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SUSCEPTIBILITY OF SOME FIAX GENOTYPES TO POWDERY MILDEW AND EFFECT OF THE DISEASE ON YIELD AND YIELD COMPONENTS

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ABSTRACT

A four-years field study was conducted in El-Gemmeiza Agricultural Research Station to assess the susceptibility of 10 flax genotypes to powdery mildew and to determine the effect of the disease on yield and yield components. Disease incidence was used to evaluate susceptibility of the genotypes to the disease. None of the tested genotypes showed satisfactory levels of resistance to the disease. However, cultivar Giza 7, line 366/2/1/2 and line 5 were the least susceptible genotypes. These genotypes showed superiority in some agronomic traits compared to the other genotypes. Many significant correlations were observed among agronomic traits as well as technological traits each year. On the other hand, very few significant correlations were observed between disease intensity variables (DI and DS) and agronomic or technological traits.

INTRODUCTION

Powdery mildew (PM) of Flax (*Linum usitatssimum* L.)is caused by the obligate pathogen *Oidium lini* Škoric. This fungus is found on flax in Egypt only in its imperfect stage. The pathogen infects all above ground flax organs including stems, leaves, flowers and capsules. PM occurs annually in all flax production areas in Egypt. Physiological races of the pathogen have not been identified because no differential host lines are available to date (Aly *et al*., 2001).

Accurate assessment of losses due to the disease in Egypt has not been reported. However, Aly *et al*. (1994) found significant negative correlations between disease intensity ratings and agronomic traits (yield and yield components). Perryan and Fitt (2000) reported a substantial yield loss in flax due to the decrease in yield components by powdery mildew disease.

Fungicides are currently the only commercially available management practice for controlling the disease and minimizing associated losses in seed and straw yield (Aly *et al*., 1994 and Mansour, 1998). Complete dependence on fungicides for the disease control carries risks for the producers, in that accurate coverage and distribution of fungicides may not be achieved and there are potential problems with correct timing of applications. Furthermore, increasing concern for the environment will likely mean greater regulation of pesticide usage (Pearce *et al*., 1996).

Use of cultivars with PM resistance can resolve all these problems. Therefore, there is a need to improve PM resistance in flax cultivars through the introgression of resistance genes.

Extensive genetic variation for PM resistance has been identified in some flax populations. For example, Prasad *et al*. (1988) evaluated 2822 linseed varieties for rust and PM resistance. The germplasm was classified depending on percentage of leaf area infected / plant. Only 24 lines were free from both rust and PM and 17 showed multiple resistance. In addition, 38 genotypes were free from rust and resistant to PM, and 3 were free from PM and resistant to rust. Sinha *et al*. (1993) evaluated 313 germplasm of lines for their reaction to rust and powdery mildew over three years. 22 showed resistance towards rust and one variety showed resistance to

rust and powdery mildew. Basandrai *et al*. (1994) evaluated 200 indigenous and exotic flax genotypes for resistance to PM under field conditions. Twenty-four genotypes were free of infection, and 12 genotypes were resistant to PM and also possessed plant height for fiber flax. Mahto *et al*. (1995) found a significant variability among 26 flax genotypes in resistance to PM. Eleven had above average stability and 7 of these had high yields. Tomas *et al*. (1999) found that powdery mildew (*Oidium lini*) occurred in linseed cultivar trials every year from 1993 to 1998 in either the south or east of the UK, but not in central areas. Significant differences in the level of disease occurred between 19 cultivars. These differences were consistent from year to year, and site to site. No cultivar was immune to PM infection, but high levels of partial resistance were recorded.

The objectives of this study were to assess susceptibility of ten flax genotypes to powdery mildew and to determine effects of the disease on yield and yield component.

MATERIALS AND METHODS

Experiments were conducted over four successive growing seasons in El-Gemmeiza Agricultural Research Station, beginning in the fall of 1997. Experiments consisted of a randomized complete blocks design of 5 replicates in all seasons. Plots were 2 x 3 m (6 m^2). Seeds of each genotype were sown by hand at a rate of 70 g/plot. Planting dates were 18 Nov. 1997, 7 Nov. 1998, 10 Nov. 1999 and 1 Nov. 2000. All cultural practices usually used in flax production were followed. Disease incidence (DI) and disease severity (DS) were related visually on 15 to 30 April in each season. DI was measured as percentage of infested plants in a random sample of 100 plants / plot. DS was measured as percentage of infected leaves / plant in a random samples of 10 plants / plot (Nutter *et al*., 1991).

At full maturity, ten plants were taken at random from each plot and observations were recorded on individual plants for each of the following agronomic and technological traits:

A. Straw yield and its related characters:

1. **Total plant height (cm):** plant height from the cotyledonary node to the apical bud of each plant.
2. **Technical stem length (cm):** The length of the main stem from the cotyledonary node to the first or lowest branching point.
3. **Number of fruit branches:**Total number of fruit branches of plant.
4. **Straw yield / plant (g):** Weight of the mature air-dried straw per plant after removing the capsules.
5. **Straw yield / feddan (ton):** Estimated based on the area of whole plot.
6. **Fiber yield / feddan (kg):** Estimated based on the area of the whole plot.

