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SUNFLOWER BASAL STALK ROT (*Sclerotinia sclerotiorum*): ITS RELATIONSHIP WITH SOME YIELD COMPONENTS REDUCTION

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SUMMARY

The aim of the work was to study the relationships between different pathological characters and some yield components reduction in sunflower hybrids artificially inoculated at the base of the stem with the fungus *Sclerotinia sclerotiorum*. Eight commercial hybrids were inoculated at the closed flower-bud stage at three planting dates. They were evaluated for their susceptability by recording: the lesion lenght (LL), the percentage of dead plants (PD) and a disease severity index (DSI) based on the wilting degree at three different moments. At physiological maturity both non-inoculated and inoculated plants from all the hybrids were harvested to determine the number of fertile capitula, number of seeds per capitulum and 1000-cypselae weight. The percentages of yield reduction in the diseased plants were calculated with respect to each hybrid check.

Correlation studies showed highly significant and positive coefficients between all the pathological characters and yield reduction at two evaluation moments (10 and 13 days after inoculation) at first planting date. At second planting date the same type of correlation was observed for LL (7 and 13 days), and for DSI (13 days). At third planting date (most severe environment), yield reduction was not correlated with the pathological characters.

Positive and significant correlation coefficients were found between the lesion lenght measured 7 days after the inoculation with all planting dates. It was concluded that lesion lenght measured few days after the inoculation seems to be a simple and direct evaluation method that also related with yield reduction in moderate-attack conditions.

Key words: **Basal stalk rot, *Helianthus annuus*, *Sclerotinia sclerotiorum*, sunflower yield components reduction**

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INTRODUCTION

Stalk rot caused by the fungus *Sclerotinia sclerotiorum* (Lib.) de Bary is an important disease of sunflower (*Helianthus annuus* L.) in some crop zones of Argentina, United States and Australia (Pereyra and Escande, 1994; Gulya, 1996). Initial infection occurs at the base of the stem. Rapid drying of the leaves and development of lesions on the tap roots and basal portion of the stem caused susceptible plants to die within a few days after the onset of wilting. Plants wilted at any stage from flowering to near maturity have significantly reduced seed weight and yield (Dorrell and Huang, 1978).

Direct and indirect characters have been used to evaluate the disease in different materials. From these, the lesion lenght shows to be a simple and direct screen method which has a good correlation with other pathological characters as wilting and plant death (Sedun and Brown, 1989; Bazzalo *et al.*, 1991). Nevertheless no study about relationship between pathological characters and yield has been made to confirm its use as selection or evaluation criteria.

The aim of this work was to study the relationship between the pathological characters (lesion lenght, percentage of dead plants and disease severity index) and the reduction of some yield components (number of fertile capitula and reduction in number and weight of 1000 cypselae), in the diseased plant.

MATERIALS AND METHODS

Field trial during 1990/1991 growing season was carried out at Balcarce Agricultural Station INTA-College of Agronomic science (UNMP) (Argentina) as a complete randomized block design with two replications and three planting dates (4^{th}, 14^{th}, and 24^{th} of December). Field plots were planted in three rows 6 m in lenght with 0.7 m spacing between rows and 0.3 m apart within rows. The middle row was used for measurements.

The highly virulent isolate #16 of *Sclerotinia sclerotiorum* kept at the College of Agronomic Science (Balcarce, Argentina) was used in the experiments.

Eight Argentine commercial sunflower hybrids were tested: Norkin Punta, Contiflor 9, Contiflor 3, P 81, SPS 7115, ACA 882, Sungro 380 and Dekalb G 100.

Plants were inoculated at closed flower-bud stage (highest susceptibility, Bazzalo *et al.*, 1985) by the method without wounding described previously (Bazzalo *et al.*, 1991). Ten plants / hybrid / replication were tested.

Susceptibility was evaluated 7, 10 and 13 days after the inoculation with exception of the third planting date (7 and 13 days) through three pathological characters: lesion lenght (cm), severity index based on the wilting degree (Bazzalo *et al.*, 1985) and percentage of dead plants. Ten non-inoculated capitula /hybrid/ replication and the inoculated ones were harvested at physiological maturity stage in order

to determine some yield components: number of seeds per capitulum and 1000-cypselae weight.

