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CLIMATOLOGICAL FACTORS AFFECTING THE STRAWBERRY LEAF SPOT DISEASES

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ABSTRACT: *Strawberry leaf spots caused by Mycosphaerella fragaria (Tul.) Lindau , Alternaria alternata (Fr.) kessler f. sp. fragariae. Dingley and leaf blight Dendrophoma obscurans (Ell. & Ev.) Sutton are the most important diseases on strawberry in Egypt especially under drip irrigation used in nurseries or warm humid weather in the productive areas.*

The optimum temperatures for M. gragariae, D. obscurans, A. alternata f. sp. fragariae were (20, 25 and 30°C, respectively) while the reverse was true according to relative humidity as the optimum R.H. for M. fragariae, D. obscurans, A. alternata f. sp. Fragaria were (100%, 95% and 84%, respectively).

Macroclimate meteorological factors provided a strong statistical correlation with strawberry leaf spot incidence. The lowest disease incidence related with the lowest amount of relative humidity (48-52%), the lowest rainfall value (0.0-0.3 ml), the lowest wind speed (1.2 Km/h), the highest number of sunshine duration hours (10 h/day) and a varied scale of air temperature for different strawberry leaf spot pathogens (20-30°C). On the contrary macro-climate meteorological factors were recorded in the case of the highest disease occurrence as the relative humidity was (70-80%), rain fall was (13.7-18.5 ml, wind speed was (3 Kg/h), sunshine duration was (13.5 h/day) and temperature degree was (18-22°C).

The most important micro-climate meteorological factors were relative humidity (78.7-85.0%) and leaf wetness (4.7-5.0µ) also proved satisfactory correlation with strawberry leaf spots occurrence. The highest disease incidence was correlated with the highest percent of relative humidity (55.9-58.4%), the highest leaf wetness (0-0.1µ). Whereas lower values of both mentioned micro climatological factors were recorded during the lowest disease incidence.

Key words: Strawberry, Leaf spots, Climatological factors.

INTRODUCTION

Strawberry (*Fragaria vesca* L.) is considered one of the most favorite and tasty fruits in Egypt, Arabic and European countries. The weather influences the distribution of this important plant diseases.

Fall (1951) reported that *M. fragariae* showed no growth at 35C. It was optimum for growth at 25C and still evident at 5C and conidia were killed at 35C. Spore production occurred between 5 to 30C with optimum at 20 to 25C. Conidia failed to germinate below 98% relative humidity and the germination being at maximum at 15C. and nearly as good at 20C. Nemec (1972) found that the most normal lesions of *M. fragariae* on plant grown during warm days and nights or warm days and cool nights and the optimum growth occurred at 18 - 24 C.

On the other hand, frequent rains or dew are necessary for sporulation of *Alternaria* on the lesion of tomato plants, but spores; mainly wind dispersed; where the maximum concentration of spores in the air was observed daily during the driest and windiest hours (Rotem ,1964 and Richard,1964). Whereas Rotem and Palti (1969) indicated by different ways in which irrigation affects plant disease epidemics. The physiology of the host crop may be sufficiently affected as to change in predisposition to disease. Trellised tomatoes dry quickly, whereas the foliage in dense banana plantation may stay wet four hours after sprinkler irrigation. These decrease the leaf, and canopy temperature, as well as, increases the relative humidity, and may prolong dew periods, also irrigation may affect spore production and spore discharge of some fungi as well as splash dispersal. Therefore Waggoner and Horsfall (1969), published a stimulator of epidemics of *A. solani* disease written for computer as the first trail in the field of plant pathology. They reported that an epidemic marching through a population of plants reflects the integration of a very large number of factors in the environment and characteristics in pathogen and host. These act and interact on each other in a fabulous array that boggles the mind. This stimulator called EPIDEM employs the temperature, relative humidity, wind speed, sunniness and wetness for each 3 hours of each day.

Abd El-Rahman, (1979) concluded that hundred percent and 95% R.H. were more favourable for the growth rate of *D. obscurans* while the highest sporulation was recorded at 73-90%. She added that the highest percentage of infection in greenhouse was obtained at 100% when incubated at 20 and 27C for *M. fragariae* and *D. obscurans*, respectively.

