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EVALUATION OF CULTIVATED SUNFLOWER GERMPLASM FOR RESISTANCE TO SUNFLOWER MOTH, *Homoeosoma electellum* (Lepidoptera: Pyralidae)

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SUMMARY

The sunflower moth, *Homoeosoma electellum* (Hulst), is a major pest of sunflower (*Helianthus annuus* L.) mainly in the central and southern United States. The sunflower moth is most commonly controlled with pesticides. Resistant plants would provide an environmentally friendly approach to controlling this pest. Evaluation of 680 cultivated sunflower accessions in the U.S. National Plant Germplasm System's sunflower (*Helianthus* spp.) collection at the North Central Regional Plant Introduction Station, Ames, IA, USA. revealed 51 accessions resistant to sunflower moth feeding. A 1-3-5-7-9 rating scale is presented to compare accessions damaged by the pest. The proceeding evaluation data were entered into the Germplasm Resources Information Network (GRIN) and made available to researchers worldwide.

Key words: **Sunflower, *Helianthus*, *Homoeosoma electellum*, plant germplasm, host plant resistance to insects, sunflower moth.**

INTRODUCTION

The United States National Plant Germplasm System's collection of sunflower, *Helianthus* spp., contains 3,670 accessions of which 1,495 are cultivated (*H. annuus* L.). From 1985 to 1992, 680 cultivated accessions were evaluated for sunflower moth, *Homoeosoma electellum* (Hulst)(*Lepidoptera: Pyralidae*), resistance. The procedure used for these evaluations involved placing eggs on sunflower heads and covering with a Delnet® bag until harvest. Seeds from each head were weighed and counted after removing those that were damaged or immature. Head diameter was measured, the total head area was calculated, as was the number and weight of mature, uninfested seed per unit area. These data were then used to compare the host-plant resistance of accessions to sunflower moth. In 1993,1994, and 1995, 90 accessions identified as resistant in the 1985 to 1992 trials were retested in the field to confirm their resistance.

This study reports the results of retesting accessions from 1993 to 1995 that were previously found resistant to sunflower moth. We also report on refinements of the technique for evaluating sunflower germplasm for resistance to the sunflower moth. A 1-3-5-7-9 rating scale is presented for comparison of the accessions tested.

MATERIALS AND METHODS

On 17 May 1993, 90 sunflower accessions were planted at Ames, Iowa, in single 7.6 m long rows. The test plots were direct-seeded with a two-row planter. Rows were alternately spaced 0.9 m and 1.5 m apart. Plants were thinned to one per row foot when 15 cm tall. Check cultivars included were Ames 7573 "Arrowhead" (sunflower moth susceptible) and Ames 7576 "894" (moderately resistant to sunflower moth). Daily monitoring of the field plots started when the plants reached the late bud or R4 stage (Schneiter and Miller, 1981).

When 10 or more plants in a single accession reached 20% pollen shed or stage R5.2 (Schneiter and Miller, 1981), five plants were randomly selected and infested with sunflower moth eggs. The eggs were collected on 1 cm square fabric pads during days 3-5 of the moth's oviposition period. Each fabric egg pad contained ca. 30 eggs and was stored at 4.5° C for up to six days before use (Wilson, 1990). To ensure that the plants received an adequate insect infestation, accessions with head diameters of less than 5 cm at stage R5.2 received 1-2 egg pads per head and accessions with larger head diameters received 3-4 egg pads per head. Five additional plants per accession were randomly identified for treatment with the insecticide Asana® (active ingredient, esfenvalerate), seven days later. These plants served as the control for each accession. To ensure adequate pollination and seed set, all heads were left open to natural pollinators for at least one week. One or two days after the insecticide treatment was applied, muslin bags were placed on the 5 heads with egg pads and the 5 control plants in each accession to protect them from bird damage and other insect pests.

During 1993, infestations were made from 23 July to 27 August and insecticide spray was applied from 8 August to 3 September. The test plots were hand harvested by removing heads with hand pruners on 6 October. The heads were placed in harvest bags and dried in forced-air dryer bins at 29.5° C until 18 October. Dried material was stored in a screened cage at 15.5° C and 50% RH until processing was begun.

