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RELATIONS BETWEEN THE REACTION OF SUNFLOWER GENOTYPES TO TESTS OF RESISTANCE TO ROOT AND LEAF ATTACKS BY *Sclerotinia sclerotiorum*.

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SUMMARY

Attacks of sunflower roots and leaves by *Sclerotinia sclerotiorum* are as economically important as those of capitula. Varieties resistant to several forms of *Sclerotinia* attack are therefore necessary, but breeding is complicated by the general independance of resistance of different plant organs.

The reponse to artificial infections of roots and leaves of two series of sunflower genotypes was studied.

Genotypes differed significantly in their reactions. For two of three trials there were significant phenotypic correlations between the reponse to the root and leaf test.

Further studies are made to determine if there exists any genetic linkage, which would make possible indirect selection for root resistance through the leaf test. Such a system would have the advantage of permitting simultaneous selection for two types of resistance and of avoiding contamination of breeding nursery soil by large numbers of sclerotia.

Possible selection efficiency and genetic gains are discussed.

INTRODUCTION

The attacks of sunflower leaves and roots by *Sclerotinia sclerotiorum* cause, in some countries, economic losses as great as those caused by attacks of this parasite on capitula (TOURVIEILLE & VEAR, 1990; CASTAÑO *et al.* 1992). The resistance of different parts of sunflower plant to *Sclerotinia* generally appear independant, which complicates breeding for genotypes with a good overall level of resistance.

However, in a series of resistance tests carried out on inbred sunflower lines (CASTAÑO *et al.* 1989), the reactions to leaf infections and to root infections were correlated.

This paper reports futher studies to determine whether the resistances of two organs are truly related and discusses how such a relation could permit indirect selection for root resistance using the leaf resistance test.

MATERIALS AND METHODS

Sunflower Genotypes: 6 trials were made using two series of inbred lines. These genotypes, maintained at INRA Clermont Ferrand, were chosen to represent a wide variability of response to *Sclerotinia* attacks.
Trials 1 and 2, made in 1989, used the following 14 inbreds : 62 (Ha 89), SD, GH, RHA266, PAC1, PRS7, PRS2, PSC4, PSC8, CX, CC40, SN, SP and CP73.
Trials 3 and 4, made in 1990, used the same 14 inbreds as above, together with: Ha61, CANP3, CERN5.1, RE, 2603 and UD.
Trials 5 (in 1989) and 6 (in 1988) used 12 inbreds lines: 62 (Ha 89), SD, GH, RHA266, PAC1, B11A3, GU, F10, V135, PRS5 and RHA274.
All the genotypes were sown in the field in rows of 10 to 12 plants each.

Sclerotinia isolates: In the absence of any sunflower genotype/*Sclerotinia* isolate interaction (CASTAÑO *et al.* 1991), a mixture of sclerotia from several origins was used for the root infections, and mycelium of two *Sclerotinia* isolates (SS26 and SS29) for the leaf infections.

Root (or basal stem) resistance test: This test was described by TOURVIEILLE and VEAR (1990). One gramme of small sclerotia (each weighing about 0.02g) were placed 5 to 10 cm below the soil surface, in contact with the stem base or upper root of each plant. There were two replications each of 10 plants, except in trial 2, where there was only one block. The infections were made when the flower bud measured between 1 and 2 cm in diameter. Soil humidity was maintained by weekly irrigations of 15 mm.
Observations were made once a week until maturity of numbers of plants attacked (wilting and light brown rot of the stem base). Percentage attack was calculated and transformated in arcsin square root (SNEDECOR, 1957) for statistical analyses.