7- Stem diameter (cm).

B. Seed yield and its related characters:

1. **Number of capsules per plant:** Number of harvested capsules per plant.
2. **Number of seeds per capsule:** Number of harvested seeds per capsule.

3. **Seed yield per plant (g):** Weight of harvested seeds per plant.
4. **Seed yield per feddan (kg):** Estimated based on the area of the whole plot.

Technological traits:

1. Fiber length (cm).
2. Fiber fineness in metrical number (Nm): Calculated according to the following formula.

$$\text{Fiber fineness (NM)} = \frac{N \times L}{G}$$ (Radwan and Momtaz, 1966)

Where:

N = Number of fibers (20 fibers).
L = Length of fibers in cm.
G = Weight of fibers in mg.

3. Oil percentage was determined by soxhlet apparatus according to Horwitz *et al*. (1965).
4. Oil yield per feddan (kg): Oil % x seed yield feddan (kg).

Statistical analysis of the data:

Analysis of variance (ANOVA) was performed on agronomic traits, technological traits, and disease intensity variables to determine genotype effects. Mean comparisons for variables were made among genotypes by using least significant difference. ANOVA, correlation analysis were performed by a computerized program (MSTAT-C).

RESULTS AND DISCUSSION

The present study was conducted in 1997/98, 1998//99, 1999/2000, and 2000/2001 growing seasons (hereafter referred to as years 1998, 1999, 2000 and 2001, respectively). High disease pressure is considered a prerequisite condition for any meaningful field evaluation for disease resistance. The environmental conditions in the four years of the present study was favorable for epiphytotic spread of the disease. This was apparent as these environmental conditions resulted in high levels of DI and DS on all the tested genotypes-that is, the genotypes were screened for PM-resistance under high disease pressure.

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Table 2. Correlation coefficients between severity and incidence of powdery mildew disease on ten flax genotypes evaluated under field conditions in El-Gemmeiza Agric. Res. Station.

Year	Correlation coefficient (r)
1997/98	0.589 x
1998/99	0.850 **
1999/2000	0.921 **
2000/2001	0.853 **

Linear correlation coefficient (r) was significant at P≤ 0.10 (x) or P≤ 0.01 (**).

DI and DS were used as criteria to evaluate disease intensity on the tested genotypes (Table 1). Although DI and DS were highly correlated in 3 years and correlated in one year (Table 2). DI was more appropriate to evaluate susceptibility of the genotypes to PM because it is more precise (Rouse *et al*., 1981) and more heritable than DS-that is, it was less affected by environment (Aly *et al*., 2001), therefore DI was used to evaluate susceptibility of the genotypes to PM.

Certain details in Table 1 are worthy of mention. None of the tested genotypes showed satisfactory levels of resistance to the disease. Thus, DI of the genotypes ranged from 52.00 to 90.40%, from 62.80 to 94.00%, from 56.00 to 90.00%, and from 53.60 to 94.00% in 1998, 1999, 2000 and 2001, respectively.

The differences in DI between most of the genotypes were inconsistent from year to year, for example, DI on line 1 was significantly less than DI on line 3 in 1998, 2000, while in 1999, DI on line 1 was significantly higher than DI on line 3. The two lines showed non-significant difference in DI in 2001. Sakha 1 was significantly more susceptible than Sakha 2 in 1998 and 2001, while it was less susceptible in 1999. The two cultivars were equally susceptible in 2000. This lack of consistence was not in agreement with the results of Tomas *et al*. (1999), who reported consistent differences in PM levels on flax cultivars from year to year. This result may indicate that the reaction of the tested genotypes to PM was sensitive to environmental changes. From practical point of view, this result implies that flax genotypes should be tested for PM resistance over as many years as possible as this may improve the chance of identified genotypes resistant to the disease over as many environment as possible. Both the commercial cultivars Giza 7 and Giza 8 were susceptible to the disease. However, susceptibility of Giza 7 was consistently less. Considering the performance of the genotypes over the four-years period, it seems reasonable to conclude that cultivar Giza 7, line 366/2/1/2, and line 5 were the least susceptible genotypes to PM.

It is noteworthy that these three genotypes showed superiority in some agronomic traits compared to the other genotypes. Thus Giza 7 was superior in seed yield per feddan in 1998 (Table 3), total length, No of seeds / capsule in 2000 (Table 5), No. of apical branches, and seed yield / plant in 2001 (Table 6).

Superiority of line 366/2/1/2 was evident in No of seeds per capsule in 1998 (Table 3), 1999 (Table 4) and 2000 (Table 5).

3,4

5,6

This line also had significantly the highest No of capsules per plant and the highest seed yield per plant in 1998 (Table 3). In 2001, it showed the highest No of apical branching zone and the highest seed yield per plant (Table 6).

