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RELATIONSHIP OF POWDERY MILDEW DISEASE ON FLAX TO PHYSICAL AND CHEMICAL EDAPHIC FACTORS.

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ABSTRACT

Nine clay soil samples were obtained from different flax-growing areas. The relationships of powdery mildew intensity variables (PMIV) to 22 physical and chemical factors of these soils were studied by simple correlation and stepwise regression analysis. It was found that nitrogen (ppm), potassium (ppm), iron (ppm), Cl^- (meq/100 g soil), Ca^{++} (meq/100 g soil), Mg^{++} (meq/100 g soil), Na^+ (meq/100 g soil), electric conductivity (ds/m), coarse sand (%), and fine sand (%) were the most important edaphic factors contributing to PMIV. Of these factors, potassium, Mg^{++}, and fine sand were negatively correlated with PMIV, while the others were positively correlated. Coefficient of determinations (R^2) of the 4 regression models that described the relationship between PMIV and edaphic factors ranged from 74.66-100%. The results of the present study demonstrated that under Egyptian soil conditions, certain physical and chemical edaphic factors affect development of powdery on flax, and that control of the disease may be possible by modifying the nutritional status of the plant.

INTRODUCTION

Powdery mildew caused by *Oidium lini* Škoric is currently the most common, conspicuous, widespread, and easily recognized foliar disease of Flax (*Linum usitatissimum* L.) in Egypt. Over the last decade, the importance of this disease has increased probably due to the appearance and rapid distribution of new races capable of attacking the previously resistant cultivars. Currently, resistance is not available in commercially grown flax cultivars in Egypt. Therefore, in years when environmental conditions favor the development of the disease, foliar application of fungicides has become the only commercially available management practice for the disease.

A number of studies of other pathosystems indicated that management of flax nutritional status could be a supplementary method to control this disease. For example Zubko (1962) reported that infected wheat seeds with *Ustilago tritici* and *U. nuda* were given a pre-sowing treatment with $MnSO_4$ at 2 g/L water and $CuSO_4$ at 1 g, then sown in spring in plots with complete fertilizer. Plant development was better and infection with *Ustilago nuda* was reduced by 8.9%. Seed treatment with manganese gave a 2-4 fold reduction in infection with powdery mildew (*Erysiphe graminis*). Under the influence copper and manganese in the plant tissues, regressive changes were noted in *Ustilago nuda*. These changes were more pronounced than those resulting from NPK alone. Yaroshenko (1962) found that manganese, copper and boron in association with NPK increased resistance of rye to stalk smut (*Urocystis acculta*). Mironenko (1965) reported that seed treatment of watermelon with CuSO4. ZnSO4, streptomycin, and biomycin significantly reduced the infection with powdery mildew (*Erysiphe cichoracearum* and *Sphereotheca fuligine*). Soliman (1976) studied the effect of different concentrations of some trace elements, i.e. manganese sulphate ($MnSO_4$), copper sulphate ($CuSO_4$), zinc sulphate ($ZnSO_4$), lithium chloride (LiCl) on barley growth and its infection with powdery mildew. He found that these microelements caused a considerable effect on plant height, but were not, statistically so effective in reducing the percentage of infection with powdery mildew. Sugarcane rust in Florida has been sever on sugarcane grown on organic soils formerly used for vegetable production that are high in soil fertility and poorly drained. It has also been observed that rust on highly organic soils is often less severe or nonexistent near the edges of fields close to limestone roads and ditch spoil banks. From these observations, it was hypothesized that rust development on sugarcane might be affected by the soil and plant nutrient status (Anderson and Dean, 1986). Sindhan and Parasher (1990) reported that maximum disease was caused by *Erysiphe pisi* in plants supplied with high N and Fe, with low doses of P, K, Zn and Cu. Spraying the microelements Fe, Mn, and Zn each alone or in combination on barley plants grown in clay soil resulted in significant decrease in severity of powdery mildew on barley. This decline in disease severity was reflected on significant increases in plant growth and yield. However, the effects of spraying the same microelements on plants grown in sandy soil were not in full harmony with those of plants grown in clay soil (Moustafa, 1992). In this study, we analyzed relationships between various physical and chemical edaphic variables and the intensity of powdery mildew on flax.