Elliott (1988) recorded that the longistic rate of germination of *M. fragaria* conidiophores reached its maximum at 22.4C. The maximum fraction of germination was constant at 0.94 from 5 to 30C, but dropped sharply between 30 and 35C. He added that no germination was seen below 98% R.H

and the germination rate at 98-100% did not differ from germination with free moisture.

The present investigation represents the results of the effect of the meteorological factors or physical conditions (Macro and Microclimate) which are actually in charge of the host-pathogen relationship and greatly affect the complex interaction in such relation either by direct or indirect ways, including the disease development operation, and the build up of epidemics.

MATERIALS AND METHODS

A. Effect of different temperatures and relative humidity on linear growth of strawberry leaf spot pathogens:

The linear growth of *M. fragaria, D. obscurans* and *A. alternaria* f. sp. *fragaria* was measured at different temperatures i.e, 5, 10, 15, 20, 25, 30, 35 and 40C. The effect of each temperature was estimated at different relative humidities, 100, 95, 90, 84, 73, 65, 50 and 14.5. These different relative humidity percentages were offered around the fungi inoculated inside the Petrl-dishes by using different concentrations of sodium chloride and potassium hydroxide solutions according to Solomen 1951. The inoculated Petri-dishes were turned up-side down and ten ml of the particular solution were poured in the lid of each dish. The experiment was conducted in split plot design with three replicates.

B. Effect of Macro-climatelogical factors:

The monthly means of temperature, relative humidity, wind speed, rainfall and possible sunshine duration in the field for two successive seasons 1994/1995 and 1995/1996 at Giza, Kalubia, Sharkia and Ismaillia Governorates have been obtained from the Egyptian General Meteorological Authority, Koubry El-Qoubba, Cairo, Egypt.

Percentage of infection and disease severity of strawberry leaf spots observed and recorded as monthly means during1994/1995 and 1995/1996 at the previously mentioned four Governorates.

All macroclimate elements were statistically analyzed, correlated and computed to investigate and end up with the major factors playing the most effective role in disease severity. The analysis was carried out using the ready made software computer program "Storm" University of Cleveland Copyright 1996, and the microsoft Excel for windows 95.

The (monthly mean) macroclimate data are arranged in columns as follows :

Tem : The monthly mean air temperature

R.H. : The monthly mean relative humidity

W.S : The monthly mean wind speed (m/sec.)

R.F : The monthly mean amount of rain fall.

P.S.D: Total sunshine duration (all over the month).

Using such software & cross correlation performed between the percent of disease severity and each of the above meteorological parameters.

ANOVA analysis:

Using the Analysis of Variance (ANOVA) to figure out the source of variation, degree of freedom (df), critical F values and the significance level of treatment F test which indicated that there are some significant differences among treatment level means, when the interaction is significant, we can compare the treatment means at each parameter separately. So, both macroclimate elements (factors) and disease data (% of severity) were evaluated for normality to insure that parametric methods are appropriate, through statistical multiple regression model:

$$y = a + bX_1 + CX_2$$

Where a,b and c are constants.

The coefficient of multiple correlation is defined by :-

$$R = \frac{(R_1)^2 + (R_2)^2 + (R_3)^2 + 2R_1 R_2 R_3}{1-(R_3)^2}$$

Where R_1 is correlation coefficient between y and X_1, R_2 is correlation coefficient between y and X_2 and R_3 is correlation coefficient between X_1 and X_3. The regression equation of y on X_1,X_2 and X_3 can be written as :

$$y = a + bX_1 + cX_2 + d X_3$$

Where a, b, c and d are constants.

C. Effect of micro-climatelogical factors:

The microclimate elements in strawberry canopy such as, temperature (c), relative humidity (%), precipitation (mm), wind speed (km), wind direction (o) and leaf wetness (u), have been collected, sent to the computer and calculated as monthly means using the most advanced Agro-measuring station. The station is equipped with a transmitter and receiver, collected weather data is transmitted to a central unit via various regional station and to the main computer for evaluation and analysis, covering large geographical area (about 1000 feddans). The direct radio range up to 20 km.