Line 5 was superior in straw yield per plant in 1999 (Table 4), No of seeds / capsule in 2000 (Table 5), No of apical branching zones, seed yield / plant in 2001 (Table 6). Regarding technological traits (Tables 7-10), the superiority of these genotypes were less obvious.

Many significant correlations were observed among agronomic traits as well as among technological traits each year (Tables 11-14). On the other hand, very few negative significant correlations were observed between disease intensity variables (DI and DS) and agronomic or technological traits. This lack of correlation implies that selection for PM resistance would not necessarily lead to an improvement in agronomic or technological traits and *vice versa*. In other words, this lack of correlation may complicate flax breeding programs, which aim to the development of PM-resistant cultivars with superior agronomic and technological traits.

Table 7. Technological traits of ten genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 1997/98 growing season.

Genotype	Fiber length (cm)	Fiber fineness (NM)	Fiber yield per fed. (Kg)	Oil (%)	Oil yield per fed. (Kg)
Giza 7	64.86* bcd	155.06 bc	589.50 ab	38.54 c	242.80 b
1	72.56 a	144.76 ef	550.00 ef	36.18 h	200.28 f
3	68.52 abc	150.94 cd	583.64 ab	37.84 e	233.22 c
366/2/1/2	65.32 bcd	147.80 de	563.73 cde	36.64 g	209.52 e
422/10/1/3	69.14 ab	159.28 b	599.84 a	37.16 f	222.00 d
Giza 8	60.20 d	140.00 f	538.04 f	39.26 b	211.00 e
Sakha 1	72.26 a	164.90 a	581.42 bc	38.10 de	257.78 a
Sakha 2	72.12 a	144.40 ef	548.30 ef	40.34 a	226.18 d
5	70.66 ab	148.28 de	554.72 def	37.12 f	238.06 c
402/20/18/3	62.80 cd	152.22 cd	572.44 bcd	38.38 cd	244.28 b

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 8. Technological traits of ten genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 1998/99 growing season.

Genotype	Fiber length (cm)	Fiber fineness (NM)	Fiber yield per fed. (Kg)	Oil (%)	Oil yield per fed. (Kg)
Giza 7	80.74* bcde	156.1 b	593.90 b	38.96 a	247.20 b
1	92.16 a	143.2 d	545.90 e	36.54 a	205.40 f
3	86.82 ab	152.8 b	580.70 c	38.24 a	229.20 c
366/2/1/2	87.52 de	148.2 c	563.30 d	36.98 a	210.70 e
422/10/1/3	81.44 bcd	161.3 a	610.70 a	37.50 a	221.60 d
Giza 8	77.98 cde	133.7 e	548.20 e	37.12 a	217.40 d
Sakha 1	81.98 bcd	152.9 b	599.40 b	39.40 a	256.30 a
Sakha 2	86.04 abc	140.5 d	574.60 c	38.02 a	231.50 c
5	78.94 bcde	130.6 e	529.00 f	37.52 a	232.20 c
402/20/18/3	72.78 e	121.3 f	516.70 g	38.42 a	244.20 b

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 9. Technological traits of ten genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 1999/2000 growing season.

Genotype	Fiber length (cm)	Fiber fineness (NM)	Fiber yield per fed. (Kg)	Oil (%)	Oil yield per fed. (Kg)
Giza 7	65.86* a	153.30 cd	585.80 cd	38.20 ef	166.1 g
1	66.10 a	149.10 d	573.60 d	37.90 f	164.4 g
3	59.76 a	151.00 d	580.70 cd	39.50 cd	184.5 e
366/2/1/2	64.02 a	133.20 e	512.20 e	40.18 c	197.3 d
422/10/1/3	60.92 a	158.90 bc	603.60 bc	38.80 de	175.3 f
Giza 8	61.68 a	153.20 cd	589.bcd	40.90 ab	247.7 a
Sakha 1	67.16 a	170.00 a	653.60 a	40.20 bc	256.1 b
Sakha 2	61.34 a	160.40 b	616.80 b	39.52 c	218.2 c
5	67.26 a	149.00 d	574.40 d	41.30 a	248.7 a
402/20/18/3	64.34 a	138.90 e	534.50 e	39.80 c	230.2 b

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 10. Technological traits of ten genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 2000/2001 growing season.

