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MANAGEMENT OF FLAX POWDERY MILDEW AND EFFECT OF CLIMATIC CONDITIONS ON AGRONOMIC TRAITS AND FIBER TECHNICAL CHARACTERS

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ABSTRACT

Field trials of flax plants were sown during two successive growing seasons 2006 and 2007at Gemiza Agriculture Research Station, Gharbiya governorate, Egypt. The effects of relative humidity (RH) and temperature on flax powdery mildew (*Oidium lini* Sikoric) were studied in controlled environments to define conditions that affect disease development in flax. In this study, four cultivars; Sakha2, Giza8, Liflora and Escalina were evaluated for disease development. Two different fungicides; Bayfidan, Tobas 100-EC and two novel antifungal compounds; Bion and Tannic acid were foliar sprayed at three intervals to control powdery mildew. Data showed that the germination of conidia and symptoms appearance at a constant temperature at 25˚C failed to occur at 0% RH but by increasing the RH to 50, 60 and 75% infection process occurred by conidia and symptoms appeared. The highest level of conidia germination and infection establishments expressed as high diseases incidence percentage was observed at 25˚C and 75-100% RH. Disease control with fungicides and antifungal compounds showed significant differences among all treatments sprayed with Tobas 100-EC, Bayfidan, Bion and Tannic acid compared with the control. Significant effects were observed on yield, yield components, technological characters for fiber and chemical character of seed oil.

INTRODUCTION

Flax (*Linum usitatissimum* L.) is an economically important fiber crop. The cellulose fibers (bast fibers) of this plant are characterized by a number of physicochemical and mechanical properties of importance in the textile and composite polymer industries (Baley 2002). Bast fibers are located in the stem cortex between the epidermis and the xylem core and are considered as primary sclerenchyma phloem fibers. Currently there is considerable interest in increasing the use and improving the quality of fibers from flax and other plants for industrial use Knowledge of the structure and physical characteristics is required to define quality for the industrial application of plant fibers (Van Dam *et al* 1994). The present work was carried out to study flax cultivars at Gharbiya governorate as main area of flax production in Egypt through evaluation the effect of climatic conditions of temperature and relative humidity on powdery mildew disease development. Also; to determine the effect of disease control with different fungicides and antifungal compounds on disease development and both agronomic and technical characters of flax crop.

MATERIALS AND METHODS

Effect of relative humidity (RH) and temperature on disease development.

Flax plants grown under controlled conditions of temperature and RH in greenhouse and growth chamber were inoculated with fresh conidia collected from other infected plants in the fields. Six temperature regimes (5, 10, 15, 25, 30 and 35 C) and six RH regimes (0, 10, 15, 25, 50, 75 and 100 % RH) were adjusted in combination each time for 2 weeks to grow inoculated mature flax plants transferred from greenhouse (10 plants plus control) to growth chamber to study the effect of each combination of temperature and RH. Growth chamber was adjusted for light periods, temperature and RH as in manual of operation. Assessment of disease incidence was done weekly. Other experiments during the two seasons were carried out to study the effect of temperature and RH under natural field condition. Temperature and RH at field site was recorded weekly and means of RH and temperature were calculated monthly. The disease incidence was determined for susceptible cultivar (Escalina) during the periods extended from early November to late May in both 2005/2006 and 2006/2007 of each growing season.

Field experiments

Field experiments of this investigation was carried out at Gemmeza Research Station in Gharbiya governorate during two successive winter seasons; 2005/2006 and 2006/2007 to study the management and reaction of four flax (Saka2, Giza8 Liflora and Escalina) varieties to powdery mildew disease. The sowing date was on November 7th and 3rd in 2005/2006 and 2006/2007 growing seasons, respectively. The sowing method was broadcast in each subplot (6 m2) equal 1/700 feddan (feddan = 4200 m^2) and the irrigation was done at the next day from sowing in both seasons. Normal cultural practices were conducted as recommended for growing flax. At full maturity, ten guarded plants were chosen at random from each subplot to study yield, yield components and quality characters. While straw, seed and fiber yield per feddan were determined on plot area basis. Field experiments consisted of a randomized complete block design of four replications (blocks). Plots (1.5 x 4.0 m) were planted with these four flax cultivars at the rate of 50 kg seeds/feddan. Each experiment consisted of 60 different treatments resembled interaction among cultivars, fungicides or chemicals, and time of spray. Powdery mildew was allowed to develop naturally and the applications of antifungal compounds; Bayfidan (as Triadiminol 15% EC), Tobas 100-EC 100EC (Penconazol or 1-(2-(2,4-diclorofenil)-n-pentil)-1H-1,2,4,-triazol), Bion or BTH (benzo (1,2,3) thiadiazole-7-carbothioic acid S-methyl ester) and Tannic acid were foliar sprayed at 3 intervals with recommended or suggested doses 0.15 ml/L, 0.50 ml/L, 0.3 g/L, 15 g/L respectively. First spray was before symptoms appearance or flowering stage, the second was coincided with the first sign of the disease and third as a boost spray was two weeks after the second. Disease intensity variables

(Disease incidence and disease severity) were used as criteria for assessing prevalence of the disease. Disease incidence and disease severity were measured according to; (Seem, 1984) and (Nutter *et at.,* 1991). Disease incidence (DI) was measured as percentage of infected plants in a random sample of 50 plants/10 m2 (three samples from each plot). Disease severity (DS) was measured as percentage of infected leaves/plant in a random sample of 10 plants/6 m2 (three samples from each plot). At harvest, a random sample of 10 plants was taken from each plot and observations were recorded on each individual plant for the following agronomic and technical fiber traits;Total plant height (cm) measured from the cotyledonary node to apical bud of each plant, Technical stem length (cm). measured from the cotyledonary node to the first apical branches of the main stem, Main stem diameter (mm) measured at the middle region to the nearest 0.1 mm by using boucles, Straw yield per plant (gm) calculated as a total weight in grams of the air dried straw per plant after removing the capsules, Number of the apical branches, was counted for each plant, Number of capsules per plant, Number of seeds per capsules, Seed yield per plant, Seed index (determined as the weight of 1000 seeds randomly taken from the seed lot of each plot).

