	0.0	
2	1	0.0	
2	1	0.0	
2	2	0.0	0
2	2	0.0	
2	2	0.0	
2	2	0.0	
2	3	0.0	0.5
2	3	1.0	
2	3	0.0	
2	3	1.0	
2	4	1.0	2.975
2	4	1.0	
2	4	4.8	
2	4	5.1	
2	5	8.7	8.55
2	5	7.9	
2	5	8.1	
2	5	9.5	
2	6	13.2	13.775
2	6	13.2	
2	6	14.2	
2	6	14.5	
2	7	19.1	19.375

ISOLATE	DAY	GROWTH (mm)	MEAN
2	7	18.9	
2	7	18.2	
2	7	21.3	
2	8	25.6	25.925
2	8	24.8	
2	8	24.1	
2	8	29.2	
2	9	32.0	32.725
2	9	35.0	
2	9	29.8	
2	9	34.1	

Table 9: Thermogradient Plate Data Temperature 19.4° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	0.0	0.25
1	1	0.0	
1	1	0.0	
1	1	1.0	
1	2	1.0	1.5
1	2	4.0	
1	2	1.0	
1	2	0.0	
1	3	12.1	8.625
1	3	12.0	
1	3	1.0	
1	3	9.4	
1	4	21.5	17.55
1	4	20.0	
1	4	10.8	
1	4	17.9	
1	5	29.0	26.475
1	5	29.2	
1	5	26.8	
1	5	20.9	
1	6	39.9	36.45
1	6	36.1	
1	6	31.8	
1	6	38.0	
1	7	42.4	46.7
1	7	52.0	
1	7	46.2	
1	7	46.2	
1	8	55.0	55.825

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	8	56.7	
1	8	61.2	
1	8	50.4	
1	9	63.1	66.05
1	9	74.1	
1	9	67.6	
1	9	59.4	
2	1	0.0	0
2	1	0.0	
2	1	0.0	
2	1	0.0	
2	2	1.0	1
2	2	1.0	
2	2	1.0	
2	2	1.0	
2	3	5.5	5.1
2	3	1.0	
2	3	6.0	
2	3	7.9	
2	4	14.0	12.9
2	4	10.8	
2	4	15.5	
2	4	11.3	
2	5	16.3	20.55
2	5	22.2	
2	5	20.3	
2	5	23.4	
2	6	26.8	30.325
2	6	28.8	
2	6	32.5	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	6	33.2	
2	7	40.0	38.75
2	7	33.7	
2	7	38.3	
2	7	43.0	
2	8	43.8	49.125
2	8	51.3	
2	8	48.9	
2	8	52.5	
2	9	53.8	61.425
2	9	67.9	
2	9	60.5	
2	9	63.5	

Table 10: Thermogradient Plate Data Temperature 22.0° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	0.0	0.5
1	1	1.0	
1	1	0.0	
1	1	1.0	
1	2	0.0	2.7
1	2	4.3	
1	2	5.5	
1	2	1.0	
1	3	7.7	10.025
1	3	12.3	
1	3	8.8	
1	3	11.3	
1	4	15.2	19.55
1	4	20.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	4	21.0	
1	4	22.0	
1	5	24.2	29.775
1	5	28.8	
1	5	35.6	
1	5	30.5	
1	6	42.4	42.975
1	6	50.1	
1	6	42.8	
1	6	36.6	
1	7	54.6	56.55
1	7	59.4	
1	7	64.6	
1	7	47.6	
1	8	57.5	68.75
1	8	77.8	
1	8	76.0	
1	8	63.7	
1	9	67.1	78.775
1	9	87.0	
1	9	87.0	
1	9	74.0	
2	1	1.0	0.5
2	1	0.0	
2	1	1.0	
2	1	0.0	
2	2	6.1	4.025
2	2	4.0	
2	2	1.0	
2	2	5.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	3	15.4	12.1
2	3	9.4	
2	3	13.0	
2	3	10.6	
2	4	25.0	22.725
2	4	18.3	
2	4	23.3	
2	4	24.3	
2	5	37.6	35.125
2	5	39.3	
2	5	27.1	
2	5	36.5	
2	6	53.5	53.05
2	6	44.3	
2	6	59.1	
2	6	55.3	
2	7	73.5	70.55
2	7	68.9	
2	7	59.5	
2	7	80.3	
2	8	82.9	82.6
2	8	73.5	
2	8	87.0	
2	8	87.0	
2	9	87.0	87
2	9	87.0	
2	9	87.0	
2	9	87.0	