The station has a solar unit to keep it independent of external electrical connections. The microclimate conditions were obtained throughout 1996/1997 at Sharkia Governorate and 1998 at Ismaillia Governorate. The experiment was carried out under field condition, plants were left to natural infection, the percentage of infection and disease severity on Shandler cultivar. were observed and recorded as monthly means, the micro-climate data were studied to figure out the most favourable time for strawberry leaf

spots infection and severity and to compare the correlation of both macro and micro-climate on disease incidence.

RESULTS

Climatological factors affecting the strawberry leaf spot pathogen interactions:

1. Effect of different temperatures and relative humidity degrees on linear growth of strawberry leaf spot pathogens:

The effect of temperature degrees and percentages of relative humidity as shown in Table (1) revealed that the optimum temperature for *M. fragariae* linear growth was 20C. as the fungus grew slowly at lower or higher temperatures. Also, the highest linear growth was noticed at 100% relative humidity and the growth decreased as the relative humidity was less. On the other hand, higher temperature and lower relative humidity are more favorable to both *D. obscurans* and *A. alternata* f. sp. *fragariae* than *M. fragariae* and the optimum was 30C for *A. alternata* f. sp. *fragariae* and the optimum relative humidity for *D. obscurans* was 95% while 84% R.H. was optimum for *A. alternata* f. sp. *fragariae*.

2. Effect of macro-climatelogical factors:

2.1. Temperature:

Data presented in Tables (2, 4 and 6) indicate that the recorded temperature degrees all over Kalubia, Sharkia and Ismailia during 1994/95 and 1995/96 were relatively high through October and ranged from 25-28C. then gradually decreased during November and December to reach the lowest level (12-14C) in February. During the spring time (March-April and May); the temperature gradually re-increased to reach (23-25.7C). The highest strawberry leaf spots occurred in November in locations of the mentioned Governorates where the temperature degree ranged from 18-21C. However, the disease severity decreased through lower or higher temperature degrees.

The temperature through June in Giza Governorate, where the temperature in the strawberry nurseries sown at April, was 28C, then it gradually increased during summer time to the maximum degrees which ranged from 34-36C, in both seasons then re-decreased through autumn time (September, October and November) to reach (20-28C). Continuous gradual decrease in temperature recorded during December to reach its minimum temperature (13C.). It is very clear in Table (6) that both percentage and severity of infection with strawberry leaf spots were very low during May-April) then obviously increased during (November-December), recording the maximum infection rate through December.

Table (1): Linear growth (Cm.) of strawberry leaf spot pathogens under different temperature and relative humidity degrees in vitro.

Fungi	Tem.	RH								Mean	General mean
		14.5	50	65	73	80	84	95	100		
Mycosphaerella fragariae	5°C	0	0	0	0	0	0	3	3	0.75	4.31
	10°C	0	0	0	0	3	4	6	10	2.88	
	15°C	0	0	0	0	5	13	21	23	7.75	
	20°C	0	0	0	4	7	22	27	30	11.25	
	25°C	0	0	0	3	6	14	22	27	9	
	30°C	0	0	0	0	0	3	7	10	2.5	
	35°C	0	0	0	0	0	0	0	3	0.37	
	40°C	0	0	0	0	0	0	0	0	0	
	Mean	0	0	0	0.87	2.63	7	10.8	13.3		
Dendrophoma obscurans	5°C	0	0	0	0	0	0	4	0	0.50	20.5
	10°C	0	0	0	0	0	0	5	4	1.15	
	15°C	0	0	0	0	0	3	8	8	2.38	
	20°C	0	0	13	23	35	51	74	71	33.38	
	25°C	0	0	28	47	60	71	85	80	46.38	
	30°C	0	0	28	41	55	67	81	77	43.63	
	35°C	0	0	2	14	43	64	77	72	34.00	
	40°C	0	0	0	0	0	4	99	8	2.63	
	Mean	0	0	8.8	15.6	24.1	33.4	42.9	40		
A.alternata f.sp. *fragariae*	5°C	0	0	3	4	3	4	1	2	2.13	31.16
	10°C	0	5	7	11	11	15	11	13	9.13	
	15°C	0	5	7	13	47	63	37	25	24.64	
	20°C	0	35	45	61	49	55	45	31	40.13	
	25°C	3	39	45	65	65	79	75	73	55.50	
	30°C	0	2	55	65	65	83	81	73	53.00	
	35°C	0	1	9	55	55	75	75	69	37.38	
	40°C	0	0	0	46	49	61	59	45	27.83	
	Mean	0.380	10.9	21.4	43	43	54.4	48	41.4		
General mean (RH)		0.13	3.36	10.1	23.3	23.3	31.6	33.9	31.5		