Technological and chemical characters:

At harvesting 18 plants were sampled at random from each of the selected locations at every plot. After deseeding of another three samples of 50 plants, each sample was subjected to a retting process then fiber yield per plant, in stem fiber were determined. Fiber percentage, was calculated according to the following equation (Fiber percentage = Weight of the fiber / weight of the total straw after retting X 100), The fiber yield was determined as the weight of total separated fiber per plant and calculated as (Fiber yield = weight of total separated fiber / weight of unretted (yellow) straw. Fiber length was estimated from sample often fiber ribbons. Fibers were separated into long fibers (more than 50 cm in length); medium fibers (ranging from 10 to 50 cm in length). Long fiber fineness was determined in metrical number (Nm) according to Radwan and Momtaz (1966) using the following formula:

$$Nm = N \times L/G;$$

Where; N = number of fibers (20 cuts of fiber, each 10 cm), L = total length of the 20 parts of fiber in mm (2000 mm) and G = weight of fibers in mg. The above formula revealed that the more metrical number, more fineness of the fiber at the following table that express the rating of fineness according to the international measures:

Grade	Rating	Metrical Number
1	Very fine	4 00 and more
2	Fine	350 – 399
3	Relatively coarse	300 – 349
4	Medium coarse	250 – 299
5	Coarse	Under 250

Oil percent was determined by micro-Soxhlet extraction of the crushed seeds with petroleuim ether (bp 30-600). Weight percentages of the fatty acids were determined from area measurements by calibration with pure fatty acid esters. Oil percent and fatty acid composition assuming 100% triglyceride composition of the oil. Theoretical iodline values were calclulated from fatty acid composition. Iodine value was determined by the Hiscox method (1948).

Data obtained were statistically analyzed factorially according to procedures outlined by Snedecor and Cochran (1980) and the least significant difference (L.S.D.) was used to determine the significance of differences between treatment means at 0.05 level. As for the chemical properties considered in the study, the t-test computed in accordance with standard deviation was utilized to verify the significance between every two treatment means at the 0.05 level of significance.

RESULTS

Effect of temperature and relative humidity on disease development

In experiments carried out under laboratory and greenhouse controlled conditions of temperature and relative humidity on replicated individual plants grown in pots inside controlled greenhouse were inoculated with fresh conidia at different regimes of temperatures and relative humidity. Data showed that the germination of conidia and symptoms appearance at a constant temperature at 25˚C failed to occur at 0% RH but by increasing the RH to 50, 60 and 75% infection process occurred by conidia and symptoms appeared. At constant 50% RH, infection process and conidia germination failed to occur at temperature below 15˚C, by increasing the temperature to 20 and 25˚C the symptoms started to appear successfully. The highest level of conidia germination and infection establishments expressed as high diseases incidence percentage was observed at 25˚C and 75-100% RH. (Table 1)

Under field conditions; the effect of temperature and relative humidity showed very highly significant effects on disease development and progress (Figs. 1 and 2). Field observations showed that the relative humidity ranged from 50-73% during the period from November to May of the growing season 2005-2006 (Fig. 2-1) and 49-69% of the same period in the growing season 2006-2007 (Fig. 2-2). The mean of maximum day temperatures recorded during the period from November (sowing month) to May (harvest month) were 25.2˚C at sowing and gradually decreased to 17.1˚C in January then gradually increased by time to reach 27˚C and 31.2˚C in April and 1st May in the growing season 2005-2006 while the minimum day temperatures were 11.4˚C at sowing and gradually decreased to 6.1˚C in January then gradually increased by time to reach 10.5˚C and 13.5˚C in April and 1st May (Fig.1-1). Both Maximum and minimum temperature recorded in the next growing season 2006-2007 showed the same trend with slight difference in temperature degrees. Field observation showed that the initial disease symptom was observed on mid of March with slight difference of days before or after the next growing season in the same area of flax fields (Fig. 1-2).

Disease intensity variables of disease incidence (DI) and disease severity (DS) used as criteria for assessing prevalence of powdery mildew disease.

Table (1) Disease incidence % of powdery mildew symptoms appeared on artificially inoculated flax plants under controlled greenhouse conditions with different regimes of temperatures and relative humidity.

Disease incidence %						
RH%	Temperature (˚C)					
	5˚C	10˚C	15˚C	25˚C	30˚C	35˚C
0% RH	0	0	0	0	0	0
10% RH	0	0	0	0	0	0
15% RH	0	0	0	20	20	0
25% RH	0	0	0	25	25	0
50% RH	0	0	10	75	50	30
75% RH	0	0	15	100	65	25
100% RH	0	0	18	85	75	0

As shown in Table (2) significant differences were found in the first season between all treatments and control treatments. The antifungal compounds were ranked for DI reduction as follow; Tobas 100-EC100EC, Bayfidan, Bion and Tannic acid compared with the control. Regarding the effect of cultivars on DI, Sakha2 cultivar showed lowest DI followed by Giza8, and Liflora while Escalina cultivar was higher in DI compared with others cultivars. DI was decreased at 1st survey then more reduction occurred at 2nd survey and reached to the higher reduction of DI at the 3rd survey before harvest for all the treatments received 3 times of sprays with antifungal chemical compounds compared with control treatments for all cultivars.