Each head was processed as follows. The head was removed from the muslin bag and the head diameter was measured at 2 locations. The average diameter was recorded to the nearest 0.5 cm. Seed was stripped by hand from the head over cleaning screens and large pieces of debris were removed. A Hoffman® blower was used to do the final cleaning of the seed. Total seed count from the head was made with Seedburo® 801 Count A Pak, and the total seed weight was measured on a Mettler® PM 2000 laboratory balance.

The following data were entered into a computer data base file for each of the 10 heads tested per accession: head diameter, seed count, and seed weight of the cleaned, undamaged seed collected per head. By using the CALC program of MSTATC (MSTAT Development Team, 1989), we calculated the head area in cm^2, and determined the number of seed per cm^2 and the grams of seed per cm^2. The mean of the 5 infested heads and the mean of the 5 sprayed heads were calculated for each accession. The two means were used to calculate the percent of control for both grams of seed per cm^2 and number of seeds per cm^2 for each accession by using the following formula: percentage of control = (mean of infested plants/mean of sprayed plants) x 100. If both the percentage of control values for seed weight and the seed number were equal to or greater than 90%, the accession was considered to exhibit resistance to the sunflower moth.

In 1994 and 1995, we used a larger sample size to provide more accurate information on the highly variable germplasm being evaluated. In 1994, half of the 1993 accessions were planted, and in 1995, the remaining half of the 1993 accessions were planted in the field as described in the 1993 test. The evaluation procedure was the same as 1993 except that 10 heads were randomly selected for infestation with sunflower moth eggs, and 10 heads were randomly selected for spraying with Asana®.

The 1994 test plot was planted on 11 May. Heads were infested from 27 June to 2 August and plants were sprayed with insecticide from 21 July to 9 August. Heads were hand harvested from 1 September to 14 September. All bags were moved from dryer bins to the storage cage by 22 September. Data were collected on 46 test accessions and two checks.

The 1995 test plot was planted on 17 May. Heads were infested from 18 July to 11 August and plants were sprayed with insecticide from 26 July to 18 August. Heads were hand harvested from 30 August to 15 September. All bags were moved from dryer bins to the storage cage by 29 September. Data were collected from 40 test accessions and two checks.

To determine if we needed to measure data for both seed number and for seed weight, a correlation analysis was run, using Microsoft Excel Analysis ToolPak (Grey Matter International, Inc., 1993) to compare the percentage of control for seed number with the percentage of control for seed weight.

The following 1-3-5-7-9 rating scale was used to compare accessions:

Rating 1 - % of control for seed weight > 90%

Rating 3 - % of control for seed weight 75 - 89%

Rating 5 - % of control for seed weight 50 - 74%

Rating 7 - % of control for seed weight 30 - 49%

Rating 9 - % of control for seed weight ≤ 29%

RESULTS AND DISCUSSION

Results of the correlation analysis showed the correlation between the percentage of control for seed number to the percentage of control for seed weight to be $r=0.83$ ($p<0.001$, $n=90$). Because of this highly significant result, we decided to eliminate measurement of seed number. In the future, this will save considerable time processing seed samples.

Table 1 presents the ratings for the 1994 and 1995 tests. By using the percentage of control for seed weight, 51 accessions rated 1 (resistant) and 20 accessions rated 3 (moderate resistance). The rest were considered susceptible accessions.

The ratings were submitted to the National Plant Germplasm System sunflower curator for inclusion in the Germplasm Resources Information Network (GRIN) data base where they are available to researchers worldwide.

Changing the technique from bagging heads immediately after infesting with egg masses to allowing one week for natural pollination before bagging, improved the overall technique because this allowed pollination of self-incompatible sunflower heads to proceed normally. By using our previous technique, the early bagging of heads blocked natural pollinators from providing maximum seed set. This prevented us from obtaining evaluation data for self-incompatible accessions.

Table 2 lists the countries where the resistant germplasm originated. Of the 51 resistant accessions (Table 1), 27 were obtained from Turkey. All were added to the U.S. National Plant Germplasm System's *Helianthus* collection by J. Harlan during 1948 and 1949, except PI 301060, which was added in 1964 by P. Knowles.

