RELATIONS BETWEEN OIL CONTENT AND RESISTANCE TO SCLEROTINIA SCLEROTIORUM IN SUNFLOWERS

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SUMMARY

Resistance of sunflowers to capitulum attack by Sclerotinia sclerotiorum has been studied using observations of natural attack and infections with ascospores and mycelium. Significant, heritable genotypic differences have been demonstrated but the most resistant genotypes often had rather low oil contents. A study of the relations between Sclerotinia resistance and oil content was undertaken. Among both hybrids and inbred lines significant correlations between capitulum susceptibility to Sclerotinia and oil content were found whereas resistance to root attack was quite independant of oil content. Pedigree and recurrent selection programmes were started to determine whether it is possible to break the linkage observed by genetic recombination. In the pedigree programme susceptibility to the mycelium test was significantly correlated with oil content in 5 of 18 F2 progenies, particularly when RHA 299 was a parent. Among the F3 only 4 of 33 families showed a significant relation and in the F4 the means of 22 progenies showed a significant positive correlation between Sclerotinia resistance and oil content. A recurrent selection programme also indicated that it was possible to obtain recombination between the two agronomic characters. Selection of high oil sunflowers with satisfactory capitulum resistance to Sclerotinia appears possible, but it will be important to search for the underlying affects of the most significant genes that were involved in the linkage.

INTRODUCTION

In France, there are attacks by Sclerotinia sclerotiorum on sunflower capitula, flowerbuds, stems and roots, with different resistance factors involved for each type of attack (Tourvieille and Vear, 1984). Capitulum and root attack have been the most studied so far (Bazzalo et al., 1987). For capitulum attack, methods of observation of natural attack and tests with mycelium and ascospores have been developed (Tourvieille and Vear, 1984 ; Vear and Tourvieille, 1987). These test methods have made it possible to breed successfully for Sclerotinia resistance (Vear and Tourvieille, 1985). However, it was noticed that the more resistant genotypes often had rather low oil contents (eg Rémil, Frankasol), whereas the best varieties for oil content were often highly susceptible to Sclerotinia. (eg Airelle, Topflor).

A study of the relations between Sclerotinia resistance and oil content was therefore undertaken. Several examples of negative correlations between improved disease or insect resistance and yield or earliness have been reported (Miller and Norden, 1980). However, although Sclerotinia resistance may be linked to the phenolic metabolism in sunflowers (Hemery et al., 1988) there is no evident relation between the metabolisms of phenols and oil (Jay, personal communication). If the relation is not biochemical, the greatest probability is that it results from an unfavorable chromosomal linkage between genes for oil content and for Sclerotinia resistance. Pedigree and recurrent selection programmes were started to determine whether it is possible to break the linkage by genetic recombination. This paper reports observations over 4 generations of pedigree selection and 2 cycles of recurrent selection. Possible acheivements in future breeding programme are discussed.

MATERIALS AND METHODS

1 - Finished genotypes

The hybrids studied were experimental or precommercial, representative of the

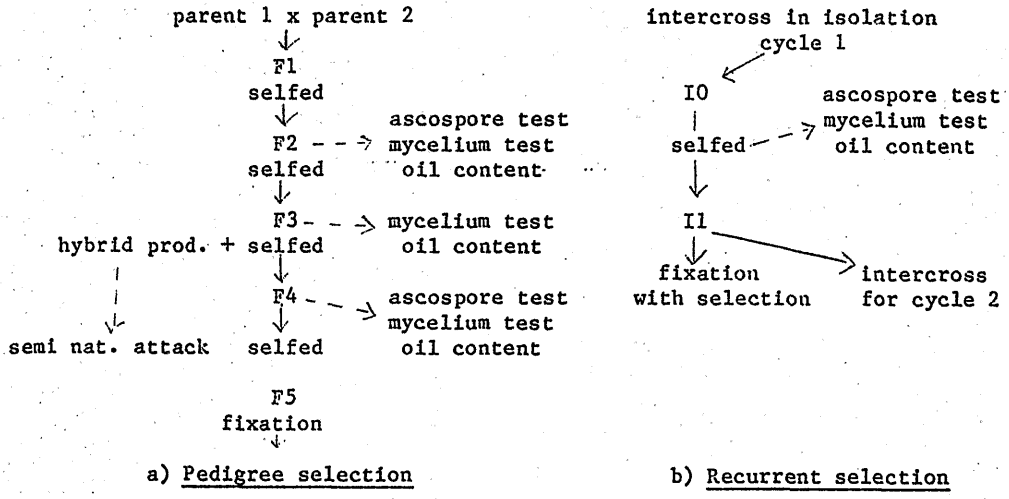
range of sunflower varieties grown in France. One series of 36 hybrids had been specially obtained to represent the known range of Sclerotinia reaction (ROBERT et al.). The inbred lines represent a wide range of genetic origins.