Table (2) Effect of different antifungal compounds on disease incidence% (DI) of flax powdery mildew surveyed at 3 different times during 2005/2006 growing season.

	Cvs/Treatment	Tobas	Bayfidan	Bion	Tannic	control
		% Disease Incidence				
1st Survey	Sakha2	١,٧٤ op	٨,٥٠ i	١,٥٠ p	١١,٥٠h	١٦,٥٠ f
	Giza8	٣,٥٠ lm	٤,٦٠ k	٢,٥٠ no	١٢,٥٠g	٢٠,٥٠ d
	Liflora	٣,٠٠ mn	٣,٥٠ lm	٢,١٠nop	١١,٠٠h	١٨,٦٠ e
	Escalina	٥,٦٠ j	٢٥,١٠ b	٤,١٠ kl	٢٢,٥٠c	٤٤,٥٠ a
	LSD 0.05= 0.919					
2nd Survey	Sakha2	٢,٨٠ m	٧,١٠ j	٢,٥٠ m	١٠,٥٠ i	٢١,٨٠ e
	Giza8	٦,٥٠ jk	١٠,٢٠ i	٥,٥٠ k	١٨,٥٠ g	٣٢,٥٠ c
	Liflora	٥,٤٠ k	٩,٦٠ i	٤,٢٠ l	١٢,٥٠ h	٣٦,٥٠ b
	Escalina	٩,٥٠ i	٢٧,٠٠ d	٦,٥٠ jk	٢٠,٥٠ f	٦٥,٠٠ a
	LSD 0.05= 1.249					
3rd Survey	Sakha2	١,٢٠ l	٥,١٥ jk	٠,٠٠ l	١٦,٥٠gh	٤٤,٨٠ d
	Giza8	٢,٧٠ kl	١٤,٥٠ h	٢,٨٠ kl	٢٤,١٠ f	٧٩,٥٠ b
	Liflora	٣,٥٠ jkl	١٣,٧١ h	٢,٤٠ kl	١٩,٥٠ g	٧١,٦٠ c
	Escalina	٩,٨٠ i	٢٢,٥٠ gh	٦,٨٠ ij	٣٤,٥٠ e	١٠٠,٠0a
	LSD 0.05= 3.672					

*** Values of each survey in each survey followed by the same latter are not significantly different according to Duncan multiple range test (*P=0.05*)**

In the 3rd survey of DI; all field plots received 3 times of sprays except control plots. Significant differences were clearly observed among field plots where plants received more sprays showed less DI percentage compared with 1st and 2nd surveys especially in field plots treated with Tobas 100-EC100EC and Bayfidan. In some treatments the disease incidence or symptoms were almost eliminated in Sakha2 X Tobas 100-EC100-EC (1.2%) and Sakha2 X Bayfidan (0%). Data in Table (3) revealed significant differences between all treatments and its controls in disease severity (DS).

Table (3) Effect of different antifungal compounds on disease severity % (DS) of flax powdery mildew surveyed at 3 different times during 2005/2006 growing season.

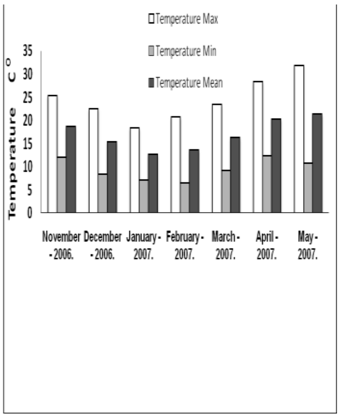
	Cvs/Treatment	**Tobas**	**Bayfidan**	**Bion**	**Tannic**	**Control**
		% Disease severity				
1st Survey	**Sakha2**	٤,٥٠ l	٨,٥٠ j	٣,٢٠ l	٧,٥٠jk	٢٤,٠٠ f
	Giza8	٨,١٠ j	١٨,٥٠ h	٨,١٠ j	٢١,٠٠g	٦٢,٠٠ b
	Liflora	٧,٢٠ jk	١٥,٥٠ l	٦,٥٠ k	١٨,٩٠h	٦١,٠٠ b
	Escalina	٢٥,٥٠ e	٣١,٠٠ d	١٨,٠٠h	٣٢,٥٠c	٧٣,٥٠ a
	LSD 0.05= 1.47					
2nd Survey	**Sakha2**	٦,٨٠ l	١٢,٥٠ j	٤,٥٠m	١٥,٥٠ i	٢١,٠٠ g
	Giza8	١٢,٠٠ jk	٢٤,٠٠ e	١١,٠٠jk	٢٦,٠٠ c	٦١,٠٠ b
	Liflora	١٠,٥٠ k	٢١,٠٠ g	١٠,٥٠jk	١٨,٥٠ h	٦٠,٠٠ b
	Escalina	٢١,٠٠ fg	٢٢,٨٠ ef	١٦,٥٠ i	٢٨,٥٠ c	١٠٠,٠٠ a
	LSD 0.05= 1.58					
3rd Survey	**Sakha2**	٧,٥٠no	١١,٥٠ kl	٦,٥٠ o	١٦,٥٠ ij	٢٧,١٠ d
	Giza8	١١,٥٠kl	١٨,٥٠ gh	٩,٥٠ m	١٩,٠fg	١٠٠,٠0 a
	Liflora	١٠,٨٠ l	١٧,٥٠ hi	٨,٥٠ mn	٢١,٠٠ e	٩٣,٠٠ b
	Escalina	١٥,٥٠ j	٢٠,٠٠ ef	١٢,٥٠ k	٣٥,٥٠ c	١٠٠,٠0 a
	LSD 0.05= 1.23					