LSD at 1 % level:

Fungi (F)	=	0.331	FXT	=	0.953
Temperature (T)	=	0.540	FXR	=	0.953
Relative humidity (R)	=	0.540	TXRR	=	1.527
			FXTXR	=	2.645

2.2. Relative humidity:

At the beginning of growing seasons of both 1994/95 and 1995/96 at Kalubia, Sharkia, and Ismaillia Governorates the percent relative humidity ranged from 60-65% through October, then gradually increased during October and November to reach the maximum rate (70-76%) then decreased to a moderate range (65-70%) during winter time (December-February) and continuous decrease in the relative humidity was recorded through spring time (March-April and May) to reach the minimum range (50-55%).

In most growing areas as shown in Tables (2, 4 and 6) the highest percentage of infection and disease severity of strawberry leaf spots were correlated also with maximum ranges of relative humidity particularly during November. During the period from October to December in particular with December in strawberry nurseries at Giza Governorate

2.3. Rain fall:

It is also clear from Tables (2, 4 and 6) that the rate of rainfall was sharply high during 1994/95 season (ranged from 6.5 to 18 mm) during October, November and December at Sharkia, Kalubia and Ismailia, while at Giza Governorate (4.3 mm only). Other rainfall was recorded at the three previous Governorates during March but it reached not more than 2 mm, so it is clear that there is an obvious positive correlation between rainfall and strawberry leaf spot disease, the more rainfall the higher disease severity occurred, particularly during November 1994/1995.

2.4. Period of sun duration :

Tables (2, 4 and 6) indicate also that the lowest period of sun duration (PSD) happened during November, December and January and PSD ranged from 10.2-11.2 h. /day during this period. In most cases data showed that the highest severity of infection was recorded during November and December.

Positive correlation between the weather parameters in different Governorates was recorded in (Tables 3 and 5).

Table (2): Effect of climatelogical factors on percentage of strawberry leaf spots infection and severity at Kalubia Governorate.

Year	Month	TEM.	R.H.	W.S.	R.F.	P.S.D.	% of infection	Severity of infection %
94 – 95	Oct.	22.6	65	1.1	0.1	11.8	38.75	26.19
	Nov.	19.6	74	1.3	18.5	10.9	47.25	33.66
	Dec.	12.2	74	1.2	0.9	10.3	47.50	38.64
	Jan.	14.0	71	2.1	0.0	10.3	51.50	40.31
	Feb.	12.8	56	2.4	0.0	10.9	49.75	39.71
	Mar.	14.1	67	2.5	1.4	11.7	49.50	38.95
	Apr.	18.5	54	2.0	0.0	12.6	43.25	33.05
	May.	20.9	54	1.8	0.0	13.4	47.50	32.15
95 - 96	Oct.	23.7	69	1.7	0.0	11.8	42.50	29.25
	Nov.	19.4	71	1.9	0.0	11.1	45.25	31.50
	Dec.	13.1	74	0.8	0.0	10.3	48.50	33.67
	Jan.	14.5	65	2.4	0.9	10.3	44.75	29.92
	Feb.	15.5	56	2.5	1.4	11.1	45.75	33.07
	Mar.	15.7	52	3.0	0.6	10.9	46.75	34.56
	Apr.	17.6	66	2.4	0.0	12.6	39.25	28.05
	May.	23.2	57	2.4	0.0	13.4	36.75	26.23

TEM= Temperature R.H. =Relative humidity W.S =Wind speed

R.F.= Rain fall P.S.D.=Possible sunshine duration

Table (3) : Correlation between macro-climatelogical factors and percentage of disease severity at Kalubia Governorate

Year	Variables	TEM	R.H.	W.S.	R.F.	P.S.D.	Severity %
94 - 95	TEM	1					
	R.H.	- 0.35343	1				
	W.S.	- 0.26883	-0.49018	1			
	R.F.	0.411818	0.500297	-0.52487	1		
	P.S.D.	0.729217	-0.76719	0.195469	-0.21913	1	
	Severity %	-0.9496	0.402064	0.389281	-0.34547	-0.75465	1

	Variables	TEM	R.H.	W.S.	R.F.	P.S.D.	Severity %
95 - 96	TEM	1					
	R.H.	-0.23376	1				
	W.S.	0.288548	-0.84432	1			
	R.F.	-0.44165	-0.52305	0.456675	1		
	P.S.D.	0.852974	-0.30242	0.318189	-0.41734	1	
	Severity %	-0.72221	-0.0176	-0.16954	0.387561	-0.7999	1

Table (4): Effect of climatelogical factors on percentage of strawberry leaf spots infection and severity at Sharkia Governorate.