In order to determine the percentages of the yield components reduction in the diseased plants the following formulae were used for each hybrid:

Percentage of fertile capitula (**PFC**):

$$\frac{\text{Number of fertile capitula of infected plants}}{\text{Number of total infected plants}} \times 100$$

Percentage of reduction in the number of cypselae per capitulum (**PRCN**):

$$100 - \frac{\text{Average number of cypselae per capitulum of the diseased plants}}{\text{Average number of cypselae per capitula of healthy check}} \times 100$$

Percentage of reduction in 1000-cypselae weight (**PRCW**):

$$100 - \frac{\text{Average 1000-cypselae per capitulum of the diseased plants}}{\text{Average plot 1000-cypselae weight of healthy check}} \times 100$$

An analysis of variance performed for each character by using standard statistical procedures (Sokal and Rohlf, 1979), with hybrid and planting date as random effects. Multiple comparisons were made according to Duncan method (Steel and Torrie, 1980). Pearson correlations coefficient among the different characters were calculated (Steel and Torrie 1990). The percentages were transformed to arc sin p/100 for statistical analysis.

RESULTS AND DISCUSSION

Evaluation of susceptibility

The incidence of the disease was 100% for all the inoculated hybrids indicating that barriers to penetration are not present at the base of the stem in these materials. This agrees with the data previously reported when inbred lines were inoculated without the production of tissues injures (Bazzalo *et al.*, 1991).

Highly significant differences between hybrids and planting dates for lesion lenght, percentages of dead plants and disease severity index at the three evaluation dates were found (Table 1). Interactions between hybrids and planting dates were found for the 10^{th} and 13^{th} day. In those cases an analysis of variance was performed within each planting date (Table 2 a, b and c). At second planting date significant differences between hybrids were not found for lesion lenght on the 10^{th}

Table 1: F values (Fisher test) for different pathological characters, evaluation dates and eight hybrids at three planting dates

	PATHOLOGICAL CHARACTERS								
Factor	Lesion lenght (cm)			Percentage of dead plants			Disease severity index		
Day	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}
H	14.3**	10.9**	8.9**	3.8**	20.1**	6.5**	4.8**	12.5**	5.7**
PD	143.4**	105.2**	12.7**	4.2**	203.4**	24.9**	20.5**	62.4**	31.3**
H*PD	2.1	3.2**	2.3**	1.0	12.0**	2.9**	2.2	3.9**	3.4**

H: hybrid, PD: planting date, H*PD: hybrid x planting date interaction.

*: P<0.05, **: P<0.01

Table 2: a, b and c. F Values (Fisher test) for different pathological characters for three planting days at 10^{th} and 13^{th} days inoculation

a) First planting date

	PATHOLOGICAL CHARACTERS					
	Lesion lenght (cm)		% of dead plants		Disease severity index	
Day	10^{th}	13^{th}	10^{th}	13^{th}	10^{th}	13^{th}
Hybrid	11.5*	5.6**	28.9**	23.51**	11.3**	4.3*

b) Second planting date

	PATHOLOGICAL CHARACTERS					
	Lesion lenght (cm)		% of dead plants		Disease severity index	
Day	10^{th}	13^{th}	10^{th}	13^{th}	10^{th}	13^{th}
Hybrid	1.6 NS	3.18*	5.1*	4.4*	4.2*	5.6**

c) *Third* planting date

	PATHOLOGICAL CHARACTERS					
	Lesion lenght (cm)		% of dead plants		Disease severity index	
Day	10^{th}	13^{th}	10^{th}	13^{th}	10^{th}	13^{th}
Hybrid	-	1.5 NS	-	2.6 NS	-	1.1 NS

*: P<0.05, **: P<0.01, NS: no significative, -: no measured

Table 3: Means of the pathological characters at the 7^{th} day after inoculation for the eight hybrids and three planting dates

HYBRID	PATHOLOGICAL CHARACTERS		
	Lesion lenght (cm)	% of dead plants	Disease severity index
SPS 7115	5.2 a	33.7 a	2.4 a
ACA 882	5.0 a	23.0 ab	2.1 ab
Sungro 380	5.0 a	14.8 bcd	1.7 bc
Contiflor 3	4.3 b	16.5 abc	1.8 bc
Norking Punta	3.8 bc	15.5 abc	1.6 c
Contiflor 9	3.8 bc	4.2 cd	1.5 c
Deklab G100	3.5 c	0.0 d	1.3 c
P 81	3.4 c	12.8 bcd	1.5 c

Means followed by different letters are significantly different from one another at the 5% level. Comparison are only valid within columns

day. In the case of third planting date the pathological characters did not differ between the hybrids when they were measured on the 13th day.

The means of the three pathological characters on the 7th day after the inoculation are presented in the Table 3. It could be observed that the relative susceptibility ranking of hybrids was similar independently of the criterion used.

