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SUPRESSION OF PODWERY MILDEW ON FLAX BY FOLIAR APPLICATION OF FUNGICIDES

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ABSTRACT

A two-year field study was conducted at El-Ismailiya Agricultural Research Station to evaluate the fungicides Bellis and Micronized Sulphur, applied as foliar sprays, for control of powdery mildew on six flax cultivars (Giza 9, Giza 10, Sakha 3, Sakha 4, Istro, and Jiteka) with varying levels of susceptibility to the disease. Disease severity, agronomic traits, and technological traits were used as criteria for evaluating the performance of the tested fungicides. Bellis and sulphur were effective in controlling the disease (reducing the disease severity) in 2011 and 2012 on all the tested cultivars; however, efficiency of the fungicides (magnitude of reduction in the disease severity) in controlling the disease differed from one cultivar to another and from year to year. Bellis did not contribute to significant increases in many agronomic and technological traits of the tested cultivars in 2011 and 2012, while sulphur significantly improved, with few exceptions, almost all the tested traits. In conclusion, the present study demonstrated that both Bellis and sulphur were effective in reducing the disease severity; however, sulphur surpassed Bellis in improving agronomic and technological traits. Therefore, sulphur is better choice than Bellis for controlling the disease.

Keywords: Flax (*Linum usitatissimum* L.) cultivars, powdery mildew (*Oidium lini* Škoric), fungicides, disease severity.

INTRODUCTION

Powdery mildew, caused by *Oidium lini* Škoric, is widely distributed and a destructive disease of flax (*Linum usitatissimum* L.) in Egypt. Flax is grown for both seeds and fibers in the Nile Delta, in particular, the northern governorates. This area is characterized by the prevalence of warm, wet weather during the late period of flax growing season. Such weather favors epiphytotic spread of the disease when virulent isolate of *O. lini* presents (Mansour, 1998). However, yield losses and disease intensity vary from year to year depending on location, fertilization, weather conditions, and cultivars (Mansour, 1998).

Currently, resistance to powdery mildew 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 control. These fungicides include sulpher and sterol biosynthesis inhibitors, such as Bayleton, Bayfidan, and Rubigan (Khalil *et al.*, 1987, Aly *et al.*, 1994, Mansour, 1998, Mansour *et al.*, 1999, and Aly *et al.*, 2000).

The objective of this study was to evaluate the effects of foliar fungicides on the development of powdery mildew epidemics and on agronomic and technological traits of flax cultivars with varying levels of susceptibility to *O. lini*.

MATERIALS AND METHODS

Experiments were conducted over two successive growing seasons at El-Ismailiya Agricultural Research Station, beginning in the fall of 2010. Experiments consisted of a randomized complete block design of four replications (blocks). Plots were 2x3 m (6 m²) and consisted of 20 rows spaced 10 cm apart. Plots were manually planted with the tested cultivars (Table 1) at a rate of 50 kg/feddan on 20 November 2010 and on 25 November 2011. All the agricultural practices for growing flax were conducted according to the recommendations. Powdery mildew was allowed to develop naturally, and the initial fungicide application to cultivars coincided with the first sign of the disease. Foliar sprays were applied at the recommended rates (Table 2) on 10 and 24 April 2011 and on 25 April and 10 May 2012. Disease severity (Nutter *et al.*, 1991) was rated visually on 10 May 2011 and on 25 May 2012. Disease severity was measured as percentage of infected leaves/plant in a random sample of 10 plants/plot. Fungicidal efficiency was calculated based on disease severity according to the following formula [(DSC-DSF)/DSC] x 100, where DSC is disease severity of the control (untreated plots) and DSF is disease severity of fungicide-treated plots.

Table (1). Origin, type, and pedigree of flax cultivars used in the present study.