Year	Month	TEM.	R.H.	W.S.	R.F.	P.S.D.	% Infection	Severity of infection %
94 – 95	Oct.	27.7	63	2.6	0.1	11.7	27.75	18.90
	Nov.	20.7	96	2.1	6.8	10.9	67.25	45.15
	Dec.	13.3	67	2.5	0.6	10.3	32.25	23.89
	Jan.	15.1	64	2.9	0.0	10.3	28.50	16.81
	Feb.	14.0	52	2.6	0.0	10.9	25.25	18.25
	Mar.	15.6	61	3.0	2.0	11.7	28.75	18.00
	Apr.	20.4	49	2.6	0.0	12.6	25.50	18.25
	May.	22.6	50	3.0	0.0	13.4	26.75	21.00
95 - 96	Oct.	25.4	61	3.1	0.0	11.7	36.50	22.75
	Nov.	21.2	73	1.5	0.0	10.6	42.50	29.25
	Dec.	14.6	66	1.8	0.0	10.3	37.75	22.05
	Jan.	13.8	70	1.8	0.0	10.6	32.75	18.90
	Feb.	16.8	49	3.6	0.4	11.1	28.25	17.75
	Mar.	16.7	46	4.0	1.0	10.9	27.50	17.90
	Apr.	19.4	56	3.4	0.0	12.6	34.50	25.15
	May.	25.7	48	3.9	0.0	13.4	33.25	21.18

TEM = Temperature R.H = Relative humidity W.S = Wind speed

R.F. = Rain fall P.S.D = Possible sunshine duration

Table (5) : Correlation between macro-climatelogical factors and percentage of disease severity at Sharkia Governorate.

Year	Variables	TEM	R.H.	W.S.	R.F.	P.S.D.	Severity %
94 - 95	TEM	1					
	R.H.	0.058985	1				
	W.S.	-0.07719	-0.70595	1			
	R.F.	0.292686	0.91605	-0.67878	1		
	P.S.D.	0.772874	-0.51555	0.401389	-0.2158	1	
	Severity %	0.374191	0.899799	-0.80969	0.929016	-0.19733	1

	Variables	TEM	R.H.	W.S.	R.F.	P.S.D.	Severity %
95 - 96	TEM	1					
	R.H.	-0.29844	1				
	W.S.	0.367828	-0.98355	1			
	R.F.	-0.23304	-0.61811	0.56748	1		
	P.S.D.	0.778728	-0.55509	0.648035	-0.20775	1	
	Severity %	0.429451	0.566477	-0.48577	-0.55976	0.067636	1

3.Effect of micro-climatelogical factors:

Data in Tables (6) and (7) indicate the relation between the average of weather station output microclimatological factors in the strawberry canopy throughout 1996/1997 in Sharkia and 1997/1998 in Ismailia (Salhia) and the strawberry leaf spots severity which calculated from the period extended from October to May of both seasons. It is very clear that the highest percentage of infection and disease severity (67.75% and 46.19% respectively) occurred in December 1996 in Sharkia through the lowest temperature degree (12.3C) in the strawberry canopy, the highest relative humidity (79.1%), the highest leaf wetness (0.6 μ) and the lowest wind speed (3.4 Km/h). On the other hand, the lowest infection and severity (20% and 11.91% respectively) were recorded in May when the temperature increased to 15.8 and relative humidity decreased to 75.7%, the leaf wetness disappeared (0μ) and wind speed increased to 4.3 Km/h.