Highest disease severity index and percentage of dead plants mean values were obtained at the third planting date independently of the evaluation day (Table 4 a, b and c). It would indicate that environmental conditions were more adverse for the plant defence and/or more appropriate for pathogen growth in this planting date than in the others. From all these results it could be concluded that differences between materials would persist over the time when conditions were intermediate (first and second planting date).

Table 4: Means of pathological characters for three planting dates and three evaluation dates

a) Lesion lenght

	PLANTING DATE		
DAY	I	II	III
7	3.86 b	3.12 a	5.8 c
10	7.06 b	4.72 a	-
13	10.38 b	8.10 a	9.98 b

b) Percentage of dead plants

	PLANTING DATE		
DAY	I	II	III
7	21.8 b	8.10 a	14.50 a
10	56.50 b	8.80 a	-
13	64.2 b	45.70 a	82.10 c

c) Disease severity index

	PLANTING DATE		
DAY	I	II	III
7	1.80 b	1.20 a	2.20 c
10	2.80 b	1.80 a	-
13	3.30 b	2.90 a	3.70 c

Means followed by different letters are significantly different from one another at the 5% level. Comparaisons are only valid within rows, -: no measured

Yield components

The three yield components were dramatically reduced for all the hybrids and planting dates due to the disease. Nevertheless highly significant differences were found between the hybrids for the three parameters analyzed (Table 5). **PFC** and **PRCN** values were also significantly different between planting dates. No interaction between hybrid and planting date was found (Table 5).

The pattern of mean yield components reduction at the three planting dates seems to be the same as described for susceptibility. When conditions for the dise-

ase development were less severe (2nd planting date) yield components were in relative term less reduced (Table 6). When wilting occurred during the first week after the beginning of flowering similar proportion of yield reductions were obtained both under natural infection (Dorrell and Huang, 1978) and inoculation conditions (present results). The mentioned authors reported reduction in seed yield of 98%, and in 1000-cypselae weight of 65%.

Table 5: F values (Fisher test) for different yield component reduction for eight hybrids at three planting dates

Factor	YIELD COMPONENT REDUCTION		
	PFC	PRCN	PRCW
H	7.99 **	7.4**	9.6**
PD	7.62**	3.7*	3.0 NS
H*PD	0.48 NS	1.3 NS	1.6 NS

*: P<0.05, **: P<0.01, NS: no significative

Table 6: F means of the different yield component reduction for the three planting dates

Planting	YIELD COMPONENT REDUCTION		
	PFC	PRCN	PRCW
First	11.6 a	96.5 a	91.9 a
Second	25.4 b	92.0 b	87.0 a
Third	16.7 ab	94.5 ab	90.2 a

Means followed by different letters are significantly different one from another at the 5% level. Comparisons are only valid within columns

Relationships between susceptibility and yield components reduction

Pathological characters measured on the 13th (LL) or 10th and 13th day after the infection (DP and DSI) were significantly and positively correlated with yield components reduction and significantly and negatively correlated with the **PFC** at the first planting date (Table 7). At second planting date similar significant results were obtained for lesion lenght measured at the 7th and 13th days and the disease severity index measured on the 13th day. No correlation between pathological characters and yield reduction was found for the most severe (3rd) planting date. Sala *et al.* (1994) also found that the sunflower reductions in seed yield, seed number and seed weight produced by *Sclerotinia sclerotiorum* ascospore attack at the mid stalk were significantly correlated with the lenght of the lesion produced by the fungus.

The big reduction in yield observed in plants infected with *S. sclerotiorum* was due to the rapid wilting and loss of leaf tissue somewhat similar to drought or defoliation. As it is well known the sunflower cypselae weight is related with the active foliar surface during anthesis and with its persistence after flowering. Robelin (1967) has defined for sunflower a sensitive stage to drought between 20 days before (closed flower-bud stage) to 20 days after flowering. Similarly defoliation prior to flowering reduced yields by as much as 93% depending on the number and location of the leaves removed (Johnson, 1972). If culture is subject to a permanent

water deficit the yield will be reduced due to the reduction in the number of full cypselae and their mean weight.The relationships between plant disease severity and yield have been extensively review by Gaunt (1995). It has been observed in numerous species that yield reductions associated with foliar disease have more similar correlations than those produced by water deficits and shading in field crops. The frequent reduction of yield potential by premature flower senescence, fertilization fatture, and early about or young seed suggest that assimilate supply is critical at these stages (Andrade and Ferreiro, 1996). Green area and green area duration have been related both physiologically and by correlation to yield in both healthy and diseased crops of many species (Gaunt, 1995).