Genotype	Fiber length (cm)	Fiber fineness (NM)	Fiber yield per fed. (Kg)	Oil (%)	Oil yield per fed. (Kg)
Giza 7	97.04* bcd	172.70 b	656.10 b	39.70 de	224.00 e
1	106.10 a	156.70 d	595.50 de	37.16 h	172.30 i
3	103.90 ab	165.80 c	630.10 c	39.00 f	209.90 f
366/2/1/2	97.96 bcd	144.70 e	549.80 f	37.78 g	182.60 h
422/10/1/3	100.20 abc	180.10 a	676.30 a	38.20 g	197.10 g
Giza 8	89.80 e	159.90 d	608.10 d	41.70 a	276.30 cd
Sakha 1	93.72 cde	171.00 b	657.60 b	39.50 e	284.50 b
Sakha 2	95.00 cde	165.70 c	630.30 c	40.00 d	272.90 d
5	97.16 bcd	155.70 d	584.90 e	40.52 c	281.40 bc
402/20/18/3	92.86 de	145.00 e	551.00 f	41.10 b	292.20 a

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

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قابلية بعض التراكيب الوراثية للكتان للإصابة بالبياض الدقيقى وتأثير المرض على المحصول ومكوناته

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أجريت دراسة حقلية لمدة أربع سنوات بمحطة البحوث الزراعية بالجميزة وذلك لتقييم ١٠ أصول وراثية من حيث قابليتها للإصابة بمرض البياض الدقيقى ولدراسة تأثير المرض على المحصول ومكوناته٠

إستعمل حدوث المرض كمعيار لتقييم قابلية التراكيب المختبرة للإصابة بالمرض٠ أظهرت الدراسة عدم وجود تراكيب وراثية على درجة مقبولة من المقاومة للمرض ، إلا أن صنف جيزة ٧ والسلالة ٢/١/٢/٣٦٦ والسلالة ٥ كانت أقل التراكيب الوراثية قابلية للإصابة بالمرض كما أظهرت هذه التراكيب الثلاثة تفوقاً على التراكيب الوراثية الأخرى فى بعض الصفات المحصولية٠

أظهرت الدراسة وجود العديد من الإرتباطات المعنوية بين كل من الصفات المحصولية والصفات التكنولوجية إلا أن الإرتباطات كانت نادرة بين المتغيرات الدالة على كثافة المرض (حدوث وشدة المرض) وكل من الصفات المحصولية والخواص التكنولوجية.

Table 1. Powdery mildew intensity variable of ten flax genotypes under field conditions in El-Gemmeiza Agric. Res. Station in 1997/98, 1998/99, 1999/2000 and 2000/2001 growing seasons.

Genotype	1997/98		1998/99		1999/2000		2000/2001	
	Disease incidence (%)	Disease severity (%)	Disease incidence (%)	Disease severity (%)	Disease incidence (%)	Disease severity (%)	Disease incidence (%)	Disease severity (%)
Giza 7	62.00* e	62.52 d	80.80 bc	82.46 ab	56.00 g	48.34 ef	66.80 d	74.82 de
1	71.60 d	77.37 bc	94.00 a	89.01 a	68.00 ef	67.96 bc	84.00 abc	90.58 ab
3	90.40 a	76.29 bc	74.40 bcd	81.03 ab	86.40 ab	89.07 a	76.40 bcd	93.36 ab
366/2/1/2	62.40 e	78.05 bc	68.40 de	69.52 bc	66.00 f	41.89 e	53.60 e	64.33 f
422/10/1/3	73.60 cd	81.61 b	76.00 bcd	82.20 ab	76.40 cd	73.72 b	70.80 cd	86.15 bc
Giza 8	80.00 bc	92.10 a	62.80 e	60.47 c	68.00 def	57.89 cd	94.00 a	92.67 ab
Sakha 1	84.40 ab	95.20 a	69.60 de	73.24 bc	78.80 bc	81.43 ab	86.80 ab	97.15 a
Sakha 2	74.80 cd	78.88 bc	82.00 b	91.90 a	74.80 cd	69.49 bc	70.00 d	70.02 ef
5	52.00 f	71.54 c	68.00 de	64.86 c	80.40 bc	87.62 a	84.40 abc	86.42 bc
402/20/18//3	74.80 cd	92.52 a	72.00 cde	82.72 ab	90.00 a	94.00 a	75.20 bcd	80.04 cd

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 3. Agronomic traits of ten flax genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 1997/98 growing season.

