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Alternaria DISEASE DEVELOPMENT UNDER TROPICAL CONDITIONS

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SUMMARY

A field experiment with 12 sowing dates, ranging from February 2, 1989 to January 19, 1990, in monthly intervals, was carried out in a randomized block design, with four replications, with the objective to evaluate the development of *Alternaria* disease in three sunflower genotypes. The disease level was evaluated at 10-day intervals, up to physiological maturity. The interaction between sowing dates and genotypes was statistically significant; furthermore, the genotype Conti 621 showed less disease severity than VNIIMK 8931 and IAC-Anhandy. August sowing date showed, on the average, the lower area under disease progress curve (AUDPC) and disease index (DI), which should be a consequence of the low rainfall during this period.

Key words: ***Alternaria*, disease development, disease severity, *Helianthus annuus*, sunflower**

INTRODUCTION

Alternaria leaf spot, caused mainly by *Alternaria helianthi* (Hansford) Tubaki & Nishihara, is the main sunflower disease in São Paulo State, Brazil. Lack of vertical resistance, low efficiency of fungicidal control, and possibility of occurrence in different plant development stages make the disease a potential problem for sunflower crops. The pathogen can cause leaf, stem, petiole, head and flower spots. The leaf spots are round, necrotic, dark brown with chlorotic halo. These spots enlarge up to 1.5 cm in diameter, and coalesce, causing leaf drying and defoliation in severely infected plants. The stem and petiole lesions are brown linear streaks, that coalesce to form large blackened lesions.

In Brazil, the disease was first observed in 1969 in the States of Pernambuco (Aquino *et al.*, 1971), and São Paulo (Ribeiro *et al.*, 1974). According to Carson (1985), it can cause up to 60% loss, which depend on the cultivar and the weather

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conditions. In India, Balasubrahmanian & Kolte (1980) related grain losses up to 80% caused by *Alternaria* disease in 1995. In China, the yield reduction was 50% (Li & Chi, 1996).

Many factors influence the disease severity. According to Jeffrey *et al.* (1984) the cultural debris are a significant source of inoculum. The weather conditions have great influence in the disease development, specially total rainfall (Sentelhas *et al.*, 1996). Islam and Marić, mentioned by Abbas *et al.* (1995), verified that the disease development was greatly favored by temperatures between 24 and 27°C. Aćimović (1979) determined the temperature between 25 and 30°C as the best for *A. helianthi* infection.

Allen *et al.* (1983) pointed out that the occurrence of epidemics of Alternaria in sunflower are much more frequent and severe in areas with long wet summer together with daily mean temperatures between 25 and 30°C. Godoy & Gimenes Fernandes (1985) discussed the possibility of this disease to become a limiting factor to the sunflower culture expansion in Brazil, specially in the sowings from September to December since at this time the conditions for the fungus development can be ideal.

High humidity is essential for the infection to take place. The conidia need free water for germination and infection (Frezzi *et al.*, 1979; Aćimović, 1979). The infection degree is directly proportional to the water retention period on sunflower plants, increasing faster when the retention period increases from 12 to 48^h (Aćimović, 1979).

The objective of this research was to evaluate the development of *Alternaria* disease in three sunflower genotypes over 12 sowing times.

MATERIALS AND METHODS

The study was carried out in a field experiment with 12 sowing dates ranging from February 2, 1989 to January 19, 1990, in the Experimental Station of Monte Alegre do Sul (Latitude: 22°40'S; Longitude: 46°40'W).

The genotypes used in the experiments were the varieties IAC-Anhandy and VNIIMK 8931, and the hybrid Contisol 621. IAC-Anhandy is an open pollinated variety developed in the Instituto Agronomico (IAC) from cv. Peredovick; VNIIMK 8931 is a Russian variety developed in Krasnodar. They were sown monthly in a randomized block design with four replications.