Leaf resistance test: This test was described by CASTAÑO *et al.* (1992). An explant, 0.5 cm in diameter, cut from the edge of a mycelial culture on 1% malt agar was placed at the extremity of the main vein of one of the upper adult leaves of each plant. The explant was placed with the mycelium in contact with

the upper surface of the leaf, and covered with aluminium foil to hold it in place and prevent drying. Eigth to 10 plants per genotype were infected when the flower bud measured between 2 and 5 cm in diameter. Humidity on the leaves was maintained by daily 5 mm irrigations.
The lengths of the light brown rotted zones along the main vein were measured after 7 days (1989) or 5 days (1990).

Statistical analyses: Analyses of variance and linear correlations were made using the software STATGRAPHICS.

RESULTS

The means results for each genotype and each trial are given in Table 1.

1 - Distinction between genotypes: Analyses of variance showed significant differences between genotypes in the three leaf resistance trials, and in one of the two root resistance trials (trial 4) for which the analyses were possible.

1a - Leaf test: Considering either all genotypes or only the five present in all three trials, the mean symptom length was greater in trial 1 (9.19 and 6.84 cm) than in trial 3 (4.28 and 4.89 cm) or trial 5 (5.39 and 5.06 cm).
The most resistant and the most susceptible genotypes were, respectively, PAC1 (4.40 cm) and CP73 (14.80 cm) in trial 1, UD (1.86 cm) and 2603 (8.88 cm) in trial 3 and PAC1 (2.63 cm) and RHA266 (7.86 cm) in trial 5.
The correlations between results of different trials, for the 5 common inbred lines were: r=0.95* (trials 1 and 3), r=0.94* (trials 1 and 5) and r=0.90* (trials 3 and 5), where *= significant difference ($p<0.05$).
For the 13 lines common to trials 1 and 3, r=0.72** highly significant difference ($p<0.01$).

1b - Root test: For this test the percentage of diseased plants in the five common lines was constant in the three trials (84.34%, 82.14%, 78.94%). However, there were variations between reactions of individual genotypes in the different trials.
There were no significant correlations for the results of the series of 13 inbred lines.
On average, of the lines present in at least two trials, PSC4, PAC1, SD and HA61 were most resistant and CX, CP73 and RHA266 the most susceptible.

2 - Correlations between reactions to the 2 tests: Highly significant correlations ($p<0.01$) were found between reactions to the leaf and root tests in trials 1 and 2 (r=0.84) and in trials 3 and 4 (r=0.59).
Thus, in two of three series of trials, an association of reactions to different *Sclerotinia* attacks is apparent.

DISCUSSION - CONCLUSION

The *Sclerotinia* leaf resistance test is quite simple (CASTAÑO *et al.*, 1992), compared with some of the other tests involving artificial infections, such as that using ascospore on capitula in the field (TOURVIEILLE and VEAR, 1984), or those using mycelium on capitula in the growth chamber (VEAR and

GUILLAUMIN, 1977), or on stems (THUAULT and TOURVIEILLE, 1988) or terminal buds (CASTAÑO *et al.*, 1989) in the field.

The mean length of symptoms may vary according to agressivity of *Sclerorinia* isolate or environmental conditions. However, this test shows points of particular interest for the sunflower breeder:
a) it is a non destructive test, individual pants, as in F_2 progenies, or families (F_3 and more advanced generations) can be tested,
b) the results are obtained rapidly, before flowering, which makes it possible to retain only the most resistant genotypes for selfing or crossing,
c) the test provides a good distinction between genotypes, wich is repeteable between years and trials,
d) narrow sense heritability (h^2=0.61) is quite high, indicating that selection is posssible among early segregating generations (CASTAÑO *et al.*, 1992).

The root test is also quite simple to carry out. However, it shows several negative aspects:
a) it is destructive. Although most results are obtained before flowering, the absence of any complete resistance means that few plants are healthy at maturity. It is difficult to propose this test for use on individual plants of segregating progenies,
b) in one of the two trials for which statistical analyses were possible, there is a good distinction between genotypes. However, there is variation in relative classification of genotypes, with no correlations between years,
c) narrow sense heritability is lower than for the reaction to the leaf test.