Genotype	Total length (cm)	Technical length (cm)	No. of apical branches	No. of capsules per plant	No. of seeds per capsule	Stem diameter (cm)	Straw yield per plant (g)	Seed yield per plant (g)	Straw yield per feddan (ton)	Seed yield per feddan (Kg)
Giza 7	76.50* e	66.60 cd	14.48 abc	8.98 ab	4.80 abc	2.59 abc	2.42 bc	0.31 f	3.44 abc	630.24 a
1	83.10 cd	75.92 a	10.38 c	5.78 b	5.37 a	2.75 ab	2.74 ab	0.54 bcd	3.20 de	547.56 ef
3	81.58 cde	71.20 abc	15.68 a	11.20 a	4.52 bc	2.43 c	2.43 bc	0.64 ab	3.39 bcde	605.36 b
366/2/1/2	80.52 cde	67.62 bcd	15.86 a	11.28 a	5.46 a	2.71 abc	2.44 bc	0.75 a	3.08 f	585.34 bc
422/10/1/3	80.72 cde	70.90 abc	10.42 c	8.14 ab	5.18 ab	2.84 a	2.43 bc	0.49 cd	3.59 a	596.78 bc
Giza 8	77.20 de	63.76 d	14.16 abc	8.02 ab	4.06 cd	2.52 bc	2.77 a	0.46 de	3.43 abcd	538.66 f
Sakha 1	90.18 ab	74.70 a	12.88 abc	8.38 ab	4.80 abc	2.60 abc	2.73 ab	0.54 bcd	3.15 f	592.82 bc
Sakha 2	91.00 a	75.02 a	13.78 abc	8.78 ab	4.70 abc	2.62 abc	2.39 c	0.60 bc	3.35 cde	560.68 de
5	84.66 bc	72.22 ab	15.30 ab	8.78 ab	5.18 ab	2.62 abc	2.55 abc	0.34 ef	3.24 def	579.00 cd
402/20/18/3	80.60 cde	65.80 cd	11.08 bc	7.76 ab	3.58 d	2.71 abc	2.29 c	0.31 f	3.55 ab	579.68 cd

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 4. Agronomic traits of ten flax genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 1998/99 growing season.

Genotype	Total length (cm)	Technical length (cm)	No. of apical branches	No. of capsules per plant	No. of seeds per capsule	Stem diameter (cm)	Straw yield per plant (g)	Seed yield per plant (g)	Straw yield per feddan (ton)	Seed yield per feddan (Kg)
Giza 7	92.94* bcd	83.30 bc	9.46 abcd	7.25 ab	6.42 ab	2.43 ab	1.33 f	0.46 e	3.44 d	632.30 b

1	101.20 a	94.80 a	7.75 cde	6.27 bc	6.50 ab	2.27 ab	1.81 b	0.56 d	3.17 g	549.60 h
3	99.92 ab	88.90 ab	10.04 abc	5.89 c	6.66 ab	2.15 ab	1.26 fg	0.67 c	3.37 e	597.10 e
366/2/1/2	99.66 ab	79.96 c	8.76 bcd	6.08 bc	6.86 a	2.24 ab	1.55 de	0.33 f	3.27 f	570.10g
422/10/1/3	96.10 abcd	83.84 bc	6.23 e	6.82 bc	5.22 d	2.12 b	1.21 g	0.36 f	3.54 c	591.00 ef
Giza 8	87.32 d	80.18 c	8.86 bcd	6.65 bc	5.48 cd	2.16 ab	1.60 d	0.69 bc	3.47 d	584.70 f
Sakha 1	98.04 abc	84.32 bc	7.50 de	6.48 bc	6.32 abc	2.43 ab	1.68 c	0.54 de	3.96 a	654.10 a
Sakha 2	95.01 bcd	89.04 ab	11.46 a	8.25 a	5.10 d	2.23 ab	1.59 d	0.66 c	3.63 b	608.80 d
5	89.78 cd	81.58 bc	11.08 ab	7.06 abc	5.86 bcd	2.61 a	1.90 a	0.78 ab	3.36 e	619.20 c
402/20/18/3	90.20 cd	77.46 c	8.04 cde	6.40 bc	4.94 bcd	2.22 ab	1.48 e	0.85 a	3.46 f	635.70 b

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 5. Agronomic traits of ten flax genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 1999/2000 growing season.

Genotype	Total length (cm)	Technical length (cm)	No. of apical branches	No. of capsules per plant	No. of seeds per capsule	Stem diameter (cm)	Straw yield per plant (g)	Seed yield per plant (g)	Straw yield per feddan (ton)	Seed yield per feddan (Kg)
Giza 7	84.82* a	65.48 ab	11.12 b	6.68 ab	5.20 a	2.27 abc	1.50 ab	0.31 ab	3.46 cd	493.60 d
1	79.60 a	73.46 a	12.74 ab	6.54 ab	4.96 a	2.54 abc	1.27 b	0.32 ab	3.50 bcd	434.00 g
3	78.38 a	61.04 b	17.18 a	10.28 a	4.90 a	2.58 abc	1.51 ab	0.48 a	3.46 cd	468.50 e
366/2/1/2	78.34 a	67.30 ab	11.58 ab	7.02 ab	4.78 a	2.50 bc	1.52 ab	0.39 ab	3.00 f	440.40 g
422/10/1/3	76.42 a	62.56 b	13.30 ab	7.78 ab	4.76 a	2.82 a	1.70 a	0.25 b	3.68 ab	454.30 f
Giza 8	75.00 a	62.52 b	9.16 b	6.04 b	5.40 a	2.40 bc	1.37 ab	0.35 ab	3.47 cd	558.50 c
Sakha 1	81.44 a	68.72 ab	8.08 b	6.14 b	5.26 a	2.38 c	1.36 ab	0.37 ab	3.85 a	607.40 a
Sakha 2	79.52 a	65.54 ab	11.08 b	6.14 b	4.82 a	2.70 ab	1.46 ab	0.35 ab	3.62 bc	581.20 b
5	81.58 a	68.66 ab	8.08 b	5.92 b	5.60 a	2.44 bc	1.20 b	0.33 ab	3.38 de	593.20 b
402/20/18/3	82.22 a	62.96 b	13.80 ab	9.40 ab	5.54 a	2.38 c	1.21 b	0.49 a	3.25 e	612.00 a

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 6. Agronomic traits of ten flax genotypes infected with powdery mildew under field conditions in El-Gemmeiza Agric. Res. Station in 2000/2001 growing season.