Disease severity was recorded during the plant cycle, at 10-day intervals, up to physiological maturity. In the evaluations done with 10 plants per plot, the percentage of dried leaves and the foliar area affected by the fungus were studied using a diagrammatic scale proposed by Allen & Brown (1969). With these data a disease index was calculated for each evaluation and the disease amount in each cycle was obtained. The disease index was calculated using the following expression:

$DI = [(A_1 + A_2)/2 + DL]/2$ where,

A_1 = % of disease level on the first live bottom leaf

A_2 = % of disease level on the second live bottom leaf

DL = number of dried leaves multiplied by 100%

With those indices, determined for each evaluation, an *Alternaria* leaf spot progress curve was constructed, and the disease amount calculated using the area under disease progress curve (AUDPC), according to Moraes *et al.* (1988):

$AUCDP = \sum\{[(Y_{i+1} + Y_i)/2\} \{(X_{i+1} - X_i)]\}$ where,

Y_{i+1} = % of disease - infected area in the $i_{th}+1$ observation

Y_i = % of disease - infected area in the i_{th} observation

X_{i+1} = number of days from sowing in the $i_{th}+1$ observation

X_i = number of days from sowing in the i_{th} observation

All data acquired were transformed to DI and AUDPC and submitted to analysis of variance. The Duncan test at 5% was used for mean comparisons.

Table 1: Accumulated disease index[1] for the three genotypes, in twelve sowing dates, under natural field infection. Means of four replications

	Genotype						
Sowing date	IAC-Anhandy		VNIIMK 8931		Conti 621		Mean
15/12/89	226.91 a	A#	219.69 a	A	222.77 a	A	223.12 a
30/10/89[2]	228.81 a	A	214.74 ab	A	210.87 a	A	218.14 a
05/04/89	204.36 b	A	198.37 bc	AB	181.95 b	B	194.89 b
07/03/89	228.29 a	A	188.79 cd	B	159.07 c	C	192.05 b
03/10/89	193.20 bc	A	190.39 cd	A	185.23 b	A	189.61 b
01/09/89	191.21 bc	A	186.95 cd	A	177.28 b	A	185.14 b
05/05/89	166.81 de	AB	172.30 d	A	149.87 c	B	162.99 c
19/01/90	178.25 cd	A	186.91 cd	A	121.95 d	B	162.37 c
02/06/89	157.84 e	B	188.59 cd	A	130.86 d	C	159.10 c
02/02/89	131.53 f	C	175.72 d	A	151.27 c	B	152.84 cd
05/07/89	161.44 de	A	151.29 e	A	127.63 d	B	146.79 d
11/08/89	133.83 f	A	121.41 f	A	119.44 d	A	124.90 e
Mean	183.54	A	182.93	A	161.52	B	
CV(%) = 6.72							

Means followed by the same letter in the column and the same capital letter# in the line are not statistically different by Duncan at 5%.

[1] Sum of individual evaluations of disease index.

[2] Designated as November sowing because the emergency period occurred in November.

RESULTS AND DISCUSSION

The statistical analysis indicated significant differences between the diseases index (DI) and the values of the area under disease progress curve (AUDPC) for sowing dates and genotypes. Table 1 presents the sum of individual evaluations of

DI for the three genotypes. The lowest DI was obtained in August sowing for all cultivars and also in February in the case of cv. IAC-Anhandy. The interaction between sowing dates and genotypes was statistically significant; furthermore, On the average, the genotype Conti 621 showed less disease severity in comparison with the other two. Comparing the DIs, November and December had similar disease levels. According to Figure 1, the DI values of August sowing showed, until 54 days after emergence, the maximum of 13.15% for IAC-Anhandy and, at the end of this cycle, this index did not reach 31%. The low level of disease development presented in August sowing should be a consequence of the low rainfall in the period. In the first 22 days after emergency the total rainfall was 76 mm, which decreased after that, having no rain at all during the flowering period and 95.6 mm between 73rd and 82nd day after emergency.