The same correlation between the weather station output microclimatological factors in the strawberry canopy throughout 1996/1997 in Ismailia-Salhia and the strawberry leaf spots disease was approximately recorded in Table (7). It is clear that the maximum percentage and severity of infection (65.5% and 39.5% respectively) were occurred in February when temperature, maximum relative humidity, maximum leaf wetness and wind speed were (14.1C, 78.7%, 5 μ and 15.9 Km/h respectively). Whereas the lowest infection (33.5%) and the lowest severity (12.01%) were recorded during the highest temperature (24-3C), the lowest relative humidity (55.9%), the lowest leaf wetness (2.8 μ) and the lowest wind speed (7.6 Km/h).

Table (6) : Leaf spot infection in correlation to the average of weather station output microclimate data in the strawberry canopy throughout 1996 / 1997 in Sharkia .

Year	Month	Tem.	R.H.	P.	W.S.	W.D.	L.W.	% of infection	severity of infection %
96 / 97	Oct. 96	15.7	75.6	0	4.2	225.8	0.4	24.75	12.90
	Nov. 96	12.6	75.8	0	3.4	211.2	0.5	66.25	39.25
	Dec. 96	12.3	79.1	0	3.4	201.4	0.6	67.75	46.19
	Jan. 97	15.5	75.7	0	4.6	226.4	0.1	25.25	12.80
	Feb. 97	16.4	76.7	0	4.1	225.3	0	24.25	11.75
	Mar. 97	15.8	75.7	0	4.2	223.5	0	22.00	13.20
	April 97	15.9	76.5	0	4.0	222.5	0	23.25	12.25
	May 97	15.8	75.7	0	4.3	223.5	0	20.00	11.91

Tem.= Temperature (°C) W.S.= Wind speed (Km)

R.H.= Relative humidity(%) W.D.= Wind direction (O)

P.= Precipitation (mm) L.W.= Leaf wetness (U)

Table (7) : Leaf spot infection in correlation to the average of weather station output microclimate data in the strawberry canopy throughout 1997 / 1998 in Ismaillia – (Salhia) .

Year	Month	Tem.	R.H.	P.	W.S.	W.D.	L.W.	% of infection	severity of infection %
97/ 98	Oct. 97	11.9	85.0	0	14.6	221.1	5.4	37.50	19.31
	Nov. 97	13.9	72.9	0.1	16.1	224.3	3.3	41.00	21.45
	Dec. 97	14.3	76.4	0.1	19.9	228.6	4.7	43.25	18.75
	Jan. 98	12.6	76.5	0	16.1	226.7	3.9	54.25	20.09
	Feb. 98	14.1	78.7	0.1	15.9	232.2	5.0	65.50	39.50
	Mar. 98	14.6	69.3	0.1	16.3	231.8	3.2	44.75	29.18
	April 98	20.00	58.4	0	7.5	239.8	4.0	35.75	12.55
	May 98	24.30	55.9	0	7.6	240.3	2.8	33.50	12.01

Tem.= Temperature (C) W.S.= Wind speed (Km)

R.H.= Relative humidity (%) W.D.= Wind direction (O)

P.= Precipitation (mm) L.W.= Leaf wetness (U)

DISCUSSION

Several fungal diseases such as powdery mildew, red steel, crown rots, root rots, fruit rots and leaf spots attack strawberry plants. Meteorological factors or physical conditions (Macro and Microclimate) which are actually in charge of the host-pathogen relationship, greatly affect the complex interaction in such relation as direct and indirect effects, including the disease development operation, and the build up of epidemics. Disease forecasts are useful to the farmers in practical management of disease of their crops. They provide advanced worming of the likelihood that disease will occur, so that measures can be taken before the critical period arrives. Reach aimed at accurate forecasting helps us to identify information gaps in our knowledge, since they are based on detailed knowledge of the infection cycle.

Laboratory test, revealed that 20C and 100% relative humidity were the optimum degrees for the maximum linear growth of *M. fragaria*, while 25C and 95% R.H. were the optimum for the maximum growth of *D. obscurans* while 30C and 84% R.h. were the optimum for *A. alternata* f. sp. *fragariae*. These conclusions are in complete agreement with Fall (1951), Nemec (1972), Madden *et al.* (1978) and Abd El-Rahman (1978).