Table 2 provides some insight as to where we might seek additional sources of sunflower moth resistant germplasm. Resistance has been identified in germplasm originating from 14 countries. Some of the countries where resistance has been found, *e.g.*, Hungary and the United States, have several accessions in the collection that have not been evaluated for sunflower moth resistance.

CONCLUSIONS

Evaluation of 680 accessions of cultivated sunflower identified 51 as having achene feeding resistance to sunflower moth. By using the 1-3-5-7-9 rating scale developed in this study, sunflower accessions can be compared. The data will be more uniform when entered in the U.S. National Plant Germplasm System's databank and will be available to researchers worldwide.

These additional sources of resistance will provide plant breeders with germplasm to improve cultivars grown in sunflower moth areas of the United States and perhaps in countries where sunflower moth or related species reduce yield. With improved resistant cultivars, farmers might be more inclined to add sunflower to their on farm crop diversity.

Table 1: Ratings, country of origin, and plant names of 91 sunflower accessions field tested for sunflower moth resistance during 1994 and 1995, Ames, IA, USA

Accession ID number		Country of origin	Secondary name[b]	Rating[a]
Ames	1839	Hungary	IH 10	1
Ames	3003	China		3
Ames	3296	Uncertain	814151	3
Ames	3345	Uncertain	Cerflor	1
Ames	4043	United States	RHA 276	1
Ames	4050	United States	RHA 299	5
Ames	4302	United States	11603-2	3
Ames	7573	United States	Arrowhead	7
Ames	7576	Unknown	894	5
PI	162453	Uruguay	No. 140	1
PI	162454	Uruguay	Sunrise	1
PI	162675	Argentina	Klein	1
PI	162784	Argentina	No. 167	1
PI	167387	Turkey	Aycicegi	1
PI	170385	Turkey	No. 1397	1
PI	170386	Turkey	Aycicegi	3
PI	170387	Turkey	No. 1700	1
PI	170388	Turkey	No. 1738	3
PI	170389	Turkey	No. 1877	1
PI	170390	Turkey	No. 1952	1
PI	170391	Turkey	No. 2006-A	3
PI	170392	Turkey	No. 2007	1
PI	170394	Turkey	No. 2309	3
PI	170395	Turkey	No. 2018	1
PI	170397	Turkey	No. 2109	3
PI	170398	Turkey	No. 2256	5
PI	170399	Turkey	No. 2366	1
PI	170401	Turkey	No. 2513	1
PI	170403	Turkey	No. 2546	1
PI	170404	Turkey	No. 2547	3
PI	170405	Turkey	No. 3585	1
PI	170407	Turkey	No. 2658	3
PI	170410	Turkey	No. 2717	5
PI	170412	Turkey	No. 2770	5
PI	170413	Turkey	No. 2812	1
PI	170414	Turkey	No. 2855	5
PI	170415	Turkey	No. 2878	1
PI	170416	Turkey	No. 2975	1
PI	170417	Turkey	No. 3092	5

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Accession ID number		Country of origin	Secondary name[b]	Rating[a]
PI	170418	Turkey	No. 3241	1
PI	170419	Turkey	No. 3332	1
PI	170420	Turkey	No. 3334	1
PI	170428	Turkey	No. 3579	1
PI	171656	Turkey	No. 6874	1
PI	171657	Turkey	No. 6967	1
PI	172904	Turkey	No. 7728	3
PI	173704	Turkey	No. 7336	3
PI	175722	Turkey	No. 5417	5
PI	175724	Turkey	No. 5473	3
PI	175725	Turkey	No. 5764	5
PI	175728	Turkey	No. 6046	5
PI	175733	Turkey	No. 9121	1
PI	176571	Turkey		1
PI	176573	Turkey		1
PI	176574	Turkey		1
PI	176974	Turkey		1
PI	176975	Turkey	Katmer	7
PI	177398	Turkey	No. 5289	3
PI	177401	Turkey	No. 5292	1
PI	181769	Lebanon	Tournesol	1
PI	193775	Ethiopia		1
PI	195574	Ethiopia	No. 9591	1
PI	195946	Ethiopia	No. 9918	1
PI	226466	Iran	No. 14758	1
PI	228345	Iran	No. 15378	5
PI	232904	Hungary	Lovaszpatonai	1
PI	232905	Hungary	Mezohegyesi Cirmos	3
PI	243078	Jordan	W.Y. III/3	1
PI	243080	Jordan	W.Y. 117/4	1
PI	250851	Iran	Aftabgardan	1
PI	250853	Iran	Aftabgardan	1
PI	250855	Iran	No. K1464	5
PI	251466	Turkey	No. K1944	3
PI	251902	Former Soviet Union	Kruglik A-41 USSR	3
PI	251990	Turkey	No. K1879	5
PI	251992	Turkey	No. K1892	9
PI	253773	Iraq	No. K949	1
PI	256335	Pakistan		1
PI	262521	Bulgaria	No. N85	1