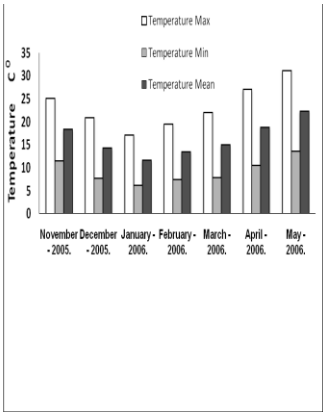
*** Values of each survey followed by the same latter are not significantly different according to Duncan multiple range test (*P=0.05*)**

The antifungal compounds were ranked for DS reduction as follow; Tobas 100-EC, Bayfidan, Bion and Tannic compared with the control. Cultivars were different in DS%; Sakha2 cultivar showed lowest DS (total mean =11.54%) followed by Giza8 cv (total mean =15.44%), Liflora (total mean =15.76%) and Escalina (total mean =58.6%). After 3 times spray with antifungal compounds a significant reduction in DS% compared with the control treatments. As shown in Table (3); the lowest reduction of DS% was 6.5% in Sakha2 cv, 8.5% in Liflora cv, 9.5% in Giza8, and 12.5% in Escalina cv compared with their cultivar control treatments 27.1%, 100%, 93% and 100%; respectively.

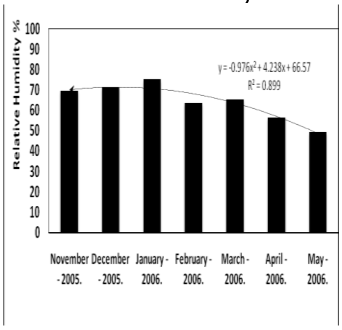
In the second experiment year 2006/2007; data shown in Table (4) indicated that plants sprayed with Tobas 100-EC reduce DI to (total mean = 2.58%), Bion (total mean = 4.83%), Bayfidan (total mean = 9.57%), and tannic acid (total mean = 24.43%) compared with the control (total mean =

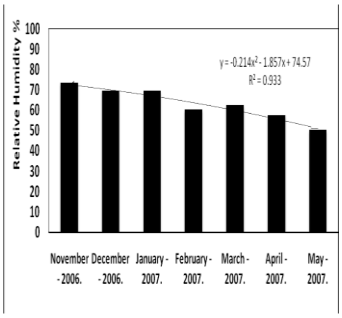
41.82%). The cultivars tolerance responses to the DI after treatment with antifungal compounds were ranked as follow: Sakha2 (total mean = 3.4%), Giza8 (total mean = 8.14%), Liflora (total mean = 13.71%) compared with the total means of DI in all control treatments 41.34%. In the 3rd survey of DI; all field plots received 3 times of sprays except control plots. As shown in Table (4) significant differences were clearly observed among field plots when plants received more sprays it showed less DI percentage compared with 1st and 2nd surveys. This was observed clearly in field plots treated with Tobas 100-EC and Bion.





Figs 1-1 and 1-2. Temperature records during 2005/2006 and 2006/2007 growing seasons at Gemiza Agric. Research station , Gharbiya governorate, Egypt.





Figs 2-1 and 2-2. Relative humidity (RH) records during 2005/2006 and 2006/2007 growing seasons at Gemiza Agric. Research station , Gharbiya governorate, Egypt.

Data presented in Table (5) showed that cultivars were different in DS%; Sakha2 cv showed lowest DS (8.60%) followed by Liflora cv (10.84%), Giza8 (12.12%) and Escalina (46.31%). At the 3rd survey; percentages of DS reached to more than 50% in some treatments sprayed with Tobas 100-EC and Bion While the DS reduction percentage in the treatments sprayed with

Bayfidan and Tannic acid was less than DS reduction occurred in the treatments sprayed with Tobas 100-EC and Bion in Sakha2 and Giza 8 cultivars (less than 50%).

Table (4) Effect of different antifungal compounds on disease incidence% (DI) of flax powdery mildew surveyed at 3 different times during 2006/2007 growing season.

	Cvs/Treatment	Tobas	Bayfidan	Bion	Tannic	Control
		% Disease Incidence				
1st Survey	Sakha2	0.50 j	1.00 j	0.75 j	3.50 hi	9.50 ef
	Giza8	1.75 hij	1.53 ij	0.75 j	10.25 de	12.0 cd
	Liflora	4.00 h	3.75 hi	0.75 j	7.50 fg	14.60 b
	Escalina	0.50 j	6.75 g	1.50 ij	14.00 bc	29.60 a
	LSD 0.05= 2.28					
2nd Survey	Sakha2	2.75 kl	6.75 i	5.50 ij	18.38 f	28.90 e
	Giza8	1.25 l	9.75 h	4.25 jk	17.50 f	45.50 b
	Liflora	1.25 l	9.75 h	3.75 jk	18.78 f	39.30 d
	Escalina	3.75 jk	12.50 g	7.25 i	41.75 c	55.40 a
	LSD 0.05= 2.26					
3rd Survey	Sakha2	3.75 no	12.25 j	6.25lm	27.75 g	45.60 e
	Giza8	1.75 o	15.75 i	9.75 k	36.25 f	69.40 b
	Liflora	4.25 mn	15.50 i	6.50 l	35.00 f	66.80 c
	Escalina	5.50mn	19.50 h	11.0 jk	62.50 d	85.30 a
	LSD 0.05= 2.17					

*** Values of each survey followed by the same latter are not significantly different according to Duncan multiple range test (*P=0.05*)**

Table (5) Effect of different antifungal compounds on disease severity % (DS) of flax powdery mildew surveyed at 3 different times during 2006/2007 growing season.