Table 11: Thermogradient Plate Data Temperature 24.0° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	1.0	0.5
1	1	1.0	
1	1	0.0	
1	1	1.0	
1	2	7.4	7.175
1	2	13.7	
1	2	6.6	
1	2	1.0	
1	3	21.2	16.675
1	3	25.0	
1	3	1.0	
1	3	19.5	
1	4	33.2	29.025
1	4	38.0	
1	4	10.2	
1	4	34.7	
1	5	46.1	39.225
1	5	52.5	
1	5	38.3	
1	5	20.0	
1	6	65.6	44.85
1	6	38.3	
1	6	20.0	
1	6	55.5	
1	7	20.0	49.35
1	7	77.4	
1	7	38.3	
1	7	61.7	
1	8	67.6	53.225

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	8	38.3	
1	8	87.0	
1	8	20.0	
1	9	70.8	54.025
1	9	87.0	
1	9	38.3	
1	9	20.0	
2	1	1.0	0.25
2	1	0.0	
2	1	0.0	
2	1	0.0	
2	2	6.1	5.275
2	2	8.8	
2	2	1.0	
2	2	5.2	
2	3	18.6	17.925
2	3	8.9	
2	3	20.2	
2	3	24.0	
2	4	23.0	33.3
2	4	35.2	
2	4	43.5	
2	4	31.5	
2	5	33.7	49
2	5	50.8	
2	5	47.7	
2	5	63.8	
2	6	44.8	67.45
2	6	67.3	
2	6	70.7	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	6	87.0	
2	7	44.8	74.875
2	7	83.5	
2	7	87.0	
2	7	84.2	
2	8	87.0	76.45
2	8	44.8	
2	8	87.0	
2	8	87.0	
2	9	87.0	76.45
2	9	87.0	
2	9	87.0	
2	9	44.8	

Table 12: Thermogradient Plate Data Temperature 26.9° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	0.0	0.5
1	1	1.0	
1	1	0.0	
1	1	1.0	
1	2	1.0	9.7
1	2	18.8	
1	2	10.0	
1	2	9.0	
1	3	22.8	20.925
1	3	27.0	
1	3	23.1	
1	3	10.8	
1	4	40.6	33.75
1	4	46.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	4	23.1	
1	4	25.3	
1	5	49.5	43.675
1	5	60.3	
1	5	41.8	
1	5	23.1	
1	6	70.2	50
1	6	55.0	
1	6	23.1	
1	6	51.7	
1	7	23.1	53.225
1	7	80.2	
1	7	57.9	
1	7	51.7	
1	8	51.7	55.45
1	8	60.0	
1	8	87.0	
1	8	23.1	
1	9	51.7	55.45
1	9	87.0	
1	9	60.0	
1	9	23.1	
2	1	1.0	0.75
2	1	1.0	
2	1	1.0	
2	1	0.0	
2	2	7.8	5.675
2	2	8.8	
2	2	1.0	
2	2	5.1	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	3	27.0	24.075
2	3	20.3	
2	3	25.1	
2	3	23.9	
2	4	46.1	39.075
2	4	32.7	
2	4	34.5	
2	4	43.0	
2	5	59.8	52.35
2	5	61.2	
2	5	42.3	
2	5	46.1	
2	6	80.9	66.925
2	6	42.3	
2	6	76.3	
2	6	68.2	
2	7	87.0	74.075
2	7	87.0	
2	7	42.3	
2	7	80.0	
2	8	87.0	74.075
2	8	42.3	
2	8	87.0	
2	8	80.0	
2	9	87.0	74.075
2	9	80.0	
2	9	87.0	
2	9	42.3	

