EFFECTS OF SOME ENVIRONMENTAL AND AGRONOMIC FACTORS ON CHARCOAL ROT OF SUNFLOWER

A. ZAZZERINI [1], M. MONOTTI [2],
R. BUONAURIO [1], V. PIRANI [3]

Severe attacks of charcoal rot caused by *Rhizoctonia bataticola* Taub. *(Macrophomina phaseolina* (Tassi) Goid.), have been observed in the sunflower growing areas of south-central Italy (Zazzerini, 1980). The disease is associated with low precipitation and high temperatures (Allabouvette and Bremeersch, 1975 ; Jiménez-Diaz et al., 1983 ; Zimmer and Hoes, 1973). The disease causes severe yield losses in Italy (M. Monotti, personal communication) and other countries (Acimović, 1962 ; Tikhonov, 1976). We report in this paper on the effects of some environmental and agronomic factors on disease incidence.

MATERIALS AND METHODS

Different types of trials were established in fields naturally infested with *Rhizoctonia bataticola* in three locations in central Italy, in 1980, 1981, 1982 and 1983. Two locations, S. Apollinare and Osimo, are located in the hills at about 280 m and 140 m above sea level ; a third, Papiano, is in the plain of the Tiber Valley, at about 180 m above sea level. In each trial 100 kg/ha of P_2O_5 and 50 kg/ha of K_2O were applied before seeding ; 60 kg/ha of nitrogen were applied at seeding time and another 40 kg/ha a month later.

A pre-emergence application of the herbicides metobromuron and prometryne was effected at 0.5 and 1 kg a.i./ha, respectively.

Disease incidence was recorded at harvest as a percentage of diseased plants. The outer rows of plots and plants at the ends of the rows were not included. Diseased plants were recognized by the presence of a characteristic browning and/or of a silvery gray discoloration at the base of the stem and by microsclerotia inside the stem.

Precipitation and temperature. The sunflower cultivars were planted at Papiano and S. Apollinare in 1980 through 1983, in a randomized block design with four replicates. Plots consisted of nine rows, each 6.12 m long and 0.68 m apart ; plant density was 4 plants/m^2.

Rainfall, mean maximum temperature (11 June—31 July), disease incidence and yield were recorded.

Plant density. Five plant populations (3.0, 4.5, 6.0, 7.5 and 9.0 plants/m^2) were evaluated at S. Apollinare in 1980 and 1981, in a split plot design with three replicates. Two open pollinated cultivars (Argentario and Egnazia) and two hybrids (Stromboli and Romsun HS 90) were used ; Egnazia and Romsun HS 90 are early maturity ; Argentario and Stromboli are late maturity cultivars.

Irrigation. The effects of irrigation were studied at Papiano in 1983. Four irrigation regimes, nine sunflower cultivars and two plant densities were compared in a split-plot design with three replicates. Irrigation regimes were : 1) no irrigation ; 2) one irrigation at beginning of flowering ; 3) two irrigations, the first at beginning of flowering and the other 15 days after flowering; and 4) irrigation water amount equal to crop requirement, according to ETa (actual evapo-transpiration). In regimes 2 and 3 the top 40 cm of soil was brought to field capacity. In regime 4 a water volume V (equal to 2/3 of the available water for the first 40 cm) was given each time that the sum of daily evapo-transpiration (ET) was equal to the volume V. The daily evapo-transpiration was evaluated multiplying the evaporation from class A pan by crop coefficients (Doorenbos and Kassan, 1979) without taking into account the rainfall lower than 10 mm within 24 hours.

The nine cultivars (Cerflor, Romsun HS 90, Florom 305, Romsun HS 301, Romsun HS 52,

[1] Istituto di Patologia Vegetale, Università di Perugia, Italy.

[2] Istituto di Agronomia e Coltivazioni Erbacee, Università di Perugia, Italy.

[3] Istituto Sperimentale Colture Industriali, Osimo (Ancona), Italy.

Novisol, Gloriasol, Stromboli and Solaris) ranged from early to late maturity : each was of 4.7 and 7.0 plants/m².

Nitrogen fertilization. Four increasing rates of urea (0, 50, 100 and 150 kg/ha) were applied to the cultivars Ala and Romsun HS 52 at Osimo in 1980. Sixty percent of each nitrogen rate was applied at seeding time and the remaining 40% was top dressed a month after emergence. A split-plot design with four replicates was used. The plots consisted of 6 rows, each 12 m long and a row spacing of 0.70 m. Stand density was 4.0 plants/m².