	Cvs/Treatment	Tobas	Bayfidan	Bion	Tannic	control
		% Disease severity				
1st Survey	Sakha2	2.50 j	3.50 j	1.50 h	5.00hi	22.00 ef
	Giza8	3.50 hij	5.25 ij	2.50 j	8.0de	55.0 cd
	Liflora	3.50 h	6.50 hi	2.50 j	8.0 fg	47.50 b
	Escalina	6.00 j	10.00 g	5.00 ij	13.0bc	45.00 a
	LSD 0.05= 2.27					
2nd Survey	Sakha2	8.00 j	10.25 hij	5.00 k	9.0 ij	30.00 d
	Giza8	13.50 fg	16.00 f	9.00 ij	15.0 f	55.00 b
	Liflora	10.00 hij	12.00 gh	8.00 j	11.0ghi	47.50 c
	Escalina	15.00 f	22.00 e	11.0ghi	22.0 e	75.00 a
	LSD 0.05= 2.93					
3rd Survey	Sakha2	9.25 ij	15.00 h	11.00 i	18.00fg	33.6 d
	Giza8	7.00 jk	20.00 ef	11.00 i	20.00ef	72.50 b
	Liflora	6.00 k	18.00 fg	8.00 jk	16.13gh	67.60 c
	Escalina	16.00gh	32.00 d	18.00 fg	22.00 e	100.0 a
	LSD 0.05= 2.34					

*** Values of each survey followed by the same latter are not significantly different according to Duncan multiple range test (*P=0.05*)**

Effect of fungicides and antifungal compounds on agronomic traits.

Data in Tables 6 and 7 for both growing seasons showed that fungicides and antifungal compounds used for powdery mildew control had significant effect on all agronomic traits and in the same trends in both growing seasons. This agronomic traits including; plant technical length (cm); number of fruiting branches; capsule number; seed number per capsule; stem thickness, straw weight were better than plants of control treatments in each cultivar.

T6

T7

The significant effect was in the treatments treated with Tobas 100-EC and Bion compared with control. Escalina was the lowest cultivar in capsule number per plant while Giza8 and Liflora were the highest cultivars in this crop trait followed by Sakha2. Escalina was the lowest cultivar in number of seed per plant while the other cultivars had the higher averages but there were no significant differences among it. Giza8 cv showed the higher increase in this crop trait followed by Sakha2 and Liflora cultivars while Escalina had the lowest averages in stem thickness measures. Bion was ranked the second after Tobas 100-EC in the averages of straw weight (g) per plant followed by Bayfidan and Tannic. No significant differences were observed among treatments with Tobas 100-EC, Bayfidan or Bion but it showed higher increase seed weight values more than control treatment.
Regarding the effect of cultivars on seed weight per plant character; data showed a significance differences among cultivars. Both Sakha2 and Giza8 cvs showed a significant increase more than Liflora and Escalina cvs. The cultivars can be ranked from the higher to the lower values as follow; Sakha2, Giza 8; Liflora and Escalina. Seed index in most treatments was comparable to the seed weight values as shown in table (6 and 7). A higher significant difference was shown between controls and any treatment received plant sprays. However; Tobas 100-EC, Bion and Tannic acid had the higher values of seed index followed by Bayfidan treatment. As calculated for yield per feddan for the seed and straw yield determined in one square meter. Significant differences were found among treatments showed a high increase in seed or straw yield in all treatments received fungicidal sprays compared with its controls. However; Tobas 100-EC had superior increase followed by Bion, Bayfidan and tannic acid in both growing seasons (Tables 6 and 7).

Effect of fungicides and chemicals on technical fiber traits.

Data presented in Table (8) showed the effect of fungicides and antifungal compounds sprays on technical characters of flax fiber and oil content of seeds during two growing seasons. In both growing seasons data taken for flax technical characters and oil content % of seed showed similar trend. Significant differences among all treatments and its controls in respect to fiber percentage and fiber length of flax. The fungicides and antifungal compounds lead to significant increase in fiber%. Tobas 100-EC was ranked the first followed by other antifungal compounds. However, no significant difference was found between Bayfidan and Bion or between Bayfidan and Tannic acid in fiber percentage. Among flax cultivars showed significant differences in fiber percentage on which Escalina cv was the first followed by Liflora, Giza 8 and Sakha2 cvs. No differences were found in fiber fineness between the effect of sprays with Tobas 100-EC and Bayfidan or between Bion and Tannic. However; all plants sprayed with chemicals were higher in fiber fineness compared with controls. Significant differences were found in oil content % in seed in different treatments. All cultivars sprayed with chemicals showed considerable increase in oil content % compared with controls. Sakha 2 was the first cultivars followed by Liflora, Giza 8 and Escalina.

Table (8) Effect of 4 different antifungal compounds on technological characters of 4 cultivars at harvest in experiments to control flax powdery mildew.