Table 13: Thermogradient Plate Data Temperature 29.6° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	1.0	1
1	1	1.0	
1	1	1.0	
1	1	1.0	
1	2	8.8	12.075
1	2	18.8	
1	2	10.0	
1	2	10.7	
1	3	26.7	25.175
1	3	27.0	
1	3	26.8	
1	3	20.2	
1	4	36.5	35.625
1	4	46.0	
1	4	31.4	
1	4	28.6	
1	5	45.2	44.45
1	5	60.3	
1	5	36.2	
1	5	36.1	
1	6	70.2	49.65
1	6	43.2	
1	6	36.1	
1	6	49.1	
1	7	36.1	54.025
1	7	80.2	
1	7	50.7	
1	7	49.1	
1	8	49.1	57.275
1	8	56.9	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	8	87.0	
1	8	36.1	
1	9	49.1	58.55
1	9	87.0	
1	9	62.0	
1	9	36.1	
2	1	1.0	1
2	1	1.0	
2	1	1.0	
2	1	1.0	
2	2	9.6	11.05
2	2	13.6	
2	2	8.5	
2	2	12.5	
2	3	31.7	26.275
2	3	28.0	
2	3	30.0	
2	3	15.4	
2	4	47.3	38.25
2	4	47.0	
2	4	36.7	
2	4	22.0	
2	5	66.0	48.7
2	5	63.7	
2	5	22.0	
2	5	43.1	
2	6	65.3	53.275
2	6	22.0	
2	6	43.1	
2	6	82.7	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	7	43.1	56.55
2	7	74.1	
2	7	22.0	
2	7	87.0	
2	8	87.0	59.05
2	8	22.0	
2	8	84.1	
2	8	43.1	
2	9	87.0	59.775
2	9	87.0	
2	9	22.0	
2	9	43.1	

Table 14: Thermogradient Plate Data Temperature 32.7° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	1.0	3.075
1	1	1.0	
1	1	9.3	
1	1	1.0	
1	2	11.8	11.775
1	2	8.6	
1	2	8.4	
1	2	18.3	
1	3	25.9	21.4
1	3	18.0	
1	3	18.3	
1	3	23.4	
1	4	37.1	30.075

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	4	27.0	
1	4	18.3	
1	4	37.9	
1	5	37.1	34.475
1	5	36.2	
1	5	46.3	
1	5	18.3	
1	6	43.3	37.275
1	6	46.3	
1	6	18.3	
1	6	41.2	
1	7	18.3	39.85
1	7	48.4	
1	7	46.3	
1	7	46.4	
1	8	50.0	41.575
1	8	46.3	
1	8	51.7	
1	8	18.3	
1	9	61.0	45.725
1	9	57.3	
1	9	46.3	
1	9	18.3	
2	1	1.0	1
2	1	1.0	
2	1	1.0	
2	1	1.0	
2	2	17.3	13.125
2	2	13.3	
2	2	10.0	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	2	11.9	
2	3	37.0	27.25
2	3	24.4	
2	3	18.9	
2	3	28.7	
2	4	27.9	38.7
2	4	30.8	
2	4	43.9	
2	4	52.2	
2	5	65.1	49.15
2	5	36.3	
2	5	36.1	
2	5	59.1	
2	6	74.1	54.375
2	6	36.1	
2	6	36.3	
2	6	71.0	
2	7	83.5	58.8
2	7	77.8	
2	7	36.1	
2	7	37.8	
2	8	82.0	59.85
2	8	36.1	
2	8	83.5	
2	8	37.8	
2	9	87.0	61.1
2	9	37.8	
2	9	83.5	
2	9	36.1	

Table 15: Thermogradient Plate Data Temperature 35.8° C

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	1	1.0	0.75
1	1	1.0	
1	1	0.0	
1	1	1.0	
1	2	20.5	7.025
1	2	5.6	
1	2	1.0	
1	2	1.0	
1	3	29.3	9.325
1	3	6.0	
1	3	1.0	
1	3	1.0	
1	4	38.0	11.575
1	4	6.3	
1	4	1.0	
1	4	1.0	
1	5	38.0	11.65
1	5	6.6	
1	5	1.0	
1	5	1.0	
1	6	9.3	16.225
1	6	5.0	
1	6	6.1	
1	6	44.5	
1	7	6.1	16.825
1	7	9.3	
1	7	7.4	
1	7	44.5	
1	8	44.5	16.825
1	8	7.4	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
1	8	9.3	
1	8	6.1	
1	9	44.5	16.825
1	9	9.3	
1	9	7.4	
1	9	6.1	
2	1	0.0	0.5
2	1	1.0	
2	1	1.0	
2	1	0.0	
2	2	7.5	4.5
2	2	5.5	
2	2	1.0	
2	2	4.0	
2	3	21.3	10.85
2	3	5.5	
2	3	8.0	
2	3	8.6	
2	4	10.0	15.375
2	4	5.5	
2	4	10.3	
2	4	35.7	
2	5	46.2	19.325
2	5	13.1	
2	5	5.5	
2	5	12.5	
2	6	56.7	22.225
2	6	5.5	
2	6	14.2	
2	6	12.5	