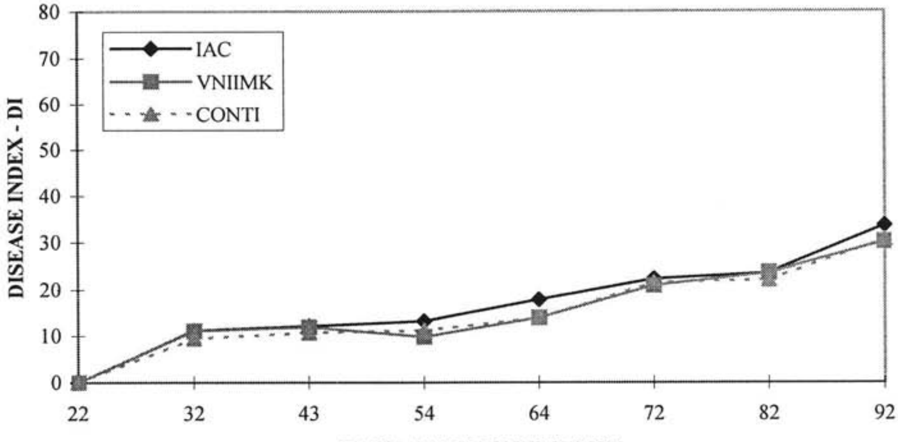

Figure 1: Seasonal patterns of DI in three sunflower genotypes sown in August

According to Godoy & Gimenes Fernandes (1985), the disease can have a fast development under favorable conditions, leading to conspicuous differences each seven days. The same happened in the present research in which, that when the total rainfall between two evaluations showed a significative volume, there was a disease index increasing in the subsequent interval.

The DI data were statistically equal in May, June and January (Table 1). For May (Figure 2) the DI almost did not change, staying between 7 and 15% until the middle of the flowering period; after that, it increased fast till physiological maturity. Between 88th and 99th day after emergence (11 days) the DI doubled, reaching 30% for VNIIMK 8931. Until 68 days after emergence the total rainfall was only 40.5 mm, and the disease was kept at very low levels; between the 69th and the 88th day after emergence the total rainfall was 98.7 mm which favored the disease development and showed that the DI of the following period was almost two times greater, for all cultivars. In the sowing of June, according to Figure 3, the DI stayed near

20% until 94th day after emergence; it jumped up to 30% in the next evaluation and stayed at this level until 115th day after emergence for IAC-Anhandy and Conti-621.

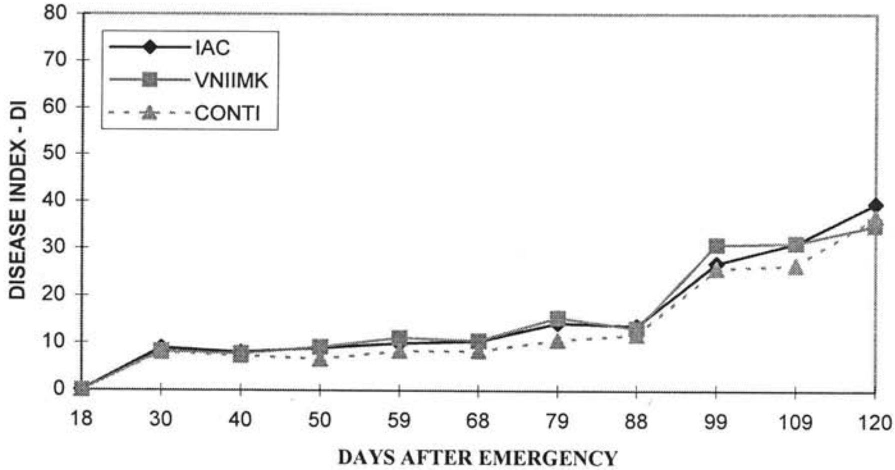

Figure 2: Seasonal patterns of DI in three sunflower genotypes sown in May

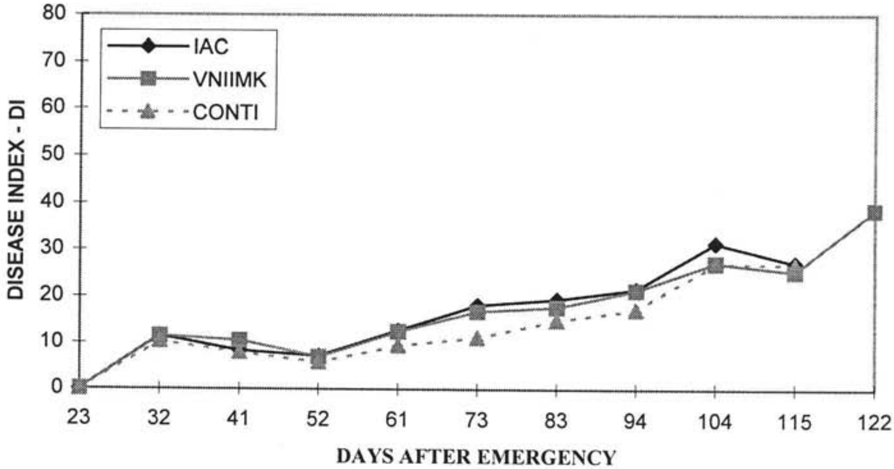

Figure 3: Seasonal patterns of DI in three sunflower genotypes sown in June

As the genotypes evaluated in the present research showed cycle interaction with sowing time, they sometimes presented different total cycles, and the number of observations were not the same in all growing seasons. According to Allen *et al.* (1983), the susceptibility to *A. helianthi* changes at different development stages of the sunflower plant. Sowings in May and June resulted in the larger life cycles of sunflower cropp. As VNIIMK 8931 enlarged its life cycle, compared with the other genotypes, in June sowing (Figure 3), its DI almost reached 40% at the end of the cycle, although the initial DIs were not high. The same happened for May sowing (Figure 2) but for all cultivars.