		Fiber (%)		Fiber length (cm)		Fiber fineness (NM)		Oil content		Iodine number (value)	
CULTIVARS	**TREATMENTS**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Sakha2	**Topas**	18.75	١٩,٠٠	88.800	٨٦,٦٠٠	125.025	126.885	٣٤,٥٠	٣٣,٠٠	170	162
	Bayfidan	17.75	١٧,٧٥	84.725	٨٤,٨٢٥	124.738	126.230	٣٣,٧٥	٣٢,٥٠	166	160
	Bion	16.50	١٧,٧٥	81.700	٨٤,٣٥٠	122.973	125.783	٣٣,٠٠	٣٢,٠٠	162	157
	Tannic acid	16.75	١٦,٠٠	76.050	٨٢,٣٠٠	121.600	122.855	٢٩,٠٠	٣١,٠٠	129	153
	Control	14.50	١٥,٠٠	75.750	٧٨,٢٥٠	119.958	121.013	٢٩,٥٠	٢٨,٧٥	132	141
Giza 8	**Topas**	19.25	١٩,٠٠	86.375	٨٢,٠٠٠	126.675	128.795	٣١,٢٥	٣٠,٥٠	154	150
	Bayfidan	19.00	١٨,٧٥	83.775	٨١,١٢٥	126.373	128.650	٣٠,٧٥	٣٠,٢٥	151	149
	Bion	19.00	١٨,٧٥	77.775	٧٨,٤٠٠	125.618	128.253	٢٩,٠٠	٣٠,٠٠	143	148
	Tannic acid	16.25	١٦,٢٥	82.625	٧٧,٤٥٥	124.400	125.208	٢٤,٧٥	٢٥,٥٠	122	126
	Control	15.75	١٦,٠٠	69.750	٧٤,٤٥٠	122.350	124.153	٢٣,٧٥	٢٤,٠٠	117	118
Liflora	**Topas**	21.25	٢٢,٢٥	99.900	٩٢,٢٠٠	179.375	179.538	٣٣,٧٥	٣٣,٧٥	166	166
	Bayfidan	20.75	٢١,٧٥	97.025	٩١,٣٠٠	178.300	178.860	٣٢,٧٥	٣٢,٥٠	161	160
	Bion	20.75	٢٠,٥٠	87.425	٩٠,٩٧٥	176.025	178.058	٣٣,٥٠	٣١,٧٥	165	156
	Tannic acid	19.00	١٨,٥٠	85.750	٨٧,٤٢٥	175.200	173.950	٢٤,٧٥	٢٦,٢٥	122	129
	Control	16.50	١٧,٢٥	81.750	٨٦,٨٥٠	163.763	169.425	٢٢,٥٠	٢٣,٢٥	111	114
Escalina	**Topas**	22.50	٢٢,٥٠	102.750	٩٦,٠٠٠	184.100	184.088	٣١,٧٥	٣٣,٢٥	156	164
	Bayfidan	22.50	٢٢,٢٥	96.400	٩٥,٩٠٠	183.650	183.890	٣٠,٧٥	٣٣,٢٥	151	164
	Bion	22.25	٢٢,٢٥	95.825	٩٥,٠٥٠	178.575	183.125	٣٠,٧٥	٣٢,٥٠	151	160
	Tannic acid	18.75	١٩,٢٥	90.425	٩١,٩٠٠	157.425	175.175	٢١,٠٠	٢٤,٠٠	103	118
	Control	18.25	١٩,٢٥	81.250	٨٩,٢٥٠	173.025	177.388	٢٠,٢٥	٢١,٥٠	100	106
LSD at 0.05		***1.52***	***1.95***	***6.47***	***7.92***	***11.51***	***12.34***	***2.54***	***1.85***		

LSD Value at the end of each column is used to calculate the difference between means and significance compared with control treatments.

DISCUSSION

The goal of the present study was to study the effect of temperature and humidity as important climatic factors affecting development of powdery mildew on flax. Environmental conditions in both growing seasons of the experiments were favorable for epiphytotic spread of the disease. This was apparent as these environmental conditions resulted in high levels of DI and DS in the control plots did not receive any fungicides. These high levels of DI and DS in the control plots indicate that compounds were tested under high disease pressure. This high disease pressure considered as a prerequisite conditions for any meaningful field evaluation of fungicides.

Data of temperature and relative humidity responses were used to simulate the effect of relative humidity at different temperatures and explained through greenhouse under controlled conditions was validated with the data taken through experiment under natural field conditions. Therefore, this data can be used to assess risk of powdery mildew in flax based on the occurrence of temperature and relative humidity during the development stages. However; other meteorological researches indicate that microclimate in flax fields in Egypt changes gradually from mild daily temperatures (often greater than 18 C) to relatively high (around 20-28 C or higher) as the season approaches the beginning of the summer. Even though night temperatures seem mostly favorable, flax powdery mildew tends to become more common when the warm maximum temperatures start to prevail. An accurate understanding of the effect of moderate and high temperatures and the effect of RH on disease expression on key infection chain components would be the basis for the development of a risk assessment model of flax powdery mildew for Egypt conditions. (Aly *et al*.,1994)

Our findings showed that Tobas 100-EC, Bayfidan, Bion and tannic acid in descending order were the best performing fungicides or antifungal compounds in controlling flax powdery mildew. This superiority was attributed to two reasons First; they provide the most consistent control of the disease. Of the 3 times sprays for each fungicide applied over 2 years experiments. Second; Bion as resistant inducer compound gave significantly superior disease control with higher seed yield over the unsprayed control in both years.

Tannic acid as a novel natural antifungal polymer compound used in this study was significantly better in reducing disease severity and enhancing linseed yield. Tannic acid exhibit antimicrobial activity against phytopathogenic fungi and bacteria. The toxicity of tannins on microorganisms operates either by their direct action on the microbial membrane or by metal ion depletion (Scalbert, 1991; Alstrom, 1992, Mehmet Nuri NAS, 2004). The Bion treatment led to a significant reduction in both disease incidence and disease severity and increase in yield and fiber characters and productivity. This novel compound improved the resistance of flax to powdery mildew infection under field conditions. Our findings are in agreements with the findings of other researchers (Zavareh *et al.,* 2004; Gado, 2006 and Hukkanen *et al.,* 2007) applied Bion to control powdery mildew in other crops.