ISOLATE	DAY	GROWTH (mm)	MEAN (N=4)
2	7	12.5	24.2
2	7	64.6	
2	7	5.5	
2	7	14.2	
2	8	73.6	26.45
2	8	5.5	
2	8	12.5	
2	8	14.2	
2	9	73.6	26.45
2	9	14.2	
2	9	12.5	
2	9	5.5	

APPENDIX B

HOST RANGE STATISTICAL DATA

TABLE: 16 *Achillea millefolium*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	11	1	12
	45.83	4.17	50.00
	91.67	8.33	
	55.00	25.00	
sr	9	3	12
	37.50	12.50	50.00
	75.00	25.00	
	45.00	75.00	
Total	20	4	24
	83.33	16.67	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	1.200	0.273
Likelihood Ratio Chi-Square	1	1.247	0.264
Continuity Adj. Chi-Square	1	0.300	0.584
Mantel-Haenszel Chi-Square	1	1.150	0.284
Fisher's Exact Test (Left)			0.953
(Right)			0.295
(2-Tail)			0.590
Phi Coefficient		0.224	
Contingency Coefficient		0.218	
Cramer's V		0.224	

Sample Size = 24
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 17: *Antirrhinum majus*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	7	1	8
	43.75	6.25	50.00
	87.50	12.50	
	63.64	20.00	
sr	4	4	8
	25.00	25.00	50.00
	50.00	50.00	
	36.36	80.00	
Total	11	5	16
	68.75	31.25	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	2.618	0.106
Likelihood Ratio Chi-Square	1	2.756	0.097
Continuity Adj. Chi-Square	1	1.164	0.281
Mantel-Haenszel Chi-Square	1	2.455	0.117
Fisher's Exact Test (Left)			0.987
(Right)			0.141
(2-Tail)			0.282
Phi Coefficient		0.405	
Contingency Coefficient		0.375	
Cramer's V		0.405	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 18: *Aquilegia coerulea*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	11 45.83 91.67 50.00	1 4.17 8.33 50.00	12 50.00
sr	11 45.83 91.67 50.00	1 4.17 8.33 50.00	12 50.00
Total	22 91.67	2 8.33	24 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.000	1.000
Likelihood Ratio Chi-Square	1	0.000	1.000
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.000	1.000
Fisher's Exact Test (Left)			0.761
(Right)			0.761
(2-Tail)			1.000
Phi Coefficient		0.000	
Contingency Coefficient		0.000	
Cramer's V		0.000	