MATERIALS AND METHODS

Soil sampling and assessment of the disease in different soils

Bulk samples of clay soils were collected from fields in different flax-growing areas in Gharbiya (one sample), Daqahliya (one sample), Kafr El-Sheikh (two samples), and Sharqiya (five samples). Each bulk sample consisted of 5 subsamples randomly selected from the same field. Soil subsamples were obtained from the upper 10-15 cm of soil with a hand spade. Composite soil samples from each field were dispensed in 15-cm-diameter clay pots and these were planted with 15 seeds per pot (cultivar Giza 7) on 13 December 1996. Pots were distributed outdoors at Agricultural Research Station, Agricultural Research Center, Giza, in a randomized complete block design of 3 replications (pots). Disease incidence (DI) and disease severity (DS) were determined on 6 March 1996 and 27 March 1996. Disease incidence was measured as percentage of infected plants in a random sample of 10 plants/pot. Disease severity was measured as percentage of infected leaves/plant in a random sample of 10 plants/pot (Nutter *et al.*, 1991). Straw weight (g/plant) was also determined on 27 March.

Soil analysis

Particle size analysis was made by the pipette method according to Piper (1950). Soil paste extract was analyzed according to Jackson (1967) for determining soil salinity, cations, anions, and pH. Nitrogen content was determined according to Markus *et al.* (1982). Calcium carbonate was determined by Collin's Calcimeter, and calculated as $CaCO_3$ percent (Wright, 1939). Phosphorus, potassium and micronutrients were extracted by ammonium bicarbonate-DTPA and determined by inductively coupled plasma (ICP400) according to Soltanpour (1985).

Data analysis

Simple correlation coefficients were calculated to evaluate the degree of association between dependent variables (DI, DS, and straw weight) and independent variables (edaphic factors). Stepwise technique with the greatest increase in R^2 as the decision criterion was used to described the relationship between dependent and independent variables. Correlation and regression analysis were performed with a computerized program.

RESULTS AND DISCUSSION

Nine soil samples were obtained from different flax-growing areas. Powdery mildew intensity variables (DI and DS) and straw weight of flax cultivar Giza 7 grown in these soils are shown in Table (1). DI and DS were always higher in the second assessment date probably due to the prevailing of higher temperature. Details of 22 physical and chemical parameters measured in the 9 soil samples are shown in Table (2). Of the 10 significant linear correlation coefficients shown in Table 3, only 2 were negative. These significant correlation coefficients ranged from 0.69 to 0.83. Data for DI, SD, straw weight, and edaphic factors were entered into a computerized stepwise multiple regression analysis. The analysis constructed a predictive model by adding predictors, in this case edaphic factors, to the model in order of their contribution to R^2. The analysis was effective in eliminating those factors with little or no predictive value by incorporating into the model only those factors that made a statistically significant contribution to the R^2 value of the model (Podleckis *et al.*, 1984). Using the predictors supplied by stepwise regression, 5 models were constructed (Tables 4 and 5). These models showed that the edaphic factors accounted for 74.66-100% of the variation in powdery mildew intensity variables (PMIV). Moreover, the variation in straw weight was completely attributed to the effects of edaphic parameters (R^2 = 100%). Both simple correlation and multiple regression analysis indicated that nitrogen (ppm), potassium (ppm), iron (ppm), Cl^- (meq/100 g soil), Ca^{++} (meq/100 g soil), Mg^{++} (meq/100 g soil), Na^+ (meq/100 g soil), electric conductivity (ds/m), coarse sand (%), and fine sand (%) were the most important edaphic factors contributing to PMIV. Of these factors, potassium, magnesium, and fine sand were negatively correlated with PMIV, while the others were positively correlated. A positive correlation coefficient (r) or a regression coefficient (slope) in a regression model indicates that the particular factor under consideration will increase intensity of the disease if it is in excess. On the contrary, a negative correlation coefficient or slope indicates that the particular factor will increase intensity of the disease if it is in insufficient quantity. The results of this study indicated that high soil nitrogen content would increase intensity of powdery mildew on flax. This result is in agreement with the earlier reports which indicated similar relationship between nitrogen and powdery mildew (Huber and Watson, 1974). Reports of potassium effects on powdery mildew are variable and include increasing, decreasing, or not affecting the disease intensity, although the majority of the reports indicate a decrease in disease development (Grybauskas *et al.*, 1988) which lends support to the findings of this study. On the other hand, the findings of this study were not in agreement with the reports which indicated a reduction in wheat powdery mildew by chloride soil amendments (Grybauskas *et al.*, 1988). The results reported here suggest that intensity of powdery mildew on flax could be reduced by avoiding excess nitrogen fertilization and by adding potassium or magnesium to the soil or as foliar sprays.