Data taken during the two growing seasons revealed that there were association between powdery mildew intensity rating and each of yield and yield-related traits due to flax genotype (cultivars). Sakha2 and Liflora cvs were more tolerant to powdery mildew disease while Escalina cv was less tolerant. This differences was explained with findings of Ashry *et al.*, (2002) who suggest as plant breeder that flax cultivar of fiber type has resistance to powdery mildew, while flax cultivars of seed type flax showed decrease in such a resistance. The effect of disease control on seed yield and other agronomic traits of flax. In our experiments, the disease was almost controlled by spraying with fungicides and significantly decreased to lower incidence percentage with Bion and tannic acid .The results showed that spraying with fungicide had a significant effect *($P<0.05$)* that reflected in increase of plant technical length, stem thickness, branches, capsules number and seed weight. There was no significant interaction effect between spraying and genotypes for any trait. Also, results indicated that technological characters of flax fiber were improved in fiber percentage, fiber length, fiber fineness in all plants sprayed with fungicides and other chemicals. From the findings of the present study, it seems that application of fungicides or natural antifungal (tannic acid) or novel chemicals (Bion) that induce resistance are needed to increase productivity and quality of flax as an economic fiber and oil crop.

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تـأثير مقاومـة مـرض البيـاض الـدقيقى فـى الكتـان والظـروف المناخيـة علـى الصـفات المحصولية والتكنولوجية للكتان

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اجريت تجارب حقلية وفى الصوب على مرض البياض الدقيقى الذى يصيب محصول الكتان فى موسمى ٢٠٠٦-٢٠٠٧ بمحطة بحوث الجميزة بمحافظة الغربية. تم دراسة تاثير الرطوبة النسبية والحرارة داخل غرف نمو وصوب متحكم فيها بيئيا وكذلك تحت ظروف الحقل الطبيعية وذلك لتحديد انسب الظروف البيئية التى تؤدى الى تكشف وظهور اعراض المرض. كما اجريت تجارب حقلية لمقاومة المرض باستخدام مبيدات فطرية مثل البايفيدان والتوباس ومركب البيون وحمض التانيك على ٤ اصناف متفاوتة فى قابليتها للأصابة وهى سخا ٢ و جيزة ٨ وليفلورا واسكالينا وذلك بالرش ٣ مرات متباعدة خلال موسم النمو. أظهرت نتائج التجارب ان اعراض المرض ظهرت بوضوح عند درجة حرارة ٢٥ درجة مئوية وبنسب متفاوتة لدرجات الرطوبة النسبية ٥٠ و ٦٠ و ٧٥% . كما اظهرت نتائج مقاومة المرض ان كل المبيدات والمركبات المستخدمة فى الرش قد اعطت نتائج ايجابية وبتأثير معنوى مقارنة بنتائج الأصابة فى النباتات التى لم ترش فى معاملات المقارنة . كما ادى الرش ايضا الى حدوث زيادة فى المحصول وموناته من الياف وبذور وكذلك فى تحسين معظم الصفات التكنولوجية لألياف الكتان والصفات الكيماوية للزيت.

Table (6) Effect of 4 different antifungal compounds on agronomic characters of 4 cultivars at harvest in experiments to control flax powdery mildew in 2005/2006 growing season.

CULTIVARS	TREATMENTS	Plant total length (cm)	plant technical length (cm)	branches No./Plant	Stem thickness (mm)	Straw wt. / Plant (g)	Capsules No./Plant	Seed No./ Plant	Seed Wt./ Plant (g)	Seed Index	Straw / Feddan (ton)	Seed Wt./ feddan (kg)
Sakha2	Topas	١٠٣,٣٥	94.18	4.55	2.463	2.92	11.25	8.58	6.63	12.27	5.99	667
	Bayfidan	١٠٤,٤٥	91.55	5.15	2.530	2.86	12.04	7.45	6.80	11.12	4.41	509
	Bion	١٠٢,٥٥	92.18	4.28	2.408	2.93	12.21	6.90	7.18	10.64	5.25	572
	Tannic acid	٩٦,١٠	86.30	3.81	2.253	2.77	9.80	7.38	6.92	8.97	4.07	467
	Control	٩٣,٢٨	84.75	3.65	2.055	2.25	9.20	6.08	5.75	8.63	3.86	410
Giza 8	Topas	١٠٢,٣٧	91.73	4.75	2.618	3.24	11.20	8.23	6.42	11.23	3.61	494
	Bayfidan	١٠٠,١٨	90.80	5.22	2.453	2.76	14.85	7.48	6.97	9.84	3.15	394
	Bion	١٠١,٦٥	92.63	4.75	2.655	3.08	13.70	7.33	5.63	9.28	3.41	457
	Tannic acid	٩٣,٤٨	90.03	3.93	2.128	2.80	10.23	7.40	6.81	8.08	2.84	368
	Control	٩٠,٨٨	83.75	3.90	2.150	2.07	10.70	6.06	5.71	7.75	2.34	326
Liflora	Topas	١١٢,٦٣	93.90	4.75	2.628	2.85	11.38	8.45	6.26	6.35	4.62	499
	Bayfidan	١٠٦,٤٥	94.03	4.93	2.365	2.72	13.90	7.66	5.83	6.00	3.83	410
	Bion	١٠٧,٤٨	91.93	4.95	2.580	2.76	11.38	6.98	4.96	5.88	4.04	436
	Tannic acid	١٠٠,٦٠	86.75	3.60	2.145	2.25	10.38	7.15	5.77	4.83	3.62	381
	Control	٩٩,٨٥	86.03	3.10	2.218	1.95	9.90	5.33	4.71	4.25	2.24	347
Escalina	Topas	١١٢,٣٠	100.75	3.01	2.228	3.66	13.90	8.33	4.95	6.35	6.75	399
	Bayfidan	١١٢,٦٠	100.43	3.10	2.275	3.25	13.95	8.20	4.46	6.05	5.46	362
	Bion	١١٣,٢٥	95.43	3.03	1.980	3.44	10.38	6.08	4.65	6.80	6.20	404
	Tannic acid	١٠٠,٦٥	91.83	2.63	1.775	2.95	9.20	7.55	2.54	4.35	5.06	278
	Control	١٠٠,١٥	86.13	2.50	1.563	2.63	8.09	5.38	4.41	4.28	4.05	252
LSD at 0.05		***7.34***	***8.24***	***0.97***	***0.35***	***0.42***	***3.76***	***1.58***	***0.91***	***1.47***	٠,١٥	٩,٥٧