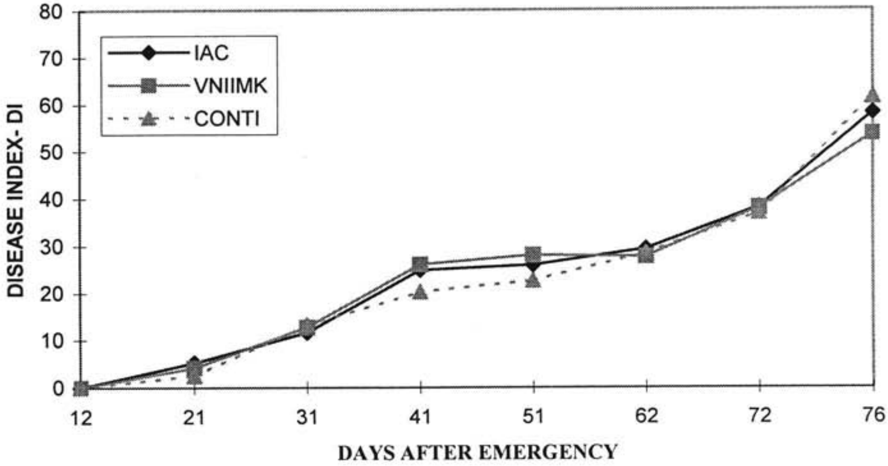

Figure 4: Seasonal patterns of DI in three sunflower genotypes sown in October

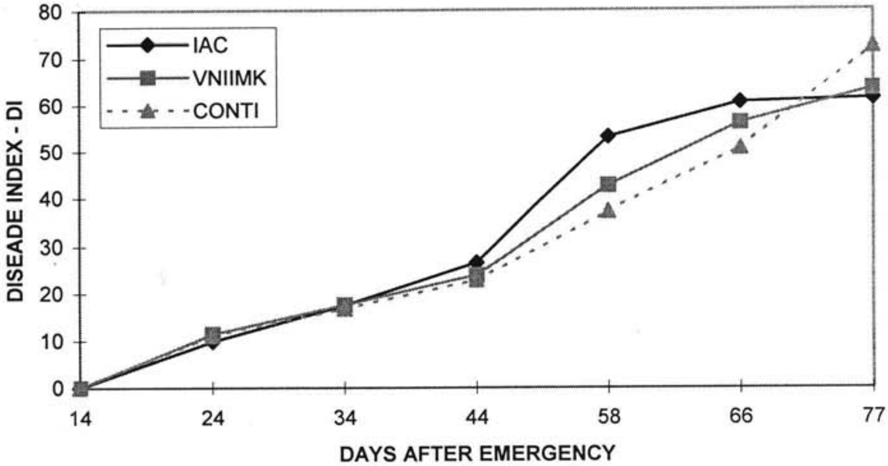

Figure 5: Seasonal patterns of DI in three sunflower genotypes sown in November

During the first 30 days after emergence, the disease was maintained at low levels (DI= 11-13%) and in the subsequent 40 days it increased about four times in the sowing in October (Figure 4). November showed the DI near 10% only 24 days after the emergence and just before harvest it reached more than 70% for Conti 621 (Figure 5). At the same periods, the sowing of December showed 25% in the 4^{th} week after emergence and near 40% at physiological maturity (Figure 6). In relation to disease index the sowing in February was classified between the lowest ones only for cv. IAC-Anhandy (Figure 7).