Table 1: Powdery mildew intensity variables (disease incidence and disease severity) and straw weight of flax cultivar Giza 7 grown in 9 soil samples.

Governorate		Disease incidence % [a]		Disease severity % [b]		Straw weight g/plant
		6 March	27 March	6 March	27 March	
1: El Gharbia	(El-Mahalla)	73.33	100.00	69.78	79.41	0.044
2: Daqahliya	(Shirbin)	80.00	93.33	63.60	81.25	0.032
3: Kafr El-Sheikh 1	(Sidi Salem)	80.00	93.33	78.63	72.38	0.037
4 :Kafr El-Sheikh 2	(Sidi Salem)	93.33	100.00	80.88	86.67	0.047
5 : El-Sharqiya 1	(Hihya)	90.00	96.67	72.14	80.92	0.021
6 : El-Sharqiya 2	(El-Qanayat)	76.67	93.33	57.62	80.47	0.030
7 : El-Sharqiya 3	(Hihya)	83.33	93.33	73.40	78.30	0.049
8 : El-Sharqiya 4	(El-Ibrahimiya)	76.67	93.33	77.42	81.78	0.023
9 : El-Sharqiya 5	(El-Qanayat)	90.00	96.67	78.92	79.02	0.037

[a] **Disease incidence was measured as percentage of infected plants in a random sample of 10 plants/pot.**

[b] **Disease severity was measured as percentage of infected leaves/plant in a random sample of 10 plants/pot.**

Table (2): Edaphic parameters measured in nine clay soil samples.

Parameter	Soil samples [a]								
	1	2	3	4	5	6	7	8	9
Nitrogen (ppm)	42.60	22.00	23.00	48.10	24.70	25.50	30.50	27.20	18.97
Phosphorus (ppm)	2.76	2.20	1.56	3.81	5.52	3.81	0.60	3.60	2.42
Potassium (ppm)	370.50	936.00	341.60	331.50	370.50	634.10	263.60	331.50	292.50
Iron (ppm)	23.07	40.23	16.73	38.02	34.53	19.12	23.32	43.98	18.20
Zinc (ppm)	1.89	1.95	1.64	1.60	2.01	1.30	1.56	1.37	0.94
Manganese (ppm)	5.27	5.23	6.16	4.61	3.53	7.25	2.44	2.85	2.55
Copper (ppm)	6.22	7.00	5.43	5.08	4.96	5.14	5.94	5.60	4.15
pH	8.05	7.99	8.35	8.10	8.29	8.15	8.44	8.55	8.29
Saturation percent %	57.3	50.0	66.7	63.3	58.30	66.7	55.0	53.3	55.7
Electric conduc. (ds/m)	0.89	1.28	2.17	2.21	1.45	0.81	1.28	0.70	1.79
HCO3- (meq/100 g soil)	3.03	2.02	2.53	3.03	1.52	3.03	3.03	2.02	3.03
Cl^- (meq/100 g soil)	2.91	5.82	8.73	12.61	6.79	2.91	4.85	2.91	8.73
$SO4^=$ (meq/100 g soil)	3.33	5.64	13.65	8.54	7.34	3.17	5.29	3.47	8.00
Ca^{++} (meq/100 g soil)	3.09	4.63	4.12	7.21	4.12	3.09	3.09	3.09	7.21
Mg^{++} (meq/100 g soil)	2.79	1.74	7.24	2.59	1.76	1.81	2.79	1.81	3.57
Na^+ (meq/100 g soil)	3.12	6.72	13.12	13.85	9.38	3.89	6.72	3.12	8.45
K^+ (meq/100 g soil)	0.27	0.39	0.43	0.53	0.39	0.32	0.57	0.38	0.53
Coarse sand %	1.94	1.25	0.55	3.29	3.07	2.43	2.16	1.92	2.09
Fine sand %	19.80	7.33	16.48	16.69	16.23	16.98	19.30	16.91	19.19
Silt %	19.08	29.33	20.37	16.35	19.66	19.94	18.26	19.99	20.01
Clay %	56.58	60.69	60.50	60.67	58.44	57.15	57.58	58.58	55.71
Calcium carbonate %	2.60	1.40	2.10	3.00	2.60	3.50	2.70	2.60	3.00