2 - Selection programmes

a - Pedigree - Crosses were made between inbred lines or F3-F6 progenies with either good Sclerotinia resistance or high oil contents. A diagram of the breeding programme is given in figure 1a

b - Recurrent - Two series of 40 inbred lines or progenies, restorer (R) and maintainer (B), with either satisfactory Sclerotinia resistance or high oil content, were intercrossed in isolation, using gibberellin on one third of the plants of each genotype to aid cross pollination. Seed harvested from these plants formed the basis of the first selection cycles. A complete cycle is described in figure 1b.

Figure 1 - Diagrams of breeding programmes



a) Pedigree selection

b) Recurrent selection

3 - Methods

Oil content was measured by N.M.R. (Brucker Mini Spec 10). Sclerotinia reaction on capitula was determined by observations of natural attack under irrigation at flowering (Vear and Tourvieille, 1987), and by mycelium and ascorpore tests (Vear and Tourvieille, 1985). For the mycelium test, results are diseased areas on the dorsal surface of capitula 3 days after inoculation. Results are given as a percentage of area on the control variety Rémil (R). For the ascospore test, results are either percentage attack or latency index which measures the delay from inoculation to symptom appearance, in comparison with the delay on control genotypes inoculated at the same time. Root reaction to Sclerotinia was measured by a test using sclerotia placed in contact with roots (Tourvieille and Vear, 1984). Results are percentages of infected plants.

RESULTS

A - Studies on finished material

Table 1 presents a series of correlations between oil content and Sclerotinia reaction, measured by observation of semi-natural attack or by resistance tests on hybrids and inbred lines. Highly significant correlations appear for very

Table 3 - Relations between Sclerotinia reaction and oil content in F4 progenies

Cross	Sclerotinia			Oil	
	% asco. 20/8	mycel. rpt.R	semi-nat. rpt.R	inbred %	hybrid rpt.T
(RHA801 PAC1)	14	77	165	46.0	103
(RHA801 PRS2.426)	10	65	86	45.5	103
(81RY PAC1)	30	104	127	42.3	103
(PAH3 PSR.20)	29	110	45	40.0	99
(PAC1 PAH3)	50	74	146	40.1	100
(RHA276 PRS2.93)	0	148	144	44.9	103
	0	111	23	41.2	99
(RHA299 PD51)	10	110	93	40.4	92
(RHA299 PAC1)	0	93	117	40.7	104
(PSR2.10 PSR201)	0	116	219	44.2	105
	0	79	134	48.8	108
	0	74	108	47.1	105
(RHA299 IS.354)	0	119	106	41.6	100
(GU PAC)	80	173	161	39.4	101
	70	142		37.7	100
(SH CD)	22	76		38.7	102
	10	64	83	43.3	103
(SH GU)	20	105		39.8	102
	0	105		39.8	102
(DT AS)	22	87	281	42.1	101
	80	76	319	-	96
(SD NG)	57	144		42.9	103
	0	79		44.9	107

Table 4 - Relations between Sclerotinia reaction and oil content in a recurrent selection programme.

