Variability among cultivated sunflower genotypes to sclerotinia head rot

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Sclerotinia head rot occurred in 1980 and was widespread in Manitoba sunflower in 1981. Agriculture Canada test plots at Thornhill and Holland, Manitoba, were almost 100% infected by the pathogen. In some tests, sclerotinia head rot was negatively correlated with height, days to bloom and days to maturity. Tests showed considerable variability in head rot intensity among the cultivars including those with closely related genotypes. Resistance to head rot appeared to be conditioned by additive genes derived from both parents. The head rot incidence in three-way crosses was similar to that predicted from single crosses.

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La pourriture sclerotique du capitule s'est declaree en 1980 et fut largement répandue dans les cultures de tournesol au Manitoba en 1981. A Thornhill et Holland au Manitoba, dans les parcelles experimentales d'Agriculture Canada presque 100% des plants furent infectes par le pathogen. Certains essais rapportes sur la pourriture sclerotique du capitule furent correles negativement avec la hauteur, les jours de floraison et les jours de maturite. Les essais ont demontre une variabilite considerable de l'intensite de la pourriture du capitule parrnis les cultivars incluant des genotypes relies de pres. La resistance a la pourriture du capitule semble être conditionnee par des genes additifs derives des deux parents. L'incidence de la pourriture du capitule avec le croisement triple a ete sirnilaire a celle prevu avec les croisements simples.

Introduction

Sclerotinia sclerotiorum (Lib.) de Bary is an important pathogen that can markedly reduce yields of sunflower (*Helianthus annuus* L.). The pathogen causes two sunflower diseases depending on the mode of sclerotial germination. In North America, hyphal outgrowths, during myceliogenic germination of soilborne sclerotinia, penetrate the plants and incite sudden wilt, considered to be the more serious disease of the two (Acimovic, 1984). Head rot, resulting from carpophoric sclerotial germination, has also resulted in serious crop losses in Manitoba and North Dakota (Hoes, 1969; Gulya *et al.,* 1989). In 1986, an estimated 10.2% of the crop in eastern North Dakota was affected by head rot (Gulya *et al.* 1989).

The development of head rot is dependent upon environmental conditions that favor production of apothecia and ascospores, ejection of ascospores, and spore germination at the time when the plants are most susceptible (Lamarque and Rapilly, 1981). Kondo *et al.* (1988) demonstrated that ascospores invaded the sunflower head mainly through florets. Head rot is probably a major disease in Argentina, France and Japan because of frequent rains during flowering (Acimovic, 1984; Kondo, 1988).

The effect of genotype on susceptibility to head rot is being studied to provide a basis for the development of resistant cultivars. In France, Leclerq, (1973) observed that shorter and earlier maturing cultivars were more susceptible to head rot. Kondo *et al.* (1988) tested eleven cultivars and reported that differences in head rot occurrences were accounted by differences in flowering time. Gulya *et al.* (1989) also reported considerable variation in head rot among 189 genotypes.

In 1980 and 1981, an unusually high natural incidence of head rot was observed in the sunflower test plots at Thornhill (8 kilometers west of Morden) and Holland, Manitoba. This provided an opportunity to evaluate the variation in susceptibility among our cultivated genotypes to head rot under natural infections.

Materials and methods

The incidence of head rot was scored from 0 to 10, with 0 assigned to uninfected sunflower and 10 to infection of all of the heads. In 1980, two trials were designed to evaluate the yield potential of new ,sunflower lines or cultivars. The first trial, part of the US. National Sunflower Performance Trial (US NSPT), contained thirty-one commercial hybrids grown in a randomized block design with four replicates. The second trial (1980 Prel) consisted of 230 entries from the Morden breeding program in ten preliminary yield tests, each with two replications. The incidence of head rot was determined one or two weeks prior to harvest in October. Data was also recorded for plant height, days to 80% bloom, days to maturity and yield. Correlation coefficients between head rot incidence and various agronomic characters were determined for the plants in both trials.

In 1981, data was collected from another US NSPT planted at Thornhill with forty-two entries. Head rot incidence and agronomic data also were collected from the Canadian Sunflower Co-operative Test (CSCT) at Thornhill with

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Table 1. Agronomic characteristics and head rot estimates of sunflower hybrids tested in 1980 and 1981.

