RESISTANCE TO *SCLEROTINIA* HEAD ROT IN SUNFLOWER AFTER ARTIFICIAL INFECTION WITH INOCULATED MILLET SEED

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Summary

Sclerotinia sclerotiorum (Lib.) de Bary is one of the most devastating pathogens of sunflower, causing yield losses up to 100 %. The objectives of this study were to (1) evaluate a number of sunflower inbred lines for their reaction to *Sclerotinia* head rot after artificial infection and (2) identify a suitable trait for screening against *Sclerotinia* head rot resistance. A set of 45 inbred lines was screened in three environments by infecting the capitulum with inoculated millet seed. The infection rate varied from 93 % in 1997 to 98 % in 1998. In 1999 the infection rate was less than 50 % and thus the data were not integrated in the study. Susceptibility was assessed by lesion length, front symptoms, and rotted part of the head. All scoring traits were correlated with each other and effective in differentiating among highly susceptible and less susceptible lines. To record the part of the rotted head about three weeks after infection can be recommended as a reliable trait for screening sunflower lines against *Sclerotinia* head rot based on its high heritability estimate ($h^2 = 0,74$). Nevertheless, using this test involves the danger to get no results in some years.

Introduction

Sunflower head rot caused by *Sclerotinia sclerotiorum* (Lib.) de Bary is one of the major diseases affecting this crop worldwide. To date, no complete resistance to *Sclerotinia* is available in cultivated sunflower, but differences in susceptibility exist (Tourvieille *et al*. 1996, Degener *et al*. 1999a, b). Screening for resistance under natural field infestation may not be reliable due to the high variability in inoculum pressure and environmental conditions for disease development between locations and years of studies. Thus an inoculation method published by Rashid (1997) was used to evaluate sunflower inbred lines for their reaction to *Sclerotinia* capitulum infection.

Material and methods:

A total of 45 inbred lines of diverse origin and without prior information on their response to *Sclerotinia* infection and five hybrid controls were evaluated for resistance to *Sclerotinia* head rot in 1997, 1998, and 1999. All experiments were grown without irrigation at Willstätt in the Upper Rhine Valley in Germany. The trials were conducted as 10 x 5 alpha design with three replications. Two with *Sclerotinia* infected millet seeds were inserted into a small cut at the back of five sunflower heads per plot (Rashid 1997). We infected all plots at one day, when the latest line started flowering. The *Sclerotinia* isolate used in this study was collected in 1995 from naturally infected sunflowers at Willstätt. We measured the lesion length on the back of the head (lesion length) and determined the number of days from infection until the lesion was visible on the front of the head (front symptoms). The symptoms were scored on a 1-7 scale in 1997: 7 represents the beginning of the scoring, when symptoms first appeared on the front of the heads (day 1, 2, 3, 4) ; 6-2 represents the number of days, based on four day intervals, for symptoms appearing later, and 1, when no symptoms appeared until the last scoring. The corresponding scoring in 1998 was based on 3-day intervals because the plants showed symptoms very quickly. About three weeks after infection, the part of the head that was rotted (rotted head) was assessed. The symptoms were scored on a 1-8 scale: 8 represents a completely destroyed head, 1 represents a lesion less than one cm. Additionally, flowering date was recorded. Analyses of variance for alpha designs were performed with field data from each environment, using plot means calculated from individual plant measurements for each trait. Plants on which the inoculum was not successful in causing *Sclerotinia* infection were excluded from the calculation of plot means. Due to the low infection rate of 1999, the data of 1999 were excluded from further calculations. All computations were performed with the computer package PLABSTAT (Utz 1997).

Results

The infection rate varied from less than 50 % in 1999 to 93 % in 1997 and 98 % in 1998. Mean and minimum values for reaction to *Sclerotinia* for all scoring traits were consistently lower in 1997 than in 1998. Inbreds in the two environments showed a wide range for all traits (Table 1).

Highly significant (P < 0.01) differences among genotypes were found for all *Sclerotinia* resistance traits. The estimated genetic variances ($\hat{\sigma}_g^2$) for all traits were high compared with the variance due to genotype x environment interactions ($\hat{\sigma}_{ge}^2$). Heritability (h^2) for resistance traits ranged from 0.65 to 0.77 (Table 1).

All resistance traits showed high and highly significant (P < 0.01) phenotypic correlations with each other (Table 2), but no phenotypic correlations to flowering date. Front symptoms and rotted head were closely associated with each other.

Table 1. Means, ranges, variance components ($\hat{\sigma}_g^2, \hat{\sigma}_{ge}^2, \hat{\sigma}^2$), and heritabilities ($h^2$) among sunflower lines for three traits of resistance to *Sclerotinia* measured in two environments.

				Variance components			
Trait	Year	Mean	Range	$\hat{\sigma}_g^2$	$\hat{\sigma}_{ge}^2$	$\hat{\sigma}^2$	h^2
Lesion length (cm)	1997	1.4	0.1 – 4.4				
	1998	4.9	3.31 – 7.5				
	Mean	3.1	0.1 – 7.5	0.66**	0.35**	0.37	0.65
Front symptoms (1-7)	1997	3.2	1.1 – 6.2				
	1998	5.0	2.7 – 6.7				
	Mean	4.1	1.1 – 6.7	0.94**	0.2*	0.36	0.77
Rotted head (1-8)	1997	3.9	1.1 – 7.0				
	1998	4.6	3.6 – 6.8				
	Mean	5.4	1.1 – 7.0	0.95**	0.31**	0.35	0.74

*, ** Significant at P < 0.05 and P < 0.01, respectively.

Table 2. Genotypic (above diagonal) and phenotypic (below diagonal) correlations among sunflower inbred lines for three traits of resistance to *Sclerotinia* measured in two environments and correlations with flowering date.

Trait	Lesion length (cm)	Front symptoms (1-7)	Rotted head (1-8)	Flowering Date (days)
Lesion length		0.88++	0.86++	0.21+
Front symptoms	0.84**		0.98++	0.31+
Rotted head	0.76**	0.94**		0.32+
Flowering date	0.21	0.26	0.27	

* Significant at P < 0.01.

+,++ Exceeded once ore twice its standard error, respectively.

Discussion

An effective artificial infection test should be (1) easy to handle, (2) produce a high infection rate, and (3) imitate the natural disease incidence (Degener *et al*. 1999a). The infection method described by Rashid (1997) is easy to handle and produced sufficient infections in 1997 and 1998. The reason for the low infection rate in 1999 remains unclear although it is probable that the high daily temperatures of the period after the infection influenced the growing of the fungus. This test is informative for the mycelial extension in the capitulum tissue, but not for resistance to penetration of the fungus into the plant.

All resistance traits are suitable for evaluating head rot resistance of sunflower genotypes. Front symptoms and rotted head showed higher h^2 estimates and less genotype x environment interaction than lesion length. As rotted head is fast to record and showed high correlations to the other traits it can be recommended for screening sunflower against *Sclerotinia* head rot.

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Acknowledgements

The author thanks Prof. Dr. W. Friedt, University of Giessen, Germany, Dr. G. Seiler and Dr. J. Miller, ARS Northern Crop Science Laboratory, Fargo, USA, and Fa. Südwestsaat, Dr. H.R. Späth and I. Gröne Rastatt, Germany, for providing sunflower lines. The technical assistance of J. Degener, Th. Mellin, C. Maus, S. Schillinger, E. Hirth, and various members of staff working at the Experimental Station, Eckartsweier, in conducting the field experiments is gratefully acknowledged. This work was supported by the Deutsche Forschungsgemeinschaft (DFG, SP 192/7-1).