Material	Correlation	Cycle 1		Cycle 2	
		N	r	N	r
Population B					
1/2 sib families	asco.test (%) - oil	27	0.02	41	0.03
	asco.test (I) - oil	27	-0.31	41	0.05
	mycel.test (%R) - oil	27	0.29	41	0.39
individuals	asco.test (%) - oil	109	0.05	276	-0.25**
	mycel.test (%R) - oil	179	0.26**	355	0.08
Population R					
1/2 sib families	asco.test (%) - oil	44	0.06	44	0.10
	asco.test (I) - oil	44	-0.19	44	0.05
	mycel.test (%R) - oil	44	0.45**	44	0.09
individuals	asco.test (I) - oil	125	-0.19*	280	0.01
	mycel.test (%R) - oil	296	-0.23*	350	0.06

forms of attack. In the recurrent selection programme, where it is possible to compare the ascospore and mycelium tests, correlations are slightly higher for the latter, but there is no great difference. Since the two tests appear

complementary judging different forms of resistance (Vear and Tourvieille, 1988) it might have been expected that one or other would be more closely linked with oil content. However the differences in results may depend on the genetic origin, for exemple, the linkage with the mycelium test was particularly strong in progenies of which RHA 299 was a parent.

The results do suggest that it is possible to break the linkage between Sclerotinia susceptibility and oil content. This result is comparable with that obtained by Patil and Goud (1979) who found a negative correlation between multigenic resistance to Helminthosporium turcicum and earliness and yield in maize, but by crosses were able to select early resistant lines. The fact that in both pedigree and recurrent selection programmes it appears possible to create favorable linkages but that, through recombination, unfavorable correlations may reappear, suggests that there must be some distance between the genes involved. Since resistance to capitulum attack of Sclerotinia in sunflowers is known to be polygenic (Vear and Tourvieille, 1988) the nature of the genes involved in this apparent chromosomal linkage may be questionned. It may be that one or a few genes with significant effects are involved. It would be of great interest to determine their direct effects for this could permit easier and more efficient measurements of resistance.

In conclusion it appears possible to breed sunflowers with good resistance to capitulum attack by Sclerotinia and high oil content, but it will be necesssary to maintain selection pressure on both characters if chance unfavorable recombinations are to be avoided. To improve the efficiency of breeding programmes research into the more direct effects of significant resistance genes becomes highly necessary.

REFERENCES

BAZZALO M.E., PEREYRA V.R., FLEGO D., 1987 - Comparacion de tecnicas para la evaluacion del compartimiento de cultivares de girasol en relacion a la prodredumbre blanda del capitulo, causada per Sclerotinia sclerotiorum. Reunion tecnica nacional de girasol, 2-4 set. 1987, Bahia Blanca, Argentine, 107-116.

HEMERY M.C., TOURVIEILLE D., JAY M., VEAR F., 1988 - Recherche des marqueurs phénotiques impliqués dans la résistance du tournesol au Sclerotinia. Inf. Techn. CETIOM (sous presse).

MILLER I., NORDEN A., 1980 - Relationship of yield, maturity and susceptibility to leaf spot diseases in peanut (Arachis hypogea L.). Agronomy Abstracts, 62.

PATIL S., GOUD J., 1979 - Correlation studies between disease reaction and yield and maturity components in Zea mays. Mysore J. Ag. Sci., 13, 1-4.

ROBERT N., VEAR F., TOURVIEILLE D., 1987 - L'hérédité de la résistance au Sclerotinia sclerotiorum (Lib.) De By. chez le tournesol. I - Etude des réactions à deux tests mycéliens. Agronomie, 7, 423-429.

TOURVIEILLE D., VEAR F., 1984 - La sélection du tournesol pour une meilleure résistance au Sclerotinia sclerotiorum. Inf. Techn. CETIOM, 88, 3-23.

VEAR F., TOURVIEILLE D., 1985 - Resistance to Sclerotinia sclerotiorum in sunflowers. Proc. 11th Int. Sunflower Conf., Mar del Plata, Argentina, 357-362.

VEAR F., TOURVIEILLE D., 1988 - Heredity of resistance to Sclerotinia sclerotiorum in sunflowers. II - Study of capitulum resistance to natural and artificial ascospore infections. Agronomie, (sous presse).