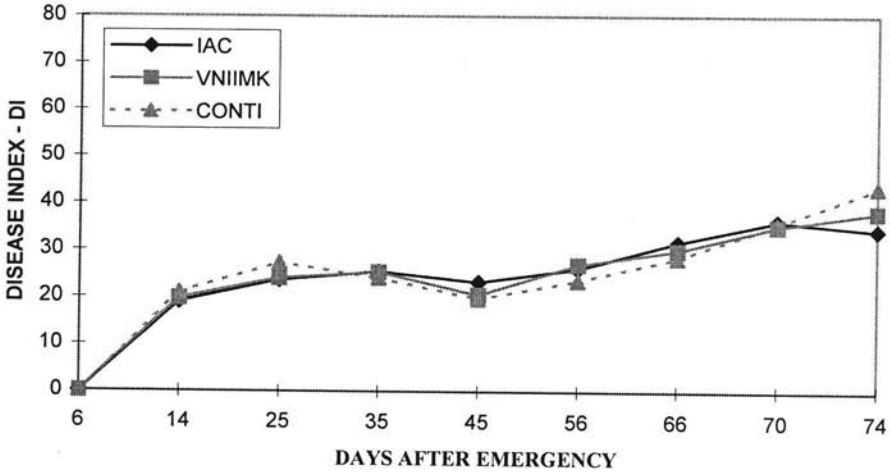

Figure 6: Seasonal patterns of DI in three sunflower genotypes sown in December

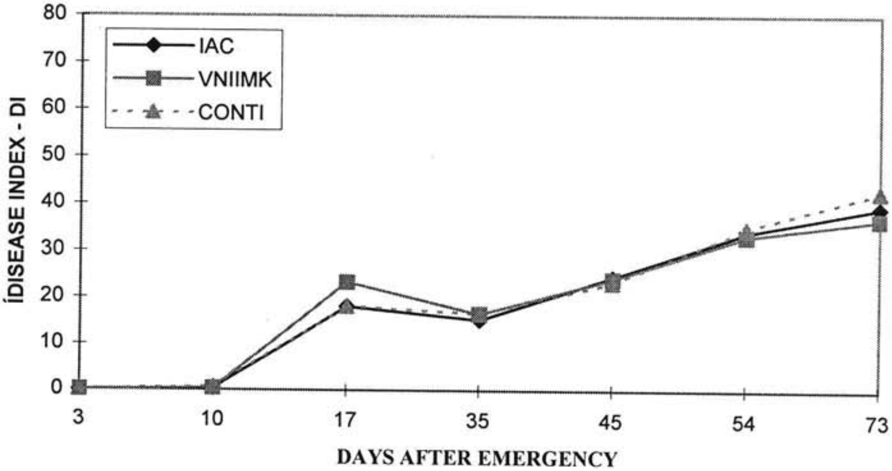

Figure 7: Seasonal patterns of DI in three sunflower genotypes sown in February

Table 2 shows the AUDPC for all cultivars and sowing times. Mean AUDPC for July and January sowings was 15% and 33% higher, respectively, than August sowing; however, the AUDPC for Conti 621 was not statistically different in those three sowing dates. May and June presented intermediate data for AUDPC. The AUDPC for May was statistically equal to January sowing date, except for Conti 621. November showed the highest AUDPC, followed by December (Table 2). Data of AUDPC for the sowing in March, April and October were intermediate.

Table 2: Area under the curve of disease progress (AUCDP) in three sunflower genotypes evaluated in twelve sowing dates under natural field disease infection. Means of four replications

	Genotype						
Sowing date	IAC-Anhandy		VNIIMK 8931		Conti 621		Mean
30/10/89	2024.47 a	A#	1939.22 a	AB	1854.48 a	B	1939.39 a
15/12/89	1875.15 abc	A	1836.95 abc	A	1819.47 a	A	1843.86 b
03/10/89	1856.06 bc	A	1842.93 abc	A	1765.00 a	A	1821.33 b
02/02/89	1522.42 ef	B	1943.17 a	A	1579.42 b	B	1691.67 c
05/04/89	1758.27 cd	A	1762.43 bcd	A	1542.54 b	B	1687.75 c
07/03/89	1978.36 ab	A	1693.60 cde	B	1333.77 cd	C	1668.58 c
01/09/89	1647.65 de	A	1608.90 de	A	1465.29 bc	B	1573.95 d
02/06/89	1489.62 ef	B	1896.77 ab	A	1213.30 d	C	1533.23 d
05/05/89	1560.83 ef	A	1589.25 e	A	1355.26 cd	B	1501.78 de
19/01/90	1573.26 e	A	1642.22 de	A	1068.18 e	B	1427.88 e
05/07/89	1410.30 f	A	1304.38 f	A	1008.20 e	B	1240.96 f
11/08/89	1154.34 g	A	1050.61 g	A	1027.11 e	A	1077.35 g
Mean	1654.23	A	1678.37	A	1419.34	B	
CV(%) = 6.45							

Means followed by the same letter in the column and the same capital letter# in the line are not statistically different by Duncan at 5%.