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Accession ID number		Country of origin	Secondary name[b]	Rating[a]
PI	301060	Turkey	No. N-77	1
PI	343785	Iran	Tchernianka Select	5
PI	372258	Former Soviet Union	Smena	1
PI	372259	Former Soviet Union	Vniimk 6540	1
PI	386230	Kazakhstan	VIR 847	5
PI	386322	Ukraine	L-2621	5
PI	430538	Former Soviet Union	Novinka	1
PI	430540	Former Soviet Union	Tambovskij Skorospelyj	5
PI	431520	Romania	Romsun V-1324	3
PI	431545	Yugoslavia	D-75-15	3
PI	480473	Zambia	CCD82	3
PI	496263	China	Damaya	1
PI	497249	Former Soviet Union	VIR 130M	5
PI	507919	Hungary	3100536	5

[a] Rating scale 1-3-5-7-9, where 1 is the least damaged and 9 is the most damaged. The scale is described in the text.
[b] The secondary name is a local cultivar name, a breeders designated identification, or a collector assigned number.

Table 2: Comparison of number of resistant accessions with total evaluated for country of origin

Country	Total no. resistant	Total no. tested	Total no. in collection
Argentina	2	17	37
Bulgaria	1	6	13
China	1	1	21
Ethiopia	3	6	6
Hungary	2	23	85
Iran	3	55	61
Iraq	1	10	10
Jordan	2	11	12
Lebanon	1	1	1
Pakistan	1	5	5
Former Soviet Union	3	118	168
Turkey	27	119	121
Unknown	1	33	185
Uruguay	2	5	7
United States	1	33	120

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RESISTENCIA A LA POLILLA DEL GIRASOL CULTIVADO

RESUMEN

La polilla del girasol, *Homoeosoma electellum* (Hulst) es una plaga mayor del girasol (*Helianthus annuus* L.) principalmente en el centro y sur de los Estados Unidos. La polilla del girasol se controla mayormente con pesticides. Las plantas resistentes darían una aproximación respetuosa con el ambiente para el control de esta plaga. La evaluación de 680 entradas de girasol cultivado en el sistema Nacional de germoplasma de plantas de girasol (*Helianthus* spp.) de Estados Unidos en el North Central Regional Plant Introduction Estation, Ames, IA, USA identificó 51 entradas resistentes a la polilla de girasol. Una escala de 1-2-3-5-7-9 se presenta para comparer entradas dañadas por la plaga. Los datos procesados de la evaluación fueron introducidos en la Red de Información de Recursos de germoplasma y puestas a disposición de los investigadores de todo el mundo.

RÉSISTANCE DU TOURNESOL À LA MOUCHE DU TOURNESOL

RÉSUMÉ

La mouche du tournesol, *Homeosoma electellum* (Hulst), est un ravageur majeur du tournesol (*Helianthus annuus* L.) principalement dans les régions centrales et méridionales des Etats Unis. La mouche du tournesol est habituellement contrôlée par des pesticides. Les plantes résistantes pourraient contribuer à une méthode de lutte respectant l'environnement. L'évaluation de 680 introductions de tournesol cultivé (*Helianthus* spp.), appartenant à la collection du National Plant Germplasm System (North Central Regional Plant Introduction Station, Ames, IA, USA) a révélé que 51 accessions vent résistantes à la mouche du tournesol. Une échelle de notation (1-3-5-7-9) est utilisée pour comparer les accessions attaquées par le ravageur. Les données d'évaluation vent enregistrées dans le réseau d'information sur les ressources génétiques (GRIN) et vent disponibles pour l'ensemble des chercheurs.