Test	No. of hybrids	Yield, kg/ha Mean SD	Days to bloom Mean SD	Days to maturity Mean SD	Height, cm Mean SD	Head rot score* Mean SD
1980 Prelim	230	1930 ± 352	66.1 ± 3.0	107.4 ± 3.4	160 ± 13	0.9 ± 1.0
1981 Prelim 1	184	2340 ± 383	80.3 ± 1.6	117.1 ± 1.8	153 ± 11	2.5 ± 1.0
1981 Prelim 2	40	1448 ± 340	79.4 ± 1.3	115.4 ± 1.2	153 ± 7	4.5 ± 2.1
1981 US NSPT	42	2233 ± 322	83.5 ± 1.9	121.0 ± 2.9	170 ± 10	1.6 ± 1.9
1981 CSTC, Holland	36	2340 ± 247			152 ± 8	2.2 ± 1.7
1981 CSTC, Thornhill	36	2293 ± 407	82.1 ± 2.1	119.2 ± 2.9	156 ± 9	2.8 ± 2.1
1981 CSTC, Combined	36	2316 ± 235			154 ± 6	2.5 ± 1.9

* Scored from 0 to 10 (0 = no infection, 10 = 100% infection).

Table 2. Correlation coefficients of head rot incidence with several agronomic characteristics in 1980 and 1981 tests.

Test	Correlation coefficient: Yield	Height	Days to bloom	Days to maturity
1980 Prelim	-.40**	-.03	-.45**	-.39**
1981 Prelim 1	-.44**	-.04	.06	-.10
1981 Prelim 2	-.75*	.08	.29	-.26
1981 US NSPT	-.58*	-.11	-.26	-.02
1981 CSTC, Holland	-.56*	-.30		
1981 CSTC, Thornhill	-.85**	-.39	-.47	-.53
1981 CSTC, Combined	-.82**	-.64*		

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

thirty-six entries. These thirty-six entries were planted at Holland, Manitoba, and data were recorded for plant height and head rot incidence. These two tests were replicated four times in a rectangular lattice design. Data was also collected from 184 experimental hybrids in eight preliminary yield tests in 1981 with two replications (1981 Prelim 1).

In another 1981 test (1981 Prelim 2), four female lines (CM 577, CM 588, CM 589 and HA 301) were used in single and three-way crosses. The four lines were used in all combinations to produce six initial crosses for use in the development of three-way hybrids. This resulted in a total of 10 cytoplasmic male sterile lines or single crosses that were used as females for production of hybrids. Four experimental restorer lines, numbers 22, 29, 33 and 55, were used to combine with each of the female parents. They consisted of two pairs of sister lines; one pair (22 and 29) was derived from a cross involving CM 469 while the other pair (33 and 55) was derived from two identical crosses involving CM 497. The line CM 497 was released earlier that shows partial tolerance to sclerotinia stem rot (Huang and Dedio, 1982). Both CM 469 and CM 497 were derived from a gene pool developed by allowing fifty inbred lines to interpollinate for three generations. The forty possible resulting hybrids from these crosses were planted at Thornhill in a randomized block design with three replicates.

The 1981 agronomic data and head rot scores are presented in Table 1. Correlation coefficients between head rot and days to bloom, days to maturity, height and yield were determined where data was available.

Table 3. Head rot score of single and three-way hybrids from four female and four male parent lines. Predicted values from single crosses are in brackets.

	Male parent				
Female parent	22	29	33	55	Mean
CM 589	8.2	9.3	6.0	4.3	7.0
CM 588	2.5	2.3	3.7	0.7	2.3
CM 577	4.3	7.3	6.3	3.5	5.4
HA 301	3.5	7.7	3.3	2.7	4.3
Single cross mean	4.6	6.7	4.8	2.8	4.7
CM 588 X CM 589	3.0(5.4)	7.3(5.8)	6.0(4.8)	2.5(2.5)	4.7(4.6)
CM 588 X CM 577	4.7(3.4)	3.7(4.8)	4.0(5.0)	0.3(2.1)	3.2(3.8)
CM 588 X HA 301	3.7(3.0)	5.7(5.0)	3.0(3.5)	3.0(1.7)	3.8(3.3)
CM 589 X CM 577	6.0(6.2)	5.0(8.3)	7.0(6.2)	3.0(3.9)	5.3(6.2)
CM 589 X HA 301	5.5(5.8)	8.0(8.5)	4.5(4.6)	2.0(3.5)	5.0(5.6)
CM 577 X HA 301	3.3(3.9)	7.3(7.5)	3.0(4.8)	2.8(3.1)	4.1(4.8)
3-way cross mean	4.4(4.6)	6.2(6.6)	4.6(4.8)	2.3(2.8)	4.4(4.7)

* Scored from 0 to 10; 0 = no infection, 10 = 100% infection.

