Reaction of *Helianthus* Species to *Erysiphe cichoracearum*

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ABSTRACT

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Three annual species or subspecies (*Helianthus bolanderi, H. debilis* subsp. *silvestris, H. praecox* subsp. *praecox*) and 14 perennial species of sunflower (*Helianthus* spp.) were resistant to *Erysiphe cichoracearum*, which causes powdery mildew of sunflower, in field and greenhouse tests. *H. grosse-serratus* and *H. maximiliani* collected from some locations were resistant but from other locations were susceptible to *E. cichoracearum*. The reaction of sunflower species in greenhouse tests was in general agreement with their reaction in field tests, except for *H. annuus, H. hirsutus,* and *H. mollis*, which were resistant to *E. cichoracearum* in the field but susceptible in the greenhouse. These three annual sunflower species were good sources of resistance to *E. cichoracearum*, and this characteristic that may be transferable to cultivated sunflower (*H. annuus*).

Erysiphe cichoracearum DC. (2) is a widely distributed pathogen of cultivated annual sunflower (*Helianthus annuus* L.). Infection of sunflower by *E. cichoracearum* causes early senescence during the flowering stage (3) and up to 15% stunting and 81% reduction in yield in the greenhouse (*unpublished data*). Powdery mildew may also cause economically significant reduction in sunflower production in tropical areas (3) and in southern Texas (Lucas Reyes, *personal communication*). Although cultivars of sunflower are known to differ in their reaction to the powdery mildew fungus (3), resistance of *Helianthus* spp. to *E. cichoracearum* has not been studied. This paper reports the reaction of several *Helianthus* spp. (see tables for botanical names) to infection by *E. cichoracearum*.

MATERIALS AND METHODS

The culture of *E. cichoracearum* used for artificial inoculations in this study was obtained from naturally infected plants in a sunflower nursery at Bushland, TX. The pathogen was maintained on plants of the susceptible hybrid sunflower cultivar 894. To provide a constant source of fresh conidia for inoculum, we replanted the hybrid at intervals so that ten 2-wk-old plants could be inoculated at 2-wk intervals throughout the course of the study. Plants used to maintain the pathogen and provide inoculum were grown in field soil in 15-cm pots. These plants were randomly placed among the test plants in greenhouse experiments.

The resistance of *Helianthus* spp. to *E. cichoracearum* was determined in both field and greenhouse experiments at Bushland. For the field tests, five to 10 plants of each species and subspecies were grown in one or two rows 10 m long. Perennial plants that showed no signs of natural infection by *E. cichoracearum* in 1978 were artificially inoculated in 1979. The plants were inoculated by dusting freshly formed conidia of *E. cichoracearum* onto leaves at approximately 0800 hr on five consecutive days beginning 3 September 1979.

For the greenhouse tests, five to 10 plants of each species and subspecies were grown in field soil in 25-cm pots (one plant per pot). These were placed at random on the greenhouse floor where the temperature and relative humidity varied from 15 to 30 C and 30 to 70%, respectively. Plants were sprayed with tap water before inoculation when the relative humidity was low (<30%) in the greenhouse. All plants in the greenhouse tests were inoculated at or after the three- to five-leaf stage by dusting freshly formed conidia onto the leaves of plants three to four times during a period of 2 wk.

Disease severity was recorded 6–8 wk after the last inoculation that was made in the greenhouse and between 28 September and 31 October in the field. The following numeric disease severity rating system was used to record the severity of infection: 0 = no infection, 1 = a few colonies of *E. cichoracearum* (less than 10% of leaf area) on the inoculated leaves or on the bottom leaves, 2 = colonies covering 11–50% of the leaf area (on inoculated and uninoculated leaves), and 3 = colonies covering more than 50% of the leaf area (on inoculated and uninoculated leaves) as well as on stems. The disease index for a *Helianthus* sp. was determined by averaging the disease severity ratings given for individual plants for each species. Species with a disease index of 0–1.0 were considered resistant; 1.1–2.0, moderately resistant; and 2.1–3, susceptible to *E. cichoracearum*.