Genotype	Total length (cm)	Technical length (cm)	No. of apical branches	No. of capsules per plant	No. of seeds per capsule	Stem diameter (cm)	Straw yield per plant (g)	Seed yield per plant (g)	Straw yield per feddan (ton)	Seed yield per feddan (Kg)
Giza 7	113.30* bc	99.60 bc	18.26 a	13.06a	6.10 ab	2.64 ab	2.11 cd	0.67 a	3.81 b	563.40 d
1	123.60 a	108.40 a	16.68 a	11.16 a	6.58 a	2.75 ab	3.89 a	0.42 a	3.45 e	462.90 h
3	121.80 ab	106.30 ab	20.10 a	14.90 a	5.54 ab	2.43 b	3.03 abc	0.52 a	3.66 cd	534.80 e
366/2/1/2	116.70 abc	100.20 bc	18.58 a	13.68 a	6.32 ab	2.61 ab	2.44 bcd	0.67 a	3.19 f	483.80 g
422/10/1/3	118.60 abc	102.50 abc	16.82 a	12.54 a	6.12 ab	2.89 a	2.31 ab	0.57 a	4.01 a	516.60 f
Giza 8	96.86 d	78.40 d	16.48 a	10.12 a	5.48 b	2.54 ab	1.66 d	0.48 a	3.58 d	627.00 c
Sakha 1	112.90 bc	95.96 c	15.62 a	12.68 a	6.18 ab	2.80 ab	1.93 cd	0.58 a	3.93 a	720.30 a
Sakha 2	116.10 abc	97.30 c	15.96 a	11.84 a	6.18 ab	2.62 ab	2.31 bcd	0.53 a	3.71 c	682.70 b
5	112.00 bc	96.80 c	16.90 a	12.40 a	6.46 ab	2.62 ab	1.66 d	0.45 a	3.44 e	694.10 b
402/20/18/3	109.40 c	95.26 c	15.76 a	13.80 a	6.36 ab	2.71 ab	1.96 cd	0.47 a	3.24 f	708.90 a

*** Mean of five replications. Means followed by the same letter(s) are not significantly different (P≤ 0.05) according to Duncan's multiple range test.**

Table 11. Correlation coefficients for agronomic traits, technological traits, and disease intensity variables of ten flax genotypes infected with powdery mildew under field conditions in 1997/98.

	Y_{15}	Y_{14}	Y_{13}	Y_{12}	Y_{11}	Y_{10}	Y_9	Y_8	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	X_2	X_1
X_1	0.106	0.319	0.167	0.170	0.006	-0.094	0.221	0.344	0.166	-0.387	-o.464	0.032	-0.184	0.097	0.174	0.589 x	
X_2	0.111	0.228	-0.219	0.123	-0.171	-0.470	0.064	0.096	0.298	0.050	-0.521	-0.258	-0.375	-0.085	0.262		

Y_1	0.293	0.208	-0.110	0.198	0.789**	-0.196	-0.421	0.303	0.111	0.009	0.188	-0.086	-0.067	0.811**			
Y_2	0.028	-0.195	-.0.056	0.193	0.988**	-0.111	-0.428	0.327	0.225	0.157	0.531	0.239	-0.231				
Y_3	0.105	0.172	0.103	-0.250	-0.186	0.242	-0.384	0.272	-0.088	-0.697*	0.096	0.810**					
Y_4	0.157	0.050	0.393	0.069	-0.178	0.502	-0.184	0.479	-0.441	-0.449	0.093						
Y_5	-0.362	-0.626	0.059	0.093	0.595	0.119	-0.586	0.427	0.203	0.383							
Y_6	-0.289	-0.462	-0.159	0.201	0.184	-0.097	0.079	-0.057	-0.156								
Y_7	-0.263	-0.177	-0.409	-0.141	0.166	-0.514	-0.451	0.091									
Y_8	-0.450	-0.165	-0.117	-0.140	0.284	-0.156	-0.529										
Y_9	0.149	0.381	0.120	0.089	-0.418	0.174											
Y_{10}	0.600	-0.109	0.921**	0.704*	0.007												
Y_{11}	0.094	-0.234	0.020	0.275													
Y_{12}	0.701*	-0.169	0.773**														
Y_{13}	0.681*	-0.115															
Y_{14}	0.307																
Y_{15}																	