Sample Size = 24
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 19: *Aster spp*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	4 50.00 100.00 57.14	0 0.00 0.00 0.00	4 50.00
sr	3 37.50 75.00 42.86	1 12.50 25.00 100.00	4 50.00
Total	7 87.50	1 12.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	1.143	0.285
Likelihood Ratio Chi-Square	1	1.530	0.216
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	1.000	0.317
Fisher's Exact Test (Left)			1.000
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.378	
Contingency Coefficient		0.354	
Cramer's V		0.378	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 20: *Aubretia deltondea*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	7	1	8
	43.75	6.25	50.00
	87.50	12.50	
	50.00	50.00	
sr	7	1	8
	43.75	6.25	50.00
	87.50	12.50	
	50.00	50.00	
Total	14	2	16
	87.50	12.50	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.000	1.000
Likelihood Ratio Chi-Square	1	0.000	1.000
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.000	1.000
Fisher's Exact Test (Left)			0.767
(Right)			0.767
(2-Tail)			1.000
Phi Coefficient		0.000	
Contingency Coefficient		0.000	
Cramer's V		0.000	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 21: *Calendula officinalis*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	8 50.00 100.00 53.33	0 0.00 0.00 0.00	8 50.00
sr	7 43.75 87.50 46.67	1 6.25 12.50 100.00	8 50.00
Total	15 93.75	1 6.25	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	1.067	0.302
Likelihood Ratio Chi-Square	1	1.453	0.228
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	1.000	0.317
Fisher's Exact Test (Left)			1.000
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.258	
Contingency Coefficient		0.250	
Cramer's V		0.258	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 22: *Campanula medium*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	8 50.00 100.00 80.00	0 0.00 0.00 0.00	8 50.00
sr	2 12.50 25.00 20.00	6 37.50 75.00 100.00	8 50.00
Total	10 62.50	6 37.50	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic		DF	Value	Prob
Chi-Square		1	9.600	0.002
Likelihood Ratio Chi-Square		1	12.173	0.000
Continuity Adj. Chi-Square		1	6.667	0.010
Mantel-Haenszel Chi-Square		1	9.000	0.003
Fisher's Exact Test	(Left)			1.000
	(Right)			3.50E-03
	(2-Tail)			6.99E-03
Phi Coefficient			0.775	
Contingency Coefficient			0.612	
Cramer's V			0.775	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 23: *Cheiranthus linifolius*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	1 12.50 25.00 100.00	3 37.50 75.00 42.86	4 50.00
sr	0 0.00 0.00 0.00	4 50.00 100.00 57.14	4 50.00
Total	1 12.50	7 87.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	1.143	0.285
Likelihood Ratio Chi-Square	1	1.530	0.216
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	1.000	0.317
Fisher's Exact Test (Left)			1.000
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.378	
Contingency Coefficient		0.354	
Cramer's V		0.378	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 24: *Chrysanthemum coccineum*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	4	4	8
	25.00	25.00	50.00
	50.00	50.00	
	80.00	36.36	
sr	1	7	8
	6.25	43.75	50.00
	12.50	87.50	
	20.00	63.64	
Total	5	11	16
	31.25	68.75	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	2.618	0.106
Likelihood Ratio Chi-Square	1	2.756	0.097
Continuity Adj. Chi-Square	1	1.164	0.281
Mantel-Haenszel Chi-Square	1	2.455	0.117
Fisher's Exact Test (Left)			0.987
(Right)			0.141
(2-Tail)			0.282
Phi Coefficient		0.405	
Contingency Coefficient		0.375	
Cramer's V		0.405	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 25: *Clarkia unguiculata*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	7 43.75 87.50 70.00	1 6.25 12.50 16.67	8 50.00
sr	3 18.75 37.50 30.00	5 31.25 62.50 83.33	8 50.00
Total	10 62.50	6 37.50	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	4.267	0.039
Likelihood Ratio Chi-Square	1	4.557	0.033
Continuity Adj. Chi-Square	1	2.400	0.121
Mantel-Haenszel Chi-Square	1	4.000	0.046
Fisher's Exact Test (Left)			0.997
(Right)			5.94E-02
(2-Tail)			0.119
Phi Coefficient		0.516	
Contingency Coefficient		0.459	
Cramer's V		0.516	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 26: *Consolida orientalis*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	8 50.00 100.00 57.14	0 0.00 0.00 0.00	8 50.00
sr	6 37.50 75.00 42.86	2 12.50 25.00 100.00	8 50.00
Total	14 87.50	2 12.50	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	2.286	0.131
Likelihood Ratio Chi-Square	1	3.059	0.080
Continuity Adj. Chi-Square	1	0.571	0.450
Mantel-Haenszel Chi-Square	1	2.143	0.143
Fisher's Exact Test (Left)			1.000
(Right)			0.233
(2-Tail)			0.467
Phi Coefficient		0.378	
Contingency Coefficient		0.354	
Cramer's V		0.378	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 27: *Delphinium elatum*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	10 41.67 83.33 71.43	2 8.33 16.67 20.00	12 50.00
sr	4 16.67 33.33 28.57	8 33.33 66.67 80.00	12 50.00
Total	14 58.33	10 41.67	24 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	6.171	0.013
Likelihood Ratio Chi-Square	1	6.511	0.011
Continuity Adj. Chi-Square	1	4.286	0.038
Mantel-Haenszel Chi-Square	1	5.914	0.015
Fisher's Exact Test (Left)			0.999
(Right)			1.80E-02
(2-Tail)			3.61E-02
Phi Coefficient		0.507	
Contingency Coefficient		0.452	
Cramer's V		0.507	

Sample Size = 24

Table 28: *Dianthus deltoides*

FUNGI	RESULT	
Frequency Percent Row Pct Col Pct	ok	Total
sd	4 50.00 100.00 50.00	4 50.00
sr	4 50.00 100.00 50.00	4 50.00
Total	8 100.00	8 100.00