Table 7: Pearson correlation coefficients between pathological characters at different evaluation dates and yield component reduction, at three planting dates

First planting date

Yield reduction	PATHOLOGICAL CHARACTERS								
	Lesion lenght (cm)			% of dead plants			Disease severity index		
	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}
PFC	-0.47	-0.58	-0.71*	-0.23	-0.79*	-0.89**	-0.16	-0.82**	-0.73*
PRCN	0.56	0.69	0.71*	0.35	0.87**	0.93**	0.26	0.87**	0.85**
PRCW	0.42	0.52	0.67	0.14	0.73*	0.82**	0.07	0.77*	0.69

Second planting date

Yield reduction	PATHOLOGICAL CHARACTERS								
	Lesion lenght (cm)			% of dead plants			Disease severity index		
	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}
PFC	-0.75*		-0.9**	-0.17	-0.16	-0.41	-0.22	-0.52	-0.43
PRCN	0.83**		0.87	0.26	0.23	0.61	0.29	0.45	0.83**
PRCW	0.88**		0.88**	0.47	0.4	0.60	0.51	0.63	0.75*

Third planting date

Yield reduction	PATHOLOGICAL CHARACTERS		
	L. L.	D. P.	D. S. I.
	7^{th}	7^{th}	7^{th}
PFC	0.30	0.60	0.33
PRCN	-0.28	0.30	-0.37
PRCW	-0.32	-0.39	-0.42

*: P<0.05, **: P<0.01

Relationships between pathological characters

Positive and significant correlation coefficients between the three pathological characters measured at any moment were found at the first and third planting dates (Table 8). At second planting dates the same type of coefficients were found between PD and DSI measured on the 7^{th} and 10^{th} day.

Lesion lenght is a pathological character which indicates the degree of fungal progression within stem tissues (being the final symptom as a result of defensive processes at the production of fungal enzymes and toxins (Lumsden, 1979), and

Table 8: Pearson correlation coefficients between pathological characters at different evaluation dates, at three planting dates

a) First planting date

		Lesion lenght (cm)			% of dead plants			Disease severity index		
		7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}
Lesion	7^{th}	1								
length	10^{th}	0.96**	1							
	13^{th}	0.88**	0.89**	1						
% of	7^{th}	0.76**	0.77*	0.60	1					
dead	10^{th}	0.80**	0.89**	0.89**	0.70	1				
plants	13^{th}	0.69	0.85**	0.86**	0.59	0.96**	1			
Disease	7^{th}	0.74*	0.74*	0.65	0.89**	0.68	0.61	1		
severity	10^{th}	0.79*	0.89**	0.88**	0.63	0.97**	0.97**	0.68	1	
index	13^{th}	0.78*	0.89**	0.86**	0.67	0.93**	0.90**	0.73	0.94**	1

b) Second planting date

		Lesion lenght (cm)			% of dead plants			Disease severity index		
		7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}	7^{th}	10^{th}	13^{th}
Lesion	7^{th}	1								
length	10^{th}	-	1							
	13^{th}	0.68	-	1						
% of	7^{th}	0.50	-	0.22	1					
dead	10^{th}	0.44	-	0.20	-0.98**	1				
plants	13^{th}	0.44	-	0.67	0.48	0.48	1			
Disease	7^{th}	0.56	-	0.26	0.98**	0.95**	0.46	1		
severity	10^{th}	0.63	-	0.62	0.81**	0.80**	0.73**	0.81**	1	
index	13^{th}	0.68	-	0.53	0.51	0.63	0.65	0.51	-.42	1

c) Third planting date

		L.L. 7^{th}
Lesion	7^{th}	1
length	13^{th}	-
% of dead	7^{th}	0.74*
plants	13^{th}	-
Disease	7^{th}	0.88**
severity	13^{th}	-
index		

: P<0.05, **: P<0.01, -: no variability

pre- or postinfectional inhibitory compounds from the host plant (Bazzalo *et al.*, 1985, 1987 and Martinson *et. al.*, 1988). On the other hand wilt severity index could be related with the susceptibility/resistance of leaf tissue to oxalic acid actions on the membrane permeability and the magnitude of the xylem vessels blocking by oxalate crystals (Noyes and Hancock, 1981). The percentage of dead plants could be the result of susceptability at stem and/or leaf level.