X_1 : Disease incidence X_2 : Disease severity Y_1 : Total plant height (cm) Y_2: Technical stem length (cm)
Y_3: No, of fruit branches / plant Y_4: No. of capsules / plant Y_5: No. of seeds / capsule Y_6: Stem diameter (cm)
Y_7: Straw yield / plant (g) Y_8: Seed yield / plant (g) Y_9: Straw yield /fed. (ton) Y_{10}: Seed yield /fed. (kg)
Y_{11}: Fiber length (cm) Y_{12}: Fiber fineness (NM) Y_{13}: Fiber yield / fed. (kg) Y_{14}: Oil (%)
Y_{15}: Oil yield / fed (kg)
Linear correlation coefficient (r) was significant at $P \leq 0.10$ (x), $P \leq 0.05$ (*), or $P \leq 0.01$ (**).

Table 12. Correlation coefficients for agronomic traits, technological traits, and disease intensity variables of ten flax genotypes infected with powdery mildew under field conditions in 1998/99.

	Y_{15}	Y_{14}	Y_{13}	Y_{12}	Y_{11}	Y_{10}	Y_9	Y_8	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	X_2	X_1
X_1	-0.216	0.045	0.135	0.250	0.606	0.331	-0.294	-0.177	0.011	-0.076	0.130	0.195	-0.580	0.775 **	0.404	0.850 **	
X_2	0.056	0.256	0.237	0.228	0.379	-0.047	-0.023	-0.079	-0.300	-0.282	-0.144	0.290	-0.042	0.803 **	0.210		
Y_1	-0.355	-0.279	0.601	0.758*	0.903**	-0.442	-0.066	-0.663*	-0.029	-0.058	0.693*	-0.162	-0.058	0.087			
Y_2	-0.067	0.209	-0.189	-0.141	0.356	-0.163	-0.179	0.311	0.051	-0.244	-0.085	-0.052	-0.063				
Y_3	0.093	0.054	-0.275	-0.322	0.067	0.126	-0.141	0.450	0.269	0.356	0.025	0.493					
Y_4	0.253	0.304	0.143	-0.071	-0.128	0.287	0.322	0.109	0.101	0.239	0.530						
Y_5	-0.170	-0.287	0.222	0.473	0.618	-0.256	-0.303	-0.452	0.077	0.242							
Y_6	0.451	0.257	-0.163	-0.146	-0.162	0.483	0.126	0.173	0.592								
Y_7	-0.135	-0.205	-0.575	-0.539	0.114	-0.081	-0.077	0.357									
Y_8	-0.278	0.385	-0.709	-0.824**	-0.481	0.329	0.012										
Y_9	0.719*	0.665*	0.489	0.198	-0.325	0.723*											

Y_{10}	0.985**	0.810**	0.138	-0.091	-0.646*												
Y_{11}	-0.555	0.434	0.296	0.487													
Y_{12}	0.001	0.064	0.937**														
Y_{13}	0.213	0.275															
Y_{14}	0.858**																
Y_{15}																	

X_1 : Disease incidence X_2 : Disease severity Y_1 : Total plant height (cm) Y_2: Technical stem length (cm)
Y_3: No, of fruit branches / plant Y_4: No. of capsules / plant Y_5: No. of seeds / capsule Y_6: Stem diameter (cm)
Y_7: Straw yield / plant (g) Y_8: Seed yield / plant (g) Y_9: Straw yield /fed. (ton) Y_{10}: Seed yield /fed. (kg)
Y_{11}: Fiber length (cm) Y_{12}: Fiber fineness (NM) Y_{13}: Fiber yield / fed. (kg) Y_{14}: Oil (%)
Y_{15}: Oil yield / fed (kg)
Linear correlation coefficient (r) was significant at P ≤ 0.10 (x), P ≤ 0.05 (*), or P ≤ 0.01 (**).

Table 13. Correlation coefficients for agronomic traits, technological traits, and disease intensity variables of ten flax genotypes infected with powdery mildew under field conditions in 1999/2000.