Modern sunflower hybrids need to carry genes giving good levels of resistance to all the different types of *Sclerotinia* attack. The genotypes most resistant to leaf and root attack must be selected by breeding tests. However, a choice of genotypes with good resistance to root attack will lead to the problems discussed above. It may, therefore, be suggested that indirect selection using results of leaf test, could be an improvement.

The significant correlation between the results of tests of inbred lines was found for two of three series of trials (1-2 and 3-4). It should be noted that in these trials, both tests were made the same year, whereas for the third series (5-6) the leaf test was made in 1989 and the root test in 1988. The difference of environmental conditions between the two years could be the cause of the absence of correlations, perhaps related to variations in root test results, for which genotype-environnement interactions appear to exist. It will be necessary, to continue this study, using further genotypes with tests in the same and different environmental conditions, to determine whether the association between results of leaf and root tests is sufficiently frequent to make general use of indirect selection in breeding programmes or whether it is limited to certain genotypes.

It will also be necessary to estimate the additive genetic correlation between the two tests, in order to measure the validity of indirect selection. Such a methodology will be efficient if there is a genetic gain for the character selected indirectly. If this gain does not exist, it would be necessary to carry out multicharacter selection (CASTAÑO *et al.*, 1991), with application of several tests in each breeding cycle. CASTAÑO (1989) and CASTAÑO *et al.* (1989) showed that a root test applied before a leaf test on the same plants, did not

Table 1: Mean reactions of sunflower genotypes to *Sclerotinia* leaf (L) and root (R) tests.

Years	1989		1990		1990	1989
Tests/(*Trial*)	L*(1)*	R*(2)*	L*(3)*	R*(4)*	L*(5)*	R*(6)*
Genotypes						
62	11.20	63.44	5.17	81.30	6.57	46.31
SD	5.50	50.77	2.56	45.00	2.25	70.87
GH	11.80	90.00	7.25	67.60	6.00	71.22
RHA266	11.30	84.26	6.78	67.80	7.86	81.24
PAC1	4.40	45.00	2.67	63.30	2.63	43.76
(Mean)	*6.84*	*66.69*	*4.89*	*65.00*	*5.06*	*62.68*
PRS7	10.00	71.56	3.80	90.00		
PRS2	7.50	50.77	4.56	61.50		
PSC4	6.60	26.56	3.25	52.90		
PSC8	5.30	33.21	3.00	75.70		
CX	12.30	90.00	8.00	90.00		
CC40	9.90	63.44	2.88	67.50		
SN	11.20	50.77	3.17	80.80		
SP	7.60	50.77	4.60	81.30		
CP73	14.00	90.00		90.00		
HA61			3.40	57.05		55.07
CANP3			4.80	90.00		
CERN5.1			2.30	55.30		
RE			2.33	55.40		
2603			8.88	90.00		
UD			1.86	58.80		
B11A3					4.13	73.74
GU					4.50	71.77
F10					7.57	60.71
V135					5.38	69.72
PRS5					7.00	55.94
RHA274						49.56
Mean	9.19	61.40	4.28	71.06	5.39	62.49
L.S.D.	1.76	N.A.	1.55	22.90	1.51	N.S.

Note:
(L) : necrosis length in cm
Trial 1 and 3= 10 plants per genotype
Trial 5= 8 plants per genotype

(R) : arcsin square root of % of diseased plants at maturity
Trial 4= 2 replications

N.A.: No analyse
N.S.: Not significant

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Trial 1 and 2=. CASTAÑO *et al.*, 1989
Trial 5= CASTAÑO *et al.*, 1992
Trial 6= TOURVIEILLE and VEAR, 1990

modify the relative classification of genotypes, compared with the leaf test applied alone. However, this double test would require addition of sclerotia in the soil, and when the objective is reduction in *Sclerotinia* attacks, this is not a satisfactory solution !!

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