RESULTS AND DISCUSSION

The reactions of *Helianthus* spp. to *E. cichoracearum* in field and greenhouse experiments are shown in Tables 1–3. The responses of *Helianthus* spp. to *E.*

Table 1. Reaction of *Helianthus* spp. to natural infection by *Erysiphe cichoracearum* in the field at Bushland, TX, in 1978 and 1979

Helianthus spp.	Disease index[a]
H. agrestis Pollard	1.5
H. angustifolius L.	2.5
H. arizonensis Jackson	3.0[b]
H. atrorubens L.	1.0
H. californicus DC.	0[c]
H. ciliaris DC.	0[c]
H. debilis Nutt. subsp. *debilis*	1.2
H. decapetalus L.	0[c]
H. giganteus L.	3.0
H. glaucophyllus Smith	3.0
H. laciniatus Gray	0[c]
H. laevigatus Torrey & Gray	0.8[c]
H. microcephalus Torrey & Gray	0.6
H. resinosus Small	1.0
H. rigidus (Cass.) Desf.	0[c]
H. salicifolius Dietr.	3.0
H. schweinitzii	3.0[b]
H. silphioides Nutt.	1.4
H. simulans Wats.	0.6[c]
H. smithii Heiser	0[c]
H. tuberosus	2.2

[a] Combined average data from five to 10 plants rated in 1978 and 1979 to obtain disease indexes: 0–1.0, resistant; 1.1–2.0, moderately resistant; and 2.1–3.0, susceptible to *E. cichoracearum*. Severity ratings were based on 0 = no infection, 1 = a few colonies of the pathogen, 2 = colonies covering 11–50% of the leaf area, and 3 = colonies covering 50% or more of the leaf area as well as stems.

[b] Perithecia developed on leaves.

[c] In addition to natural infections, plants were artificially inoculated with conidia of *E. cichoracearum* in 1979.

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Table 2. Reactions of *Helianthus* spp. to artificial inoculation with *Erysiphe cichoracearum* in the greenhouse at Bushland, TX, in 1979 and 1980

Helianthus spp.	Disease index[a]
H. argophyllus Torrey & Gray	1.6
H. bolanderi Gray	1.0
H. carnosus Small	2.0
H. cusickii Gray	3.0
H. debilis Nutt. subsp. *cucumerifolius* (Torrey & Gray) Heiser	3.0
H. eggertii Small	2.6
H. exilis Gray	3.0
H. gracilentus Gray	3.0
H. neglectus Heiser	3.0
H. niveus (Benth.) Brandegee subsp. *canescens* (Gray) Heiser	3.0
H. niveus (Benth.) Brandegee subsp. *niveus*	2.4
H. niveus (Benth.) Brandegee subsp. *tephrodes* (Gray) Heiser	3.0
H. nuttallii Torrey & Gray subsp. *nuttallii*	3.0
H. paradoxus Heiser	3.0
H. praecox Engelm. & Gray subsp. *hirtus* Heiser	3.0
H. praecox subsp. *praecox*	1.0
H. pumilus Nutt.	3.0
H. radula (Pursh) Torrey & Gray	2.0
H. rigidus (Cass.) Desf. subsp. *subrhomboideus* (Rydb.) Heiser	2.0

[a] Combined average data from five to 10 plants rated in 1979 and 1980, except for *H. praecox* subsp. *praecox* (37 plants), to obtain disease indexes: 0–1.0, resistant; 1.1–2.0, moderately resistant; and 2.1–3.0, susceptible to *E. cichoracearum*. Severity ratings were based on 0 = no infection, 1 = a few colonies of the pathogen, 2 = colonies covering 11–50% of the leaf area, and 3 = colonies covering 50% or more of the leaf area as well as stems.

Table 3. Reactions of *Helianthus* spp. to natural infection by *Erysiphe cichoracearum* in the field and artificial inoculation in the greenhouse at Bushland, TX, in 1979 and 1980

	Disease index[a]	
Helianthus spp.	Field	Greenhouse
H. annuus L.	0.8	3.0
H. debilis Nutt. subsp. *silvestris* Heiser	1.0	1.0
H. divaricatus L.	1.0	0.8
H. grosse-serratus	3.0	3.0
H. hirsutus Raf.	0[b]	3.0
Helianthus × *laetiflorus* Pers.	3.0	3.0
H. mollis Lam.	1.0	3.0
H. nuttallii subsp. *nuttallii*	3.0	3.0
H. occidentalis Riddell subsp. *occidentalis*	3.0	3.0
H. petiolaris Nutt. subsp. *fallax* Heiser	3.0	3.0
H. petiolaris Nutt. subsp. *petiolaris*	3.0	3.0
H. praecox subsp. *runyonii* Heiser	3.0	3.0
H. strumosus	0[b]	0