Conti 621 showed, in all sowing times, lower or equal accumulation of DI and AUDPC than the other genotypes (Tables 1 and 2). This fact is probably related to the hybrid precocity since Sentelhas et al. (1996) related that Conti 621 susceptibility to *Alternaria* leaf spot was greater than in VNIIMK 8931.

The level of disease incidence seems not to be strongly related to the primary inoculum; the disease evaluations were realized during the second year of trial, in area with great amount of initial inoculum since the disease appeared in the previous sowings and the debris stayed in the field. The variation in the disease level was clearly related to climatic factors, already discussed by Sentelhas *et al.* (1996).

Figures 5 and 6 exhibit the disease progress curves for November and December sowing dates, which presented the higher mean values for the AUDPC and corresponded to the periods of the greatest rainfall amount, reaching more than 600 mm for the whole culture cycle.

The difference between the genotypes susceptibility level in sunflower lines was discussed by Carson (1985) and by Lipps & Herr (1986) for 497 *Helianthus annuus* introductions.

The climatological data of the studied cycles with great level of *Alternaria* incidence presentèd high humidity and temperature (Sentelhas et al., 1996), which agree with Allen *et al.* (1983). Frezzi *et al.* (1979) and Aćimović (1979) observed that the conidia need between one and two hours of free water in order to germinate and to develop the infection. The infection rate increases fast when the water retention goes up to 48 hours (Aćimović, 1979).

In a greenhouse inoculation done by Moraes *et al.* (1983), it was observed that young leaves had isolated necrotic spots while in the old leaves the spots tend to be coalescent, the leaves present increasing dried areas, and often fall down seven days after inoculation, leading to an early senescence.

CONCLUSIONS

The genotypes showed different levels of disease susceptibility. Conti 621 was less susceptible than the others genotypes.

Conti 621 showed the lowest DI in the sowings in January, June, July and August; VNIIMK 8931 was less affected by the disease in the sowing in August, and IAC-Anhandy, in the sowing in August and February.

The level of disease incidence was not strongly related to primary inoculum.

There was a clear relationship between disease level and climatic factors.

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DESARROLLO DE LA ENFERMEDAD ALTERNARIA EN CONDICIONES TROPICALES

RESUMEN

Un campo experimental fue sembrado mensualmente del febrero de 1989 al enero de 1990, con el objetivo de evaluar el desarrollo de la enfermedad Alternaria en tres genotipos de girasol, siguiendo un diseño de bloques aleatorios con cuatro repeticiones. El nivel de la enfermedad fue evaluado en un intervalo de 10 días hasta la madurez fisiológica. La interaccción entre las fechas de siembra y los genotipos eran estadísticamente significativas; además, la severidad de la enfermedad era menor en el genotipo Conti 621 que en VNI-IMK 8931 e IAC-Anhandy. La fecha de siembra de agosto mostraba, en general, el nivel más bajo área bajo la curva del progreso de la enfermedad (AUCDP) y de índice de la enfermedad (DI), lo cual podría ser una consecuencia de la baja pluviosidad durante este periodo.

DEVELOPPEMENT DE LA MALADIE ALTERNARIA EN CONDITIONS TROPICALES

RÉSUMÉ

Un champ expérimental a été planté mensuellement, de février 1989 à janvier 1990, avec pour objectif, l'évaluation du développement de la maladie Alternaria pour trois génotypes de tournesol, selon un dispositif de blocs aléatoires avec quatre répétitions. Le niveau de la maladie a été évalué tous les 10 jours jusqu'á la maturité physiologique. L'interaction entre dates de plantation et génotypes est significativement différente; deplus, la sévérité de la maladie a été moins importante sur le génotype Conti 621 que sur VNIIMK 8931 et IAC-Anhandy. La date de plantation d'août a montré, en moyenne, la plus baisse aire en dessous de la courbe du progrès de la maladie (AUCDP) et le plus bas index de la maladie (DI), ceci pourrait être la conséquence de la faible pluviosité pendant cette période.