Weed control. Herbicides for pre-emergence application, an untreated control and a mechanically hoed control were compared in a randomized block with five replicates layed out at S. Apollinare in 1983. The hybrid Romsun HS 52 was employed with a plant population of 4.5 plants/m². The weed covering was estimated by visual evaluation using the phytosociological method of Braun and Blanquet (1951).

RESULTS

Effects of rainfall and temperature. Charcoal rot was present each year but its incidence was higher at both locations in 1983 (Table 1).

Differences in the percentage of diseased plants between years were associated with precipitation and the mean maximum temperature in June and July. This period corresponds to flowering and seed development, which are the stages of the greatest susceptibility.

The highest incidence of disease occurred in two locations, in 1980 and 1981, the years characterized by low rainfall and elevated mean maximum temperatures. Although mean maximum temperatures were high in 1981 and 1982, the severity of attack was less, due to higher precipitation. Yields were consistently reduced in the years when disease was high. In all years and in both locations all cultivars were susceptible to the pathogen, although with a wide range of variability (Table 2).

Effects of plant density. Figure 1 shows the percentage of infected plants at different plant densities. In 1980 the percentage of diseased plants increased significantly up to 4.5 plants/m², while in 1981 it increased significantly up to 6.0 plants/m². The "cultivar $\times$ stand" interaction was significant only in 1980 (Table 3).

Effects of irrigation. Increasing rates of irrigation water produced a significant decrease

Table 1

Effect of rainfall and temperature on incidence of charcoal rot and yield of sunflower over 4-years period

Year	Papiano				S. Apollinare			
	Disease[x] incidence (%)	Rainfall[y] (mm)	Mean maximum[y] temperature (°C)	Yield[x] (q/ha)	Disease[x] incidence (%)	Rainfall[y] (mm)	Mean maximum[y] temperature (°C)	Yield[x] (q/ha)
1980	80	9	28.6	23.0	75	13	26.6	35.1
1981	62	69	28.6	39.8	55	52	26.5	38.7
1982	59	114	31.5	27.9	52	45	29.6	35.8
1983	91	36	30.6	25.1	86	27	29.8	31.0

[x] Each value is the mean of ten cultivars.
[y] Data recorded between June 11 and July 31.

Table 2

Incidence (%) of charcoal rot on ten sunflower cultivars in two locations

Cultivars	Papiano				S. Apollinare			
	1980	1981	1982	1983	1980	1981	1982	1983
Airelle	85[x]	42	32	80	45	22	29	68
Ala	84	51	61	90	82	53	26	92
Argentario	65	52	50	87	73	57	38	77
Cernianka	83	62	71	95	71	48	66	84
ISEA PM 22	71	51	52	83	68	50	61	88
Romsun HS 52	65	50	68	93	65	33	43	72
Romsun HS 53	92	84	71	93	92	78	72	93
Romsun HS 90	97	81	64	98	97	81	78	97
Romsun HS 301	92	90	78	99	92	83	63	98
Stromboli	63	62	39	97	63	43	46	89
$\bar{x}$	80	62	50	91	75	55	52	86

[x] Each value is the mean of four replicates.

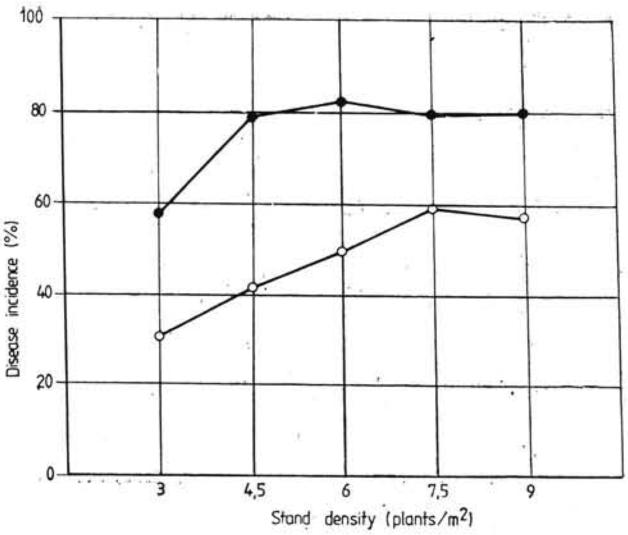

Fig. 1 — Effect of stand density on disease incidence at S. Apollinare in 1980 (dark-circles) and 1981 (open circles)

Table 3

Effect of stand density on the percentage of plants infected by *Rhizoctonia bataticola* in 1980