[a] Combined average data from five to 10 plants rated in 1979 and 1980, except for *H. praecox* subsp. *runyonii* (37 plants), to obtain disease indexes: 0–1.0, resistant; 1.1–2.0, moderately resistant; and 2.1–3.0, susceptible to *E. cichoracearum*. Severity ratings were based on 0 = no infection, 1 = a few colonies of the pathogen, 2 = colonies covering 11–50% of the leaf area, and 3 = colonies covering 50% or more of the leaf area as well as stems.

[b] Artificially inoculated with conidia of *E. cichoracearum* in 1979.

cichoracearum were similar in the field and greenhouse except for *H. annuus, H. hirsutus* Raf., and *H. mollis* Lam., which were resistant in the field but susceptible in the greenhouse. Different stages of growth at the time of inoculation of *H. annuus, H. hirsutus,* and *H. mollis* in field and greenhouse tests may have accounted for the differences in reaction to *E. cichoracearum*. It is known that adult cereal plants in some cultivars respond differently from seedling plants to infection by *E. graminis* DC. (1).

The reaction of *H. grosse-serratus* Martens and *H. maximiliani* Schrader to *E. cichoracearum* (not shown in tables) varied depending upon the location where the species were collected. *H. grosse-serratus* collected at Chase, Cherokee, and Cowley counties, KS; Sheridan County, NE; and Fannin and Montague counties, TX, were resistant to *E. cichoracearum*. Plants collected at Leflore County, MS, and Lamar County, TX, were susceptible. Also, populations of *H. grosse-serratus* from different locations within Greenwood County, KS, reacted differently to *E. cichoracearum*. *H. maximiliani* collected at Clay, Cooke, Lamar, and Wichita counties, TX, were resistant to *E. cichoracearum*, but plants collected at Cowley, Greenwood, and Marion counties, KS, were very susceptible.

The different reactions of these two species collected from different locations might have resulted from the use of different biotypes of *E. cichoracearum* as inoculum or from the incorrect classification of some plant species whose identification was not verified by us. It is also possible that plants of different genotypes of these species may have segregated and become established in localized areas, hence providing a new genetic basis for the different responses to *E. cichoracearum* within a species.

Cultivar PI 27451 [presumably (*H. tuberosus* L. × *H. annuus*) × *H. strumosus* L.] was resistant to *E. cichoracearum* in the greenhouse but was not tested in the field.

Perithecia were found on the infected leaves of *H. arizonensis* Jackson, *H. grosse-serratus* (Bushland accession 666), *H. maximiliani* (Bushland accession 660), *H. nuttallii* Torrey & Gray, subsp. *nuttallii* and *H. schweinitzii* Torrey & Gray; however, they were not found in other *Helianthus* spp. infected with powdery mildew in the field. Perithecia were not found on any infected leaves of plants in greenhouse tests.

Although a test usually had no more than 10 plants (Tables 1 and 2), the reaction of perennial species of *Helianthus* to natural infection by *E. cichoracearum* in the field was the same in 1978 and 1979. Also, artificial inoculations of the *Helianthus* perennials in the field in 1979 did not alter their response to the pathogen. The reaction of 37 plants of *H. praecox* Engelm. & Gray subsp. *praecox* (resistant from two locations) and *H. praecox* Engelm. & Gray subsp. *runyonii* Heiser (susceptible) in the greenhouse to the powdery mildew pathogen has been constant. This suggests that their response to infection by *E. cichoracearum* may be a characteristic of the population.

Because the *Helianthus* resistance to *E. cichoracearum* that was expressed in greenhouse tests and in field tests was in general agreement, a high level of confidence may be placed in results from preliminary greenhouse screening. However, selected *E. cichoracearum*-resistant types should also be tested as adult plants to insure that the resistance to the pathogen is maintained throughout the life of the plant.

The use of greenhouse tests to identify resistance to the powdery mildew pathogen in *Helianthus* spp. and breeding lines will result in a significant savings in time, labor, and field space in future screening research.

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