Table 4. Regression equations relating yield with sclerotinial head rot at Thornhill and Holland, Manitoba Sunflower Committee Tests, 1981.

Thornhill

$y = 2757 - 162.1x$

Holland

$y = 2518 - 82.3x$

y = yield (kg ha-1); x = head rot score

Results

Sclerotinia head rot was widespread in Manitoba in 1980 and was much more severe in 1981. The range of head rot scores among hybrids in the 1980 US NSPT was 0 to 0.7 in 1980, with an average of 0.3. Therefore data are not presented. On the site for the 1980 preliminary test, the mean head rot score was 0.9 and the range was 0 to 4.4 (Table 1). In the 1981 tests, head rot was much more severe with mean scores of 2.5 for Prelim 1, 4.5 for Prelim 2 and 1.6 for US NSPT (Table 1). The range of values for these three tests varied between 0 and 8.3.

In all of the 1980-81 tests, only the CSCT showed a significant negative correlation of height with head rot incidence. Days to bloom and maturity were negatively correlated with head rot incidence in the 1980 preliminary tests and 1981 CSCT at Thornhill, but not significantly in the latter test.

Considerable variation in susceptibility to head rot was found among hybrids from the four inbred lines used as females and four restorer lines (Table 3). The mean score of single cross hybrids with different females ranged from 2.3 for CM 588 crosses to 7.0 for CM 589 crosses. This was a significant difference as an LSD(.05) of 1.2 was obtained when groups of hybrids with different females were compared. When groups of hybrids with different restorers (males) were compared, the mean score ranged from 2.8 to 6.6 for single crosses and 2.3 to 6.2 for three-way crosses with an LSD(.05) of 0.8. The head rot incidence in the three-way crosses was close to the values predicted from single crosses (Table 3). The mean head rot score of the four female lines with each of the four males were 4.6, 6.7, 4.8, 2.8 compared to 4.4, 6.2, 4.6 and 2.3 for means of six single cross females with each of the four males, respectively.

Discussion

In 1981, sclerotinia head rot of sunflower was severe in Agriculture Canada test plots and other fields in Manitoba and Saskatchewan. The 1981 disease outbreak may have been related to the nine-day period of wetness that coincided with flowering periods of the different hybrids. Previous to this, the last outbreak of head rot in Manitoba occurred in 1968 (Hoes, 1969). In 1981, flowering was delayed and the disease outbreak coincided fairly closely with the wet period, 76 mm of rain in early August. Outbreaks of sclerotinia of lower intensity have appeared sporadically in Manitoba since 1981, but only the most susceptible hybrids were affected.

There was significant correlation between head rot and low yield. When plants became infected the achenes were released and the head appeared to disintegrate. From the regression equations it was estimated that when 50% of the plants were infected, a 29% yield reduction occurred at Thornhill and 16% reduction at Holland (Table 4).

The plant height, days to bloom and days to maturity were factors affecting the incidence of head rot in some tests. In this study plant height did not appear to be as important in disease incidence as postulated by Leclercq (1973). The incidence of head rot correlated significantly with days to bloom or maturity in some tests (Table 2).

The large range of head rot incidence in the various tests as indicated by the high standard deviation could not be accounted for by agronomic characteristics alone. Even within the same height or maturity requirement class, considerable variation in head rot was noted. Although considerable variation was observed among different genotypes by Kondo *et al.* (1988) and Gulya *et al.* (1989), most of the resistant lines used by the latter authors were either late flowering, very tall or susceptible to insects such as midge (*Contarinia schulzi* Gagne). In this investigation considerable variation in head rot incidence was found in agronomically desirable hybrids. Even in hybrids with related restorer lines, head rot incidence varied considerably (Table 3). The fact that the head rot incidence of three-way hybrids were close to the values predicted from single crosses would suggest additive effects of the genes are involved (Table 3).

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