RUST RESISTANCE IN WILD *HELIANTHUS ANNUUS* AND VARIATION BY GEOGRAPHIC ORIGIN

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Abstract

Wild *Helianthus annuus* L. accessions from the USDA Plant Introduction Station collection were tested for resistance to a virulent bulk of North American and Australian —rust *(Puccinia helianthi*) isolates. —One-hundred-twenty-eight (128) Plant Introductions, collected from seven widely-separated geographic sites, were tested in greenhouse trials. —Accessions from southern Texas had the highest percentage of rust resistant plants (38%), while accessions from the Pacific Northwest had the least resistant plants (0.2%). —Overall, 13% of the plants were resistant to the North American rust bulk. ——Accessions having >50% rust resistant plants were found only in collections from Kansas and Texas. ——Future germplasm explorations seeking rust resistance from *H. annuus* would be most profitable in the southern tip of Texas along the Rio Grande River and the Gulf coast.

Introduction

Since both sunflower and most sunflower diseases have coevolved in North America, it is common to find sources of disease resistance in wild *Helianthus* species. Rust, caused by *Puccinia helianthi*, is one of the few diseases commonly observed on wild sunflower (2), and is widespread on annual *Helianthus* species in the Midwest (5). On cultivated sunflower, rust is more of an economic problem on confection sunflowers, but occasionally even oilseed hybrids are severely infected (1). Since breeding for rust resistance has not been a high priority, a large percentage of U.S. commercial hybrids do not have resistance to current rust races. Sources of multi-race rust resistance have been released by the USDA (lines HAR-1 to HAR-7), with the source of resistance either originating from Argentine, Yugoslavian or Native American sunflowers. The USDA lines PH1 to PH5, derived from wild *H. annuus*, were selected for resistance to four North American races (3), but no germplasm has been developed by the USDA with resistance to a wide range of domestic and international rust races (4). The USDA collection of wild *Helianthus* germplasm has not been extensively evaluated for rust resistance, primarily because so few accessions were available due to low seed numbers. Due to recent seed regenerations, however, there are currently over 400 accessions of wild *H. annuus* accessions available. The objectives of this study was to (1) to compare the frequency of rust resistance by site of seed collection to determine if certain regions of the U.S. were more likely than others to yield rust resistance, and (2) in the process, evaluate a portion of the USDA PI wild *H. annuus* germplasm collection for rust resistance.

Materials and Methods

Seed of *Helianthus annuus* accessions was obtained from the USDA Plant Introduction Station, Ames, IA, based on availability and geographic origin. The study was designed to investigate seven geographic regions: Texas (TX), Arizona (AZ), California (CA), Kansas (KS), North Dakota (ND), the Pacific Northwest(PNW=Washington, Oregon, Idaho) and Illinois (IL). Twenty accessions were available for all locations except IL, for which only eight accessions were available. Seeds were surface sterilized, placed in wet, rolled germinator paper for two weeks to break dormancy, and then planted into 5" plastic pots containing a mixture of sandy loam and commercial potting soil. Seedlings were grown for approximately three weeks until the plants were at the V-3 growth stage.

Rust inoculations were made with two different bulk mixtures. One rust mixture was made up of two North American races which produced a virulence phenotype of '777,' which means that all nine of the rust differentials are susceptible. The second rust mixture was a blend of equal volumes of the predominant virulent races from Australia, termed the Advance and the Armitage races. This mixture produces the virulence phenotype of 337 when inoculated onto the standard USDA set of nine rust differentials. The two rust composites were inoculated onto separate leaves of each plant, using a cotton swab and a suspension of rust spores in Soltrol 170. Two weeks after inoculation the plants were scored for infection, using the pustule coverage rating diagrams. Scores of '0' (no pustules or immune) and 0.1% pustule coverage (highly resistant) were combined to calculate the percentage of resistant plants. Plants have > 0.5% pustule coverage were categorized as susceptible.