	Y_{15}	Y_{14}	Y_{13}	Y_{12}	Y_{11}	Y_{10}	Y_9	Y_8	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	X_2	X_1
X_1	0.409	0.363	0.025	0.027	-0.206	0.446	0.094	0.601	-0.291	-0.151	0.245	0.592	0.329	-0.323	-0.061	0.921**	
X_2	0.358	0.220	0.220	0.216	-0.010	0.494	0.308	0.424	-0.415	-0.150	0.585	0.464	0.228	-0.164	0.131		
Y_1	-0.032	-0.224	-0.006	-0.030	0.681*	0.312	-0.029	0.127	-0.380	-0.265	0.396	-0.035	-0.151	0.315			
Y_2	-0.048	-0.183	0.039	0.020	0.761*	-0.109	0.042	-0.336	-0.447	-0.212	0.019	-0.592	-0.433				
Y_3	-0.642*	-0.503	-0.346	-0.323	-0.604	-0.526	-0.209	0.450	0.348	0.412	-0.474	0.889**					
Y_4	-0.307	-0.189	-0.355	-0.339	-0.492	-0.206	-0.242	0.682*	0.175	0.109	-0.139						
Y_5	0.659*	0.521	-0.035	-0.066	0.523	0.724*	-0.069	0.221	-0.775**	-0.765*							
Y_6	-0.646*	-0.549	0.200	0.243	-0.552	-0.519	0.277	-0.497	0.769**								
Y_7	-0.534	-0.352	0.158	0.201	0.611	-0.578	0.164	-0.340									
Y_8	0.248	0.272	-0.384	-0.409	-0.170	0.265	-0.402										
Y_9	0.117	-0.199	0.970**	0.976**	-0.024	0.245											
Y_{10}	0.869**	0.603	0.329	0.300	0.271												
Y_{11}	0.231	0.054	0.003	0.023													
Y_{12}	0.208	-0.075	0.998**														
Y_{13}	0.237	-0.054															
Y_{14}	0.873**																
Y_{15}																	

X_1 : Disease incidence X_2 : Disease severity Y_1 : Total plant height (cm) Y_2: Technical stem length (cm)

Y_3: No, of fruit branches / plant Y_4: No. of capsules / plant Y_5: No. of seeds / capsule Y_6: Stem diameter (cm)
Y_7: Straw yield / plant (g) Y_8: Seed yield / plant (g) Y_9: Straw yield /fed. (ton) Y_{10}: Seed yield /fed. (kg)
Y_{11}: Fiber length (cm) Y_{12}: Fiber fineness (NM) Y_{13}: Fiber yield / fed. (kg) Y_{14}: Oil (%)
Y_{15}: Oil yield / fed (kg)
Linear correlation coefficient (r) was significant at P ≤ 0.10 (x), P ≤ 0.05 (*), or P ≤ 0.01 (**).

Table 14. Correlation coefficients for agronomic traits, technological traits, and disease intensity variables of ten flax genotypes infected with powdery mildew under field conditions in 2000/2001.

	Y_{15}	Y_{14}	Y_{13}	Y_{12}	Y_{11}	Y_{10}	Y_9	Y_8	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	X_2	X_1
X_1	0.481	0.448	0.143	0.125	-0.221	0.410	0.188	-0.715*	0.185	-0.004	-0.267	-0.559	-0.434	-0.442	-0.437	0.853**	
X_2	0.179	0.120	0.351	0.335	0.102	0.143	0.380	-0.526	0.113	0.091	-0.353	-0.212	-0.135	-0.101	-0.108		
Y_1	-0.677*	-0.846**	0.157	0.170	0.889**	-0.542	0.099	0.096	0.796**	0.188	0.381	0.455	0.389	0.981**			
Y_2	-0.670*	-0.810**	0.115	0.131	0.896**	-0.537	0.051	0.097	0.763*	0.198	0.425	0.523	0.419				
Y_3	-0.595	0.359	0.008	0.022	0.543	-0.615	-0.091	0.382	0.282	-0.609	-0.391	0.585					
Y_4	-0.164	0.199	-0.010	-0.101	0.290	-0.081	-0.125	0.392	0.069	-0.202	0.014						
Y_5	-0.084	0.354	-0.343	-0.328	0.198	0.043	-0.322	-0.072	0.137	0.574							
Y_6	-0.070	-0.322	0.297	0.307	0.030	0.017	0.355	0.048	0.266								
Y_7	-0.826**	-0.839**	0.189	0.210	0.875**	-0.778**	0.127	-0.123									
Y_8	-0.275	0.253	0.287	0.270	-0.089	-0.239	0.261										
Y_9	0.035	-0.053	0.992**	0.985**	0.028	0.067											
Y_{10}	0.982**	0.793**	-0.025	-0.051	-0.740*												
Y_{11}	-0.810**	-0.821**	0.112	0.139													
Y_{12}	-0.079	-0.116	0.995**														
Y_{13}	-0.053	-0.108															
Y_{14}	0.885**																
Y_{15}																	

X_1 : Disease incidence X_2 : Disease severity Y_1 : Total plant height (cm) Y_2: Technical stem length (cm)
Y_3: No, of fruit branches / plant Y_4: No. of capsules / plant Y_5: No. of seeds / capsule Y_6: Stem diameter (cm)
Y_7: Straw yield / plant (g) Y_8: Seed yield / plant (g) Y_9: Straw yield /fed. (ton) Y_{10}: Seed yield /fed. (kg)
Y_{11}: Fiber length (cm) Y_{12}: Fiber fineness (NM) Y_{13}: Fiber yield / fed. (kg) Y_{14}: Oil (%)
Y_{15}: Oil yield / fed (kg)
Linear correlation coefficient (r) was significant at P ≤ 0.10 (x), P ≤ 0.05 (*), or P ≤ 0.01 (**).