[a] Soil samples were :

1: El Gharbia (El-Mahalla)

2: Daqahliya (Shirbin)

3: Kafr El-Sheikh 1 (Sidi Salem)

4 :Kafr El-Sheikh 2(Sidi Salem)

5 : El-Sharqiya 1 (Hihya)

6 : El-Sharqiya 2 (El-Qanayat)

7 : El-Sharqiya 3 (Hihya)

8: El-Sharqiya 4 (El- Ibrahimiya)

9 : El-Sharqiya 5 (El-Qanayat)

Table 3: Relationships of powdery mildew intensity variables (disease incidence and disease severity) and straw weight (g/plant) of flax cultivar Giza 7 to edaphic parameters of 9 soil samples.

Edaphic parameter	Pearson correlation coefficients [a]				
	Disease incidence on 6/3/1996	Disease incidence [b] on 27/3/1996	Disease severity [c] on 6/3/1996	Disease severity on 27/3/1996	Straw weight (g/plant)
Nitrogen (ppm)	0.0099	0.7542*	0.1852	0.4850	0.5845
Phosphorus (ppm)	0.2573	0.3545	0.1129	0.5502	-0.6360
Potassium (ppm)	-0.1865	-0.2925	-0.7517*	0.1731	-0.4490
Iron (ppm)	0.1365	0.0469	0.0926	0.6896*	-0.3669
Zinc (ppm)	-0.1257	0.1768	0.2214	0.0489	-0.0594
Manganese (ppm)	-0.4375	-0.0643	-0.5735	-0.1679	-0.0249
Copper (ppm)	-0.5853	-0.2295	-0.4212	-0.0297	0.1280
pH	0.0304	-0.4124	-0.4960	-0.3179	-0.2131
Saturation percent %	0.0629	0.1059	0.0020	-0.2106	0.1238
Electric conductivity (ds/m)	0.7132*	0.2704	0.6205	-0.1167	0.3731
HCO_3^- (meq/100 g soil)	-0.0390	0.2886	0.0397	-0.0312	0.7977*
Cl^- (meq/100 g soil)	0.8273**	0.3927	0.6246	0.1791	0.3270
$SO_4^=$ (meq/100 g soil)	0.4704	0.0056	0.5740	-0.4520	0.1491
Ca^{++} (meq/100 g soil)	0.7969*	0.4695	0.5082	0.3588	0.2523
Mg^{++} (meq/100 g soil)	-0.0123	-0.1083	0.4616	-0.7723*	0.2986
Na^+ (meq/100 g soil)	0.7265*	0.2227	0.5753	-0.0519	0.2651
K^+ (meq/100 g soil)	-0.1327	-0.2893	-0.4249	0.1234	-0.1298
Coarse sand %	0.5663	0.5418	0.0443	0.7702*	0.0022
Fine sand %	0.1001	0.2550	0.4543	-0.1928	0.4244
Silt %	-0.1389	-0.4873	-0.3531	-0.3732	-0.3957
Clay %	0.1062	-0.2548	0.1294	0.2368	-0.2991
Calcium carbonate %	0.1917	0.2752	0.0063	0.2711	0.1060

[a] **Significant at $P < 0.05$ (*) or $P \leq 0.01$ (**).**
[b] **Disease incidence was measured as percentage of infected plants in a random sample of 10 plants/pot.**
[c] **Disease severity was measured as percentage of infected leaves/plant in a random sample of 10 plants/pot.**

Table 4: Regression equations that describe the effects of some edaphic factors on powdery mildew intensity variables (disease incidence and disease severity) and straw weight (g/plant) of flax cultivar Giza 7.

Assessment date	dependent variable	Stepwise regression model	R^2 [c]	F- value
6/3/1996	DI [a]	$Y = 73.82137 + 1.586442X_{12} + 4.032824X_{18} - 0.1921238X_1 - 0.8671781X_6$	98.39	61.16**
	DS [b]	$Y = 148.0596 - 0.07041431\ X_3 - 2.517329\ X_{19}$	88.23	22.48**
27/3/1996	DI	$Y = 86.45161 + 0.2002627X_1 + 0.7218563X_{14}$	74.66	8.84*
	DS	$Y = 79.99299 - 1.257727X_{15} + 1.661967X_{12} + 0.05672535X_1 - 5.031092X_{10} + 0.2912759X_6 - 0.3340743X_{13} - 0.1554704X_{14}$	100.00	6212.31*
	SW [d]	$Y = -0.1981476 + 0.02650651X_{11} + 0.02119799X_5 - 0.003467979X_6 + 0.002225962X_{21} - 0.00009692204X_4 + 0.0008987017X_{20} - 0.0001628462X_{17}$	100.00	19369.63**