*** LSD Value at the end of each column is used to calculate the difference between means and significance compared with control treatments.**

Table (7) Effect of 4 different antifungal compounds on agronomic characters of 4 cultivars at harvest in experiments to control flax powdery mildew in 2006/2007 growing season.

CULTIVARS	TREATMENTS	Plant total length (cm)	plant technical length (cm)	branches No./Plant	Stem thickness (mm)	Straw wt. / Plant (g)	Capsules No./Plant	Seed No./ Plant	Seed Wt./ Plant (g)	Seed Index	Straw / Feddan (ton)	Seed Wt./ feddan (kg)
Sakha2	**Topas**	١١٢,١٥	٩٧,٣٠	4.45	2.583	٢,٦٦٠	١٣,٩٠	٧,٤٠	٧,٧٢	12.31	6.75	729.75
	Bayfidan	١٠٩,٢٥	٩٦,٣٣	5.28	2.528	٢,٩٦٥	١٤,٦٥	٧,٦٨	٦,٩٤	11.35	5.39	572.25
	Bion	١٠٨,٠٣	٩٥,٨٢	3.75	2.423	٢,٣٥٨	١٤,٩٨	٧,١٣	٧,٧١	11.29	6.14	635.25
	Tannic acid	١٠٤,٢٥	٩٤,٩٨	3.98	2.358	٢,٢٢٥	١١,٨٥	٦,٨٠	٤,٧٤	10.35	4.99	530.25
	Control	١٠٣,٠٥	٩٢,٩٨	3.45	2.303	٢,١٠٠	١٠,١٣	٦,٦٣	٤,٣٩	9.10	3.93	451.50
Giza 8	**Topas**	١١١,٤٠	٩٢,٠٣	4.28	2.873	٢,٤٨٠	١٢,٩٥	٧,٧٥	٧,٤٣	12.01	4.01	535.50
	Bayfidan	١٠٩,٩٣	٩١,١٣	5.15	2.605	٢,٦٣٠	١٥,٢٥	٨,٠٠	٦,٥٠	11.45	3.50	435.75
	Bion	١٠٨,٠٣	٩٠,٥٠	4.00	2.563	٢,٣٦٠	١٣,٦٥	٧,٤٠	٧,١٧	10.49	3.79	498.75
	Tannic acid	١٠٠,٩٣	٨٩,٨٥	4.05	2.430	٢,١٠٠	١٠,٣٨	٦,٨٥	٤,٤٨	9.35	3.15	409.50
	Control	١٠٠,٨٥	٨٩,٧٥	3.25	2.350	١,٩٤٨	١٠,٩٥	٦,٧٥	٤,٤٢	8.28	2.60	367.50
Liflora	**Topas**	١١٥,٩٠	٩٦,٨٣	4.35	2.750	٢,٥٠٣	١٢,٦٣	٧,٥٥	٨,٠٣	6.00	5.57	561.75
	Bayfidan	١١٤,٢٨	٩٤,٨٣	4.85	2.450	٢,٦٠٨	١٢,٧٣	٧,٦٨	٦,٢٩	5.93	4.28	472.50
	Bion	١١٢,٩٨	٩٢,٥٥	4.75	2.438	٢,٣٨٠	١٢,٥١	٧,٥٥	٧,٥٢	5.75	5.09	498.75
	Tannic acid	١١٠,٤٣	٩٠,٦٣	3.45	2.350	٢,٣٢٨	١٠,٧٥	٧,٥٣	٤,٤٩	5.20	3.55	443.63
	Control	١٠٤,٠٣	٨٩,٨٠	3.15	2.250	١,٧٥٨	١٠,١٣	٦,٧٠	٤,٣٧	5.23	3.15	388.50
Escalina	**Topas**	١١٩,٥٥	١٠٠,٩٩	4.28	2.475	٢,٨٥٣	١١,٣٣	٦,٧٥	٦,٥٨	6.55	6.20	441.00
	Bayfidan	١١٨,٦٥	١٠٠,٩٠	4.70	2.430	٢,٩٣٥	١٤,٠٨	٦,٨٥	٦,٣٢	6.37	4.99	404.25
	Bion	١١٥,٧٨	٩٦,٠٣	3.15	2.430	٢,٥٦٠	١١,٢٥	٦,٧٣	٦,٦٣	5.93	5.99	446.25
	Tannic acid	١١٤,١٥	٩٣,٠٥	3.05	2.275	٢,٢٧٠	٨,٧٣	٦,٢٣	٤,٥٢	5.48	4.73	320.25
	Control	١١٠,٢٨	٩٢,٩٠	2.88	1.988	٢,٢٤٨	٨,٦٣	٦,١٨	٣,٢٤	4.48	4.26	315.00
LSD at 0.05		***4.51***	***6.09***	***0.88***	***0.44***	***0.78***	***2.66***	***1.38***	***0.62***	***1.47***	***0.65***	***0.17***

*** LSD Value at the end of each column is used to calculate the difference between means and significance compared with control treatments.**