Cultivars	Stand density (plants/m²)ˣ					
	3.0	4.5	6.0	7.5	9.0	Mean
Argentario	58 by	74 dh	86 im	73 dg	76 eh	74 By
Stromboli	75 dh	92 mn	90 ln	94 n	95 n	90 C
Egnazia	32 a	57 b	64 bd	66 be	71 cf	58 A
Romsun HS 90	62 bc	83 hl	82 gl	78 fi	70 cf	75 B
$\bar{x}$	57 Ay	78 B	82 B	79 B	79 B	

ˣEach value is the mean of four replicates.
ʸValues followed by the same lowercase or capital letter are not significantly different.
(P = 0.05) according to Duncan's multiple range test.

in the mean percentage of diseased plants (Table 4). Also plant population combined with irrigation influenced the mean percentage of attack. A significant "irrigation × stand density" interaction was observed. The effects of stand density were significantly higher when one or two irrigations were used. No difference was detected in plots where water was applied without limitation, or in non-irrigated plots. In the latter case disease incidence was already very high with the lower plant density. The susceptibility of cultivars varied from 63% of diseased plants in Romsun HS 52 to 92 percent in Romsun HS 301. Both interactions "cultivar × irrigation regime" and „cultivar × stand density" were significant (Table 5).

Table 4

Effect of different irrigation regimes and stand density on percentage of diseased plants at Papiano in 1983

Irrigation regimes	Stand density (plants/m²)ˣ		
	4.7	7.0	Mean
No irrigation	87 dy	89 d	88 Dy
One irrigation	80 c	88 d	84 C
Two irrigations	66 b	78 c	72 B
Irrigation according to ETa	54 a	53 a	54 A
$\bar{x}$	73 Ay	78 B	

ˣ Each value is the mean of twenty seven observations
ʸ Values followed by the same lowercase or capital letter are not significantly different.
(P = 0.05) according to Duncan's multiple range test.

Table 5

Effect of irrigation regimes, stand density and sunflower cultivars on disease incidence (%) at Papiano in 1983

Cultivars	Irrigation regimesˣ				Stand densityʸ (plants/m²)		
	NI	1I	2I	E	4.7	7.0	Mean
Cerflor	92 oqᶻ	83 im	80 il	67 eq	80 fi	82 f	81 Cᶻ
Romsun HS 90	98 q	92 np	73 fi	63 df	84 fg	85 fg	84 C
Florom 305	91 mp	81 il	52 cd	41 ab	64 bc	72 de	68 B
Romsun HS 301	93 oq	91 mp	95 pq	88 lp	93 h	91 h	92 C
Romsun HS 52	82 im	71 fi	57 ce	37 ab	53 a	72 d	63 A
Novisol	77 gj	78 hk	61 de	41 ab	61 b	68 bd	65 A
Gloriasol	82 il	73 fi	65 ef	48 bc	64 bc	71 cd	68 B
Stromboli	78 hk	84 jn	68 eh	36 a	66 bd	69 cd	68 B
Solaris	92 oq	94 oq	87 ko	58 ce	79 e	90 gh	85 C
$\bar{x}$	87 Dᶻ	83 C	71 B	53 A	72 Aᶻ	78 B	

ˣ NI = No irrigation ; 1I = One irrigation ; 2I = Two irrigations ;
E = Irrigation according to actual evapo-transpiration. Each value in the mean of six replicates.
ʸEach value is the mean of twelve replicates.
ᶻ Value followed by same lowercase or capital letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Effects of nitrogen fertilization. A linear relationship between nitrogen rates and percentages of infected plants was observed (Fig. 2).

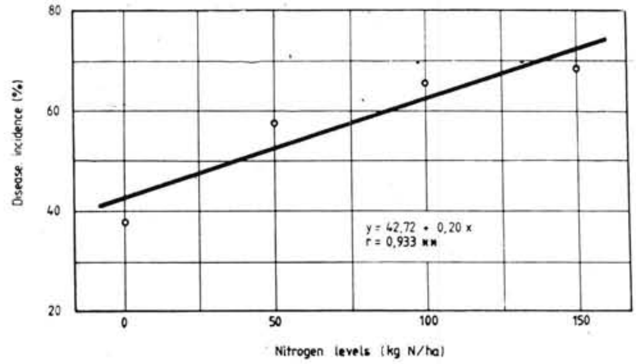

Fig. 2 — Effect of increasing levels of nitrogen on disease incidence at Osimo in 1980

Effects of weed control. The results collected from the trial on weed control are reported in Table 6. The percentage of infected plants increased when chemical herbicides were used. Weed covering was significantly different between treatments, with high values in the untreated control which also gave the lowest yield.