Table 29: *Digitalis purpurea*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	4 50.00 100.00 66.67	0 0.00 0.00 0.00	4 50.00
sr	2 25.00 50.00 33.33	2 25.00 50.00 100.00	4 50.00
Total	6 75.00	2 25.00	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	2.667	0.102
Likelihood Ratio Chi-Square	1	3.452	0.063
Continuity Adj. Chi-Square	1	0.667	0.414
Mantel-Haenszel Chi-Square	1	2.333	0.127
Fisher's Exact Test (Left)			1.000
(Right)			0.214
(2-Tail)			0.429
Phi Coefficient		0.577	
Contingency Coefficient		0.500	
Cramer's V		0.577	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 30: *Echinacea purpurea*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	7 43.75 87.50 58.33	1 6.25 12.50 25.00	8 50.00
sr	5 31.25 62.50 41.67	3 18.75 37.50 75.00	8 50.00
Total	12 75.00	4 25.00	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	1.333	0.248
Likelihood Ratio Chi-Square	1	1.381	0.240
Continuity Adj. Chi-Square	1	0.333	0.564
Mantel-Haenszel Chi-Square	1	1.250	0.264
Fisher's Exact Test (Left)			0.962
(Right)			0.285
(2-Tail)			0.569
Phi Coefficient		0.289	
Contingency Coefficient		0.277	
Cramer's V		0.289	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 31: *Erigeron speciosus*

FUNGI	RESULT	
Frequency Percent Row Pct Col Pct	infct	Total
sd	12 50.00 100.00 50.00	12 50.00
sr	12 50.00 100.00 50.00	12 50.00
Total	24 100.00	24 100.00

Table 32: *Gaillardia aristata*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	9 37.50 75.00 56.25	3 12.50 25.00 37.50	12 50.00
sr	7 29.17 58.33 43.75	5 20.83 41.67 62.50	12 50.00
Total	16 66.67	8 33.33	24 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.750	0.386
Likelihood Ratio Chi-Square	1	0.756	0.385
Continuity Adj. Chi-Square	1	0.188	0.665
Mantel-Haenszel Chi-Square	1	0.719	0.397
Fisher's Exact Test (Left)			0.903
(Right)			0.333
(2-Tail)			0.667
Phi Coefficient		0.177	
Contingency Coefficient		0.174	
Cramer's V		0.177	

Sample Size = 24
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 33: *Geranium viscosissimum*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	5 20.83 41.67 83.33	7 29.17 58.33 38.89	12 50.00
sr	1 4.17 8.33 16.67	11 45.83 91.67 61.11	12 50.00
Total	6 25.00	18 75.00	24 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	3.556	0.059
Likelihood Ratio Chi-Square	1	3.807	0.051
Continuity Adj. Chi-Square	1	2.000	0.157
Mantel-Haenszel Chi-Square	1	3.407	0.065
Fisher's Exact Test (Left)			0.993
(Right)			7.75E-02
(2-Tail)			0.155
Phi Coefficient		0.385	
Contingency Coefficient		0.359	
Cramer's V		0.385	

Sample Size = 24
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 34: *Gilia aggregata*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	4 50.00 100.00 57.14	0 0.00 0.00 0.00	4 50.00
sr	3 37.50 75.00 42.86	1 12.50 25.00 100.00	4 50.00
Total	7 87.50	1 12.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	1.143	0.285
Likelihood Ratio Chi-Square	1	1.530	0.216
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	1.000	0.317
Fisher's Exact Test (Left)			1.000
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.378	
Contingency Coefficient		0.354	
Cramer's V		0.378	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 35: *Gypsophila paniculata*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	5 31.25 62.50 100.00	3 18.75 37.50 27.27	8 50.00
sr	0 0.00 0.00 0.00	8 50.00 100.00 72.73	8 50.00
Total	5 31.25	11 68.75	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	7.273	0.007
Likelihood Ratio Chi-Square	1	9.290	0.002
Continuity Adj. Chi-Square	1	4.655	0.031
Mantel-Haenszel Chi-Square	1	6.818	0.009
Fisher's Exact Test (Left)			1.000
(Right)			1.28E-02
(2-Tail)			2.56E-02
Phi Coefficient		0.674	
Contingency Coefficient		0.559	
Cramer's V		0.674	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 36: *Hesperis matronalis*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	3 37.50 75.00 60.00	1 12.50 25.00 33.33	4 50.00
sr	2 25.00 50.00 40.00	2 25.00 50.00 66.67	4 50.00
Total	5 62.50	3 37.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.533	0.465
Likelihood Ratio Chi-Square	1	0.541	0.462
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.467	0.495
Fisher's Exact Test (Left)			0.929
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.258	
Contingency Coefficient		0.250	
Cramer's V		0.258	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 37: *Linum perenne*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	10 41.67 83.33 62.50	2 8.33 16.67 25.00	12 50.00
sr	6 25.00 50.00 37.50	6 25.00 50.00 75.00	12 50.00
Total	16 66.67	8 33.33	24 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	3.000	0.083
Likelihood Ratio Chi-Square	1	3.104	0.078
Continuity Adj. Chi-Square	1	1.687	0.194
Mantel-Haenszel Chi-Square	1	2.875	0.090
Fisher's Exact Test (Left)			0.986
(Right)			9.65E-02
(2-Tail)			0.193
Phi Coefficient		0.354	
Contingency Coefficient		0.333	
Cramer's V		0.354	