Hence, it is obviously to conclude that eye bird leaf spot (*M. fragariae*) may appear at the beginning of the growing season during the period extending from the first of October to the mid of March, whereas brown spot (*A. alternata* f.sp. *fragariae*) may be occurred during the period extending from March to May. *Dendrophoma obscurans* may appear at October and November then re-occurred through springtime.

The results proved that the three pathogens of strawberry leaf spots varied in their favourable temperature and relative humidity requirements. This is in complete agreement with Fall (1951), Nemec (1972), Abd El-Rahman (1979), Becerra (1988) and Elliott (1988).

One of the most important results of this research is the correlation between the disease infection occurrence and the Macro-climatological factors as temperature, relative humidity, Rainfall, wind speed and period of sun duration as well as the micro-climatological factors in the canopy of the strawberry plants as temperature, relative humidity, leaf wetness, wind speed which determined by the early warning apparatus in Ismailia and Sharkia Governorates.

Our results in open fields showed that the maximum strawberry leaf spots infection and severity occurred, in general, during the period from October to December seasons (1994/1995 and 1995/1996) where the microclimatological factors as lower temperature ranged from (18-21C), the highest relative humidity (70-76%) and rate of rainfall (6.5-18 mm) and the longest period of sun duration (10.2-11.2 h/day). This conclusion is confirmed by the previous laboratory results particularly the effect of temperature and relative humidity and also it is in harmony with Madden *et al.* (1978).

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العوامل الجوية المؤثرة على أمراض تبقعات الأوراق فى الفراولة

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الملخص العربى

أثبتت التجارب أن درجة الحرارة المثلى لنمو الفطر ميكوسفيريللا فراجاريا كانت أقل من تلك المناسبة للفطر دندروفوما أوبسيكيورانس وأقل من تلك المناسبة للفطر الترناريا الترناتا فراجاريا (٢٠ ، ٢٥ ، ٣٠ على الترتيب) بينما كان العكس صحيحاً بالنسبة للرطوبة النسبية المناسبة لكل منهم حيث كانت الرطوبة النسبية المناسبة للميكوسفيريللا فراجاريا أكبر من تلك المناسبة للفطر دندروفوما أوبسيكيورانس وأكبر من المناسبة للألترناريا الترناتا فراجاريا (١٠٠% ، ٩٥% ، ٨٤%) على الترتيب .

ارتبطت العناصر المناخية الكبرى للظروف الجوية ارتباطا وثيقاً بحدوث مرض تبقعات أوراق الفراولة حيث حدثت أدنى شدة إصابة بالمرض فى ظروف الحد الأدنى للرطوبة الجوية النسبية (من ٤٨ -٥٢%) وكمية المطر (من صفر - ٠,٣ مل) وأقل سرعة للرياح (١,٢ كم/ساعة) وأعلى عدد ساعات سطوع الشمس (١٠ ساعات/يوم) ومدى مختلف من درجات الحرارة حسب المسببات المختلفة يتراوح ما بين (من ٢٠-٣٠°م) ، بينما سجلت عوامل مناخية كبرى مغايرة لما سبق فى حالة انتشار المرض بدرجة شديدة حيث كانت درجات الرطوبة النسبية تتراوح ما بين (٧٠-٨٠%) وكمية المطر تراوحت ما بين (١٣,٧ إلى ١٨,٥ مم) وسرعة الرياح كانت (٣ كم/ساعة) وعدد ساعات سطوع الشمس كان (١٣,٥ ساعة/يوم) ودرجات حرارة تراوحت ما بين (١٨-٢٢ درجة مئوية) .

أهم العناصر المناخية الصغرى وهى (الرطوبة الجوية النسبية وابتلال الأوراق المحيطة بالأوراق) أبدت علاقة وثيقة بحدوث مرض تبقع أوراق الفراولة حيث حدوث المرض بدرجة عالية قد أرتبط بأعلى درجة رطوبة نسبية محيطة بالأوراق تراوحت مابين (٧٨,٧ - ٨٥%) وكذلك أعلى درجة لابتلال الأوراق (٤,٧ - ٥,٠ µ) بينما قلت النسبة المئوية لشدة الاصابة بالمرض عند درجات أقل للرطوبة النسبية حول الأوراق تراوحت مابين (٥٥,٩ - ٥٨,٤%) وكذلك أقل درجة لابتلال هذه الأوراق من (صفر - ٠,١µ) .