Table 6

Effect of herbicide treatments on disease incidence (%) and yield of sunflower at S. Apollinare in 1983 *

Treatments	Rate (kg a.i./ha)	Disease incidence (%)	Weed cover (%)	Yield (q/ha)
Metobromuron + Prometryn	0.5+1.0	85 c^x	10.5 a	32.2 c
Metobromuron	1.25	80 bc	70.3 c	31.2 bc
Linuron	0.75	76 ac	76.3 c	29.0 b
Unteated control	—	66 ab	199.0	23.1 a
Mechanical control	—	63 a	47.0 b	31.8 bc

x Numbers within columns followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

DISCUSSION

Results of trials over 4 years showed that the incidence of charcoal rot in sunflower is primarily related to rainfall during the preflowering to ripening period.

Low soil moisture content causes reduced activity of microorganisms competing with or antagonistic to *Rhizoctonia bataticola* (Palti, 1981 ; Shokes et al., 1977). Low soil moisture also produced stress in sunflower, increasing its susceptibility to the pathogen (Blanco-Lopez and Jiménez-Diaz, 1983). This consequence is not related to the potential inoculum preexisting in the soil (Alabouvette and Marty, 1977).

Results of stand density trials support the observations made by others (Pustovoit and Borodin), concerning the correlation between plant population and incidence of disease. This is due to competition for water and soil nutrients, which causes a weakening of host plant and an increase in its susceptibility. On the other hand, when plants received an unlimited water supply, stand density had no effect on the disease incidence. Cultivars showed varying degrees of susceptibility to the pathogen. Increasing rates of nitrogen are known to increase incidence of disease in most host-parasite combinations (Palti, 1981). Our results confirm reports (Sivaprakasam, 1975) of increased *Rhizoctonia bataticola* attack on sunflower as a consequence of increasing nitrogen applications.

High rates of nitrogen are known to cause luxuriant plant growth and therefore rapid consumption of the limited soil water supply (Cook, 1973). This, in turn, produces plant water stress resulting in greater susceptibility to the pathogen.

It is difficult to explain the results of herbicides trial. The percentage of diseased plants was high and significantly different from both the controls. Data from Table 6 show an inverse correlation between disease incidence and weed cover, with the only exception of mechanical control. Since weed competition caused decreased yield, it might be expected that weed competition should have resulted in plant weakening and, therefore, in a greater susceptibility to the disease.

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INFLUENCE DE QUELQUES FACTEURS AGRONOMIQUES ET DE MILIEU SUR LA POURRITURE NOIRE DU TOURNESOL

Résumé

On a étudié l'influence des précipitations, des températures moyennes maximales, de la densité des plantes, de l'irrigation, de la fertilisation à l'azote et des herbicides sur l'attaque produite par *Rhizoctonia bataticola (Macrophomina phaseolina)* chez le tournesol, en trois localités du centre d'Italie, pendant 1980—1983.

Les résultats ont montré que : a) la qualité de précipitations tombées pendant la période floraison-maturation a été directement correlée à l'apparition de la maladie ; b) l'augmentation de la densité des plantes a engendré l'intensification de l'attaque du pathogène ; c) l'accroisement de la quantité d'eau disponible du sol a contribué à la diminution de l'attaque ; d) l'augmentation des doses d'azote a favorisé l'incidence de la maladie, et e) les traitements chimiques appliqués contre les mauvaises herbes ont déterminé l'intensification de la maladie.

INFLUENCIA DE ALGUNOS FACTORES AGRONÓMICOS Y DE MEDIO SOBRE LA PODREDUMBRE CARBONOSA DEL GIRASOL

Resúmen

Se ha estudiado la influencia de las precipitaciones, de las temperaturas medias máximas, de la densidad de las plantas, riego, fertilización con nitrógeno y de las herbicidas sobre la intensidad del ataque producido por *Rhizoctonia bataticola (Macrophomina phaseolina)* en el girasol, en tres localidades del centro de Italia, en el período 1980—1983.

Los resultados mostraron que : a) la cantidad de precipitaciones caídas en el período de florecimiento-madurez fue correlada directamente a la aparición de la enfermedad, b) el aumento de la densidad de las plantas determinó la intensificación del ataque del patógeno, c) el aumento de la cantidad de agua disponible en el suelo contribuyó a la reducción del ataque, d) el aumento de las dósis de nitrógeno favorecieron la incidencia de la enfermedad y e) los tratamientos químicos para el combate de la malas hierbas determinaron la intesficación de la enfermedad.