Sample Size = 24
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 38: *Liatris spicata*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	7 43.75 87.50 53.85	1 6.25 12.50 33.33	8 50.00
sr	6 37.50 75.00 46.15	2 12.50 25.00 66.67	8 50.00
Total	13 81.25	3 18.75	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.410	0.522
Likelihood Ratio Chi-Square	1	0.417	0.519
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.385	0.535
Fisher's Exact Test (Left)			0.900
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.160	
Contingency Coefficient		0.158	
Cramer's V		0.160	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 39: *Lobularia maritima*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	7	1	8
	43.75	6.25	50.00
	87.50	12.50	
	50.00	50.00	
sr	7	1	8
	43.75	6.25	50.00
	87.50	12.50	
	50.00	50.00	
Total	14	2	16
	87.50	12.50	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.000	1.000
Likelihood Ratio Chi-Square	1	0.000	1.000
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.000	1.000
Fisher's Exact Test (Left)			0.767
(Right)			0.767
(2-Tail)			1.000
Phi Coefficient		0.000	
Contingency Coefficient		0.000	
Cramer's V		0.000	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 40: *Lupinus perennis*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	6 37.50 75.00 46.15	2 12.50 25.00 66.67	8 50.00
sr	7 43.75 87.50 53.85	1 6.25 12.50 33.33	8 50.00
Total	13 81.25	3 18.75	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.410	0.522
Likelihood Ratio Chi-Square	1	0.417	0.519
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.385	0.535
Fisher's Exact Test (Left)			0.500
(Right)			0.900
(2-Tail)			1.000
Phi Coefficient		-0.160	
Contingency Coefficient		0.158	
Cramer's V		-0.160	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 41: *Lychnis coronaria*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	2 25.00 50.00 40.00	2 25.00 50.00 66.67	4 50.00
sr	3 37.50 75.00 60.00	1 12.50 25.00 33.33	4 50.00
Total	5 62.50	3 37.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.533	0.465
Likelihood Ratio Chi-Square	1	0.541	0.462
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.467	0.495
Fisher's Exact Test (Left)			0.500
(Right)			0.929
(2-Tail)			1.000
Phi Coefficient		-0.258	
Contingency Coefficient		0.250	
Cramer's V		-0.258	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 42: *Myosotis sylvatica*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	7 43.75 87.50 53.85	1 6.25 12.50 33.33	8 50.00
sr	6 37.50 75.00 46.15	2 12.50 25.00 66.67	8 50.00
Total	13 81.25	3 18.75	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.410	0.522
Likelihood Ratio Chi-Square	1	0.417	0.519
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.385	0.535
Fisher's Exact Test (Left)			0.900
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.160	
Contingency Coefficient		0.158	
Cramer's V		0.160	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 43: *Oenothera biennis*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	3 37.50 75.00 100.00	1 12.50 25.00 20.00	4 50.00
sr	0 0.00 0.00 0.00	4 50.00 100.00 80.00	4 50.00
Total	3 37.50	5 62.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	4.800	0.028
Likelihood Ratio Chi-Square	1	6.086	0.014
Continuity Adj. Chi-Square	1	2.133	0.144
Mantel-Haenszel Chi-Square	1	4.200	0.040
Fisher's Exact Test (Left)			1.000
(Right)			7.14E-02
(2-Tail)			0.143
Phi Coefficient		0.775	
Contingency Coefficient		0.612	
Cramer's V		0.775	

Sample Size = 8

WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 44: *Papaver nudicaule*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	3 37.50 75.00 60.00	1 12.50 25.00 33.33	4 50.00
sr	2 25.00 50.00 40.00	2 25.00 50.00 66.67	4 50.00
Total	5 62.50	3 37.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.533	0.465
Likelihood Ratio Chi-Square	1	0.541	0.462
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.467	0.495
Fisher's Exact Test (Left)			0.929
(Right)			0.500
(2-Tail)			1.000
Phi Coefficient		0.258	
Contingency Coefficient		0.250	
Cramer's V		0.258	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 45: *Papaver rhoeas*