Results

A total of 128 accessions were screened for rust resistance, with an average of 20 plants for each accession. While each plant was tested with two different rust mixtures. A total of 60 accessions, or 47% of the 128 tested, had no plants resistant to either of the two rust mixtures among the 20 tested (Table 1). Another 25 accessions, or 20%, had between 1-10% of the plants tested displaying rust resistance against either the North American or Australian rust mix.. Thus, over 2/3 of the accessions tested had <10% rust resistant plants and would be unlikely sources of resistance for breeders. At the other extreme, 6 accessions were identified which each had >70% of the plants resistant to both rust mixtures. All six of these accessions were from Texas. The accessions, followed by % resistance and their Texas collection site, were: PI- 468451 (70%, McAllen), PI-468455 (77%, east of Laredo),PI- 435435 (80%, east of Laredo), PI-468519 (83%, Kingsville),PI- 435428 (86%, Corpus Christi) and PI-468457 (86%, Encinal).

Rust resistance varied considerably by region. —*Helianthus annuus* accessions collected from Texas had the highest overall percentage of resistant plants (38%), with Kansas accessions having the second highest percentage of resistant plants (Table 2). –Texas and Kansas were the only two regions which had accessions with >50% resistant plants. —In contrast, plants from the Pacific Northwest had virtually no rust resistance –(only 0.2% of 387 plants tested were resistant). Overall, 12.6% of the 2583 plants tested were resistant to the North American rust bulk, and 14.9% were resistant to the Australian bulk, and 11.9% were resistant to both race mixtures. The correlation between resistance to the North American rust bulk and resistance to the Australian bulk was 0.96, which suggests that screening against one rust bulk would likely identify sources with resistance to both rust bulks. ——While the vast majority of resistant plants were resistant to both races, 20 plants (of 2583 tested) were observed which were only resistant to the North American bulk and 78 plants were only resistant to the Australian bulk.

Discussion

This study suggests that, among the seven geographic collection sites studied, Texas is the region most likely to yield rust resistant populations, and individual populations would have the highest proportion of rust resistant plants. —Since the climate in the southern Rio Grande valley and along the Gulf coast is subtropical, both the rust fungus and wild sunflowers can grow year-round without any interruption due to a killing frost. —Such a scenario would produce multiple generations of rust per year, and over the eons would have fostered the greatest amount of natural selection in which rust resistance could develop. —Additionally, populations of wild *H. annuus* and other *Helianthus* spp. are abundant in this area. ——In contrast, the other geographic regions yielded fewer populations with rust resistance, presumably because the climate is more limiting for multiple generations of rust, and also due to the lesser abundance of wild annual sunflowers.

This study suggests that southern Texas would be the most profitable area in which to find rust resistant plants. —Whether the genes for rust resistance in wild *H. annuus* from Texas would be identical or different from resistant plants collected from other regions is yet to be determined. These same 128 accessions will also be tested with a virulent mixture of downy mildew (*Plasmopara halstedii*) races to determine the geographic frequency of mildew resistance. Individual plants resistant to both rust and downy mildew will be crossed onto released USDA lines with the aim of eventual release of mid-oleic oilseed and confection germplasm with resistance to both downy mildew and rust.

Literature Cited

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Table 1. Number of wild *Helianthus annuus* accessions with varying percentages of resistance to a bulk of North American sunflower rust (*Puccinia helianthi*) races, grouped by site of seed collection.

% Rust Resistant Plants	**AZ***	**CA**	**KS**	**ND**	**PNW**	**TX**	**IL**
0%	9	9	3	12	18	3	6
1-10	6	6	3	4	1	3	2
11-20	2	3	7	3	0	3	0
21-30	1	1	2	1	0	1	0
31-40	2	1	1	0	0	2	0
41-50	0	0	1	0	0	2	0
51-60	0	0	1	0	0	0	0
61-70	0	0	1	0	0	1	0
71-80	0	0	0	0	0	3	0
81-90	0	0	0	0	0	3	0

* AZ= Arizona, CA= California, KS= Kansas, ND= North Dakota, PNW= Pacific Northwest (Washington, Oregon and Idaho), and IL= Illinois.

Table 2. Summary statistics for rust resistance screening of 128 wild *Helianthus annuus* accessions using a bulk of virulent North American races.

	AZ	**CA**	**KS**	**ND**	**PNW**	**TX**	**IL**	**Overall**
Mean % resistant plants/ accession	8.5	6.8	20.2	4.4	0.2	38	1.6	12.6
Min.% resistant plants/acc	0	0	0	0	0	0	0	0
Max.% resistant plants/acc	40	32	65	25	5	86	10	86
Total # plants tested	376	419	371	400	387	435	195	2,583
# accessions tested	20	20	20	20	19	21	8	128