[a] **Disease incidence was the percentage of infected plants in a random sample of 10 plants/pot.**
[b] **Disease severity was the percentage of infected leaves/plant in a random sample of 10 plants/pot.**
[c] **Identification of predictors used in regression models and their relative contributions to R^2 are shown in Table 5.**
[d] **Straw weight.**

Table 5: Identification of the predictors included in stepwise regression models shown in Table 4 and their relative contribution to R^2.

Predictor		Number	Relative contribution to R^2(%)
Disease incidence on 6 March			
Cl-	(meq/100 g soil)	X12	68.44732
Coarse sand	%	X18	16.5638
Nitrogen	(ppm)	X1	9.559435
Manganese	(ppm)	X6	3.820705
Disease Severity on 6 March			
Potassium	(ppm)	X3	56.49925
Fine sand	%	X19	31.7274
Disease incidence on 27 March			
Nitrogen	(ppm)	X1	56.881
Ca++	(meq/100 g soil)	X14	17.7737
Disease severity on 27 March			
Mg++	(meq/100 g soil)	X15	59.65004
Cl-	(meq/100 g soil)	X12	27.18289
Nitrogen	(ppm)	X1	6.951988
EC	(dS/m)	X10	4.519648
Manganese	(ppm)	X6	1.368546
SO4=	(meq/100 g soil)	X13	0.2893031
Ca++	(meq/100 g soil)	X14	0.03528595
Straw weight (g/plant)			
HCO3	(meq/100 g soil)	X11	63.63667
Zinc	(ppm)	X5	15.98351
manganese	(ppm)	X6	10.38019
Clay	%	X21	5.839926
Iron	(ppm)	X4	3.320372
Silt	%	X20	0.6805003
K+	(meq/100 g soil)	X17	0.1580891

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علاقة مرض البياض الدقيقى على الكتان بالخواص الفيزيائية والكيميائية للتربة

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أجرى تقدير كمى لبعض العوامل الفيزيائية والكيميائية فى التربة وصل عددها إلى ٢٢ عامل ، وذلك فى ٩ عينات تربة طينية جمعت من المناطق الرئيسية لإنتاج الكتان. إستخدم الإرتباط الخطى البسيط والانحدار المتعدد المرحلى لدراسة العلاقة بين هذه العوامل وكثافة المرض. أظهرت الدراسة أن أكثر العوامل تأثيراً على حدوث المرض هى عنصر النتروجين (جزء فى المليون) وعنصر البوتاسيوم (جزء فى االمليون) وعنصر الحديد (جزء فى المليون) وأنيون الكلوريد (ملليمكافئ/١٠٠ جم تربة) وكاتيون الكالسيوم (ملليمكافئ/١٠٠ جم تربة) وكاتيون المغنسيوم (ملليمكافئ/١٠٠ جم تربة) وكاتيون الصوديوم (ملليمكافئ/١٠٠ جم تربة) والتوصيل الكهربى (ملليموز/سم) والنسبة المئوية لكل من الرمل الخشن والناعم. من بين هذه العوامل ، وجد إرتباط سالب مابين كثافة المرض وكلٍ من كاتيونات البوتاسيوم والمغنسيوم والرمل الناعم. أما باقى عوامل هذه المجموعة فقد إرتبطت بكثافة المرض إرتباطاً موجباً. أمكن بإستخدام أسلوب الانحدار المتعدد المرحلى التوصل إلى ٤ معادلات لوصف العلاقة بين كثافة المرض (متغير تابع) وعوامل التربة (متغير مستقل). أظهرت هذه النماذج أن نسبة تتراوح مابين ٧٤,٦٦-١٠٠% من التباين فى كثافة المرض من الممكن أن تعزى إلى تأثير عوامل التربة. تدل نتائج الدراسة الحالية على أن كثافة مرض البياض الدقيقى على الكتان تتأثر بكلٍ من الخواص الفيزيائية والكيميائية للتربة ، وأنه من الممكن مقاومة هذا المرض عن طريق التحكم فى الحالة الغذائية للنبات.