FUNGI	RESULT	
Frequency Percent Row Pct Col Pct	infct	Total
sd	8 50.00 100.00 50.00	8 50.00
sr	8 50.00 100.00 50.00	8 50.00
Total	16 100.00	16 100.00

Table 46: *Penstemon strictus*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	2 25.00 50.00 40.00	2 25.00 50.00 66.67	4 50.00
sr	3 37.50 75.00 60.00	1 12.50 25.00 33.33	4 50.00
Total	5 62.50	3 37.50	8 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.533	0.465
Likelihood Ratio Chi-Square	1	0.541	0.462
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.467	0.495
Fisher's Exact Test (Left)			0.500
(Right)			0.929
(2-Tail)			1.000
Phi Coefficient		-0.258	
Contingency Coefficient		0.250	
Cramer's V		-0.258	

Sample Size = 8
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 47: *Rudbeckia hirta*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	4	4	8
	25.00	25.00	50.00
	50.00	50.00	
	40.00	66.67	
sr	6	2	8
	37.50	12.50	50.00
	75.00	25.00	
	60.00	33.33	
Total	10	6	16
	62.50	37.50	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	1.067	0.302
Likelihood Ratio Chi-Square	1	1.082	0.298
Continuity Adj. Chi-Square	1	0.267	0.606
Mantel-Haenszel Chi-Square	1	1.000	0.317
Fisher's Exact Test (Left)			0.304
(Right)			0.941
(2-Tail)			0.608
Phi Coefficient		-0.258	
Contingency Coefficient		0.250	
Cramer's V		-0.258	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 48: *Salvia farinacea*

FUNGI RESULT

Frequency Percent Row Pct Col Pct	infct	ok	Total
sd	0 0.00 0.00 0.00	8 50.00 100.00 72.73	8 50.00
sr	5 31.25 62.50 100.00	3 18.75 37.50 27.27	8 50.00
Total	5 31.25	11 68.75	16 100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	7.273	0.007
Likelihood Ratio Chi-Square	1	9.290	0.002
Continuity Adj. Chi-Square	1	4.655	0.031
Mantel-Haenszel Chi-Square	1	6.818	0.009
Fisher's Exact Test (Left)			1.28E-02
(Right)			1.000
(2-Tail)			2.56E-02
Phi Coefficient		-0.674	
Contingency Coefficient		0.559	
Cramer's V		-0.674	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 49: *Schizanthus pinnatus*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	5	3	8
	31.25	18.75	50.00
	62.50	37.50	
	45.45	60.00	
sr	6	2	8
	37.50	12.50	50.00
	75.00	25.00	
	54.55	40.00	
Total	11	5	16
	68.75	31.25	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	0.291	0.590
Likelihood Ratio Chi-Square	1	0.292	0.589
Continuity Adj. Chi-Square	1	0.000	1.000
Mantel-Haenszel Chi-Square	1	0.273	0.602
Fisher's Exact Test (Left)			0.500
(Right)			0.859
(2-Tail)			1.000
Phi Coefficient		-0.135	
Contingency Coefficient		0.134	
Cramer's V		-0.135	

Sample Size = 16
WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Table 50: *Tagetes patula*

FUNGI RESULT

Frequency / Percent / Row Pct / Col Pct	infct	ok	Total
sd	7	1	8
	43.75	6.25	50.00
	87.50	12.50	
	100.00	11.11	
sr	0	8	8
	0.00	50.00	50.00
	0.00	100.00	
	0.00	88.89	
Total	7	9	16
	43.75	56.25	100.00

STATISTICS FOR TABLE OF FUNGI BY RESULT

Statistic	DF	Value	Prob
Chi-Square	1	12.444	0.000
Likelihood Ratio Chi-Square	1	15.902	0.000
Continuity Adj. Chi-Square	1	9.143	0.002
Mantel-Haenszel Chi-Square	1	11.667	0.001
Fisher's Exact Test (Left)			1.000
(Right)			6.99E-04
(2-Tail)			1.40E-03
Phi Coefficient		0.882	
Contingency Coefficient		0.661	
Cramer's V		0.882	

Sample Size = 16
WARNING: 100% of the cells have expected counts less than 5. Chi-Square may not be a valid test.