As the measurements on the 7th day did not vary between hybrids according the planting date (no significant interaction hybrid-planting date), early evaluations seem to be the most stable over the different environmental conditions. In order to known if lesion lenght varied in similar way in the different environments, correlation coefficients were also calculated between this character at the three planting dates. A significant and positive correlation was obtained between the lesion lenght on the 7th day after the inoculation in the first and second planting date ($r=0.72$, $P<0.05$) and the first and third one ($r=0.71$, $P<0.05$).

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PODREDUMBRE BASAL DEL GIRASOL (*Sclerotinia sclerotiorum*): SU RELACIÓN CON LA REDUCCIÓN DE ALGUNOS COMPONENTS DEL RENDIMENTO

RESUMEN

El objectivo de este trabajo fue estudiar las relationes entre distintos caracteres patológicos y la reducción de algunos components del rendimiento en híbridos de girasol artificialmente inoculados en la base del tallo com el hongo *Sclerotinia sclerotiorum*. Ocho híbridos comercial fueron inoculados en estadio de botón floral cerrado en tres fechas de siembra. Ellos fueron evaluados en tres diferentes momentos mediante la medición de: la longitud de la lesión (LL), el porcentaje de plantas muertas (PM) y un índice de severidad de síntomas (ISS) basado en el grado de marchitez foliar. En madurez fisiológica plantas inoculadas y no inoculadas fueron cosechadas para determinar: el número de capítulos fertiles, el número de semilas por capítulo y el peso de mil aquenios. El porcentaje de reducción del rendimiento en las plantes enfermas fue calculado con respecto al testigo de cada material. Se encontraron coeficientes de correlación altamente significativos y positivos entre los caracteres patológicos medidos a los 10 y 13 días y la reducción del rendimiento; y altamente significativos y negativos entre dichos caracteres y el porcentaje de capítulos fértiles, en la primer fecha de siembra. En la segunda fecha de sembra el mismo tipo de correlación fue observada para la LL (a los 7 y 13 días) y para el ISS (13 días). En la tercer fecha de siembra (ambiente de condiciones mas severas) no se encontraron correlaciones significatives entre los caracteres patológicos y la reducción en el rendimiento.

Se hallaron correlaciones positivas y significativas entre las longitudes de las lesiones medidas al día 7, en todas las fechas de siembra. Se concluye que la medida de la longitud de las leciones constituye un metodo de evaluación simple y directo que tambien está relacionado con las pérdidas del rendimiento en los ambientes que favorecen ataques moderados.

PORTITURE BASAL DU TOURNESOL (*Sclerotinia sclerotiorum*): SANS RAPPORT AVEC LA RÉDUCTION DE QUELQUES COMPOSANT DU RENDEMENT

RÉSUMÉ

L`objectif du présent travaill a éte l`etude du rapport entre les différents caracteres pathologiques et la réduction de quelques composant du rendement du tournesol inoculés artificiellment avec le champignon *Sclerotinia sclerotiorum*, a la base de la tige.

Huit hybrides commerciaux on été inoculés en stade de bouton floral fermé, en trois dates de sémilles. Ils ont été mesurés selon la longuer de la lésion (LL), le pourcentage des plantes mortes (PM) et un indice de sévérité de simptôme, basé sur le dégré de la flétrissure des feuilles.

On a récolecté des plantes inoculées et non inoculées en état de maturité physiologique pour déterminer: le nombre des capitules fertilles, le nombre des sémences par capitules et le poid de mille fruits. Le pourcentage de réduction du rendement des plantes malades a été calculé par rapport au témoin de chacque matériel. On a trouvé des coefficients de corrélations tres significatifs et positif entre les caracteres pathologiques mesurés entre le dixieme et le treizieme jour de l`inoculation de la plante et la réduction du rendement, et tres

significatif et negatifs entre les memes caracteres pathologiques et le pourcentage des capitules fertiles, à la première date de sémailles. A la deuxème date de sémilles on a observé le même type de corrélation dans le longuer de la lésion (septième et treizième jour de l`inoculation) et l`indice de séverité des symptômes (treizième jour). A la troisième date de sémailles (dans des conditions plus sévères de l`environmment) on n`a pas trouvé des correlations significatives entre les caractères pathologiques et la réduction du rendement. On a trouvé des correlations positives et significatives entre les longueurs des lésins mésurées au septième jour de l`inoculation à toutes les dates de sémailles.

On conclue que la mesure de la longuer des lésions constitue une méthode d`evaluation simple et directe qui est aussi en rapport avec les pertes du rendement dans les environnments qui favorisent des attaques modérés.