No.	Cultivar	Origin	Type	Pedigree
1	Giza 9	Local cultivar	Fiber	L. 420 x Bombay
2	Giza 10	Local cultivar	Fiber	L. 420 x Bombay
3	Sakha 3	Local cultivar	Fiber	Bleinka (2E) x 1.2096
4	Sakha 4	Local cultivar	Fiber	Bleinka (R3) x 1.2096
5	Istro	Introduced from Romania	Fiber	Unidentified
6	Jiteka	Introduced from Czech	Fiber	Unidentified

Table (2).Fungicides used for control of powdery mildew of flax under field conditions in El-Ismailiya in 2010/2011 and 2011/2012 growing seasons.

Fungicides[a]	Rate (per 100 liters of water)	Active ingredient[b]	Formulation
Bellis	50 ml	25.2% w/w boscalid (protectant) + 12.8% w/w pyraclostrobin (systemic)	A water dispersible granules
Micronized Sulphur	250 g	80% Micronized Sulphur	Wettable granules

[a] **Trade name**
[b] **Common name**

At harvest, a random sample of 10 plants was taken 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. **Straw yield/plant (g):** Weight of the mature air-dried straw per plant after removing the capsules.
4. **Straw yield/feddan (ton):** Estimated based on the area of the whole plot.
5. **Fiber yield/feddan (ton):** Estimated based on the area of the whole plot after retting.

B. Seed yield and its related characters:

1. **Number of apical branches:** Total number of apical branches of plant.
2. **Number of capsules per plant:** Number of harvested capsules per plant.
3. **Number of seeds per capsules:** Number of harvested seeds per capsule.
4. **Seed index (g):** Weight of 1000 seeds.
5. **Seed yield/plant (g):** Weight of harvested seeds per plant.
6. **Seed yield/feddan (kg):** Estimated based on the area of the whole plot.

C. Technological traits:

1. **Fiber length (cm):** Estimated as the mean of 10 fiber ribbons (bundles) from each plot.
2. **Long fiber percentage:** Calculated according to the following formula:

$$\text{Long fiber (\%)} = \frac{\text{Long fiber yield/fed}}{\text{Straw yield/fed}} \times 100$$

3. **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.

4. **Oil percentage:** Determined by Soxhlet apparatus according to Horwitz *et al.* (1965).
5. **Oil yield/fed. (kg):** Oil (%) x seed yield/fed. (kg).

Statistical analysis of the data:

Analysis of variance (ANOVA) was performed on disease severity, agronomic traits, and technological traits to determine treatment effects. Mean comparisons for variables were made among treatments by Duncan's multiple range test. ANOVA was performed with the MSTAT-C Statistical Package.

RESULTS AND DISCUSSION

The fungicides used to control powdery mildew vary in modes of action. The protective fungicides (e.g., sulphur and Boscalid) are surface protectants that suppress fungal growth and sporulation either by direct contact or vapor phase activity. Most of the systemic fungicides (e.g., pyraclostrobin) inhibit hyphal and haustarial growth and sporulation, and some also exhibited vapor phase activity (Seem *et al.*, 1981). The use of fungicides for control of powdery mildews caused by *Oidium* spp. is well documented in the literature (Strider, 1980, Quinn and Powell, 1982, Ranson *et al.*, 1991, and Lonsdale and Kotze, 1993).

In Egypt, control of flax powdery mildew (FPM) caused by *Oidium lini* under greenhouse and field conditions (Khalil *et al.*, 1987, Aly *et al.*, 1994, Mansour, 1998, Mansour *et al.*, 1999, and Aly *et al.*, 2000) in the form of foliar sprays has been shown to suppress the disease. However, field evaluation of the effect of flax genotype on the efficiency of fungicides has not been previously determined. Therefore, the present study was conducted in the 2010/2011 and 2011/2012 growing seasons (hereafter referred to as years 2011 and 2012, respectively) to explore the possible effects of six flax cultivars, with varying levels of susceptibility to powdery mildew, on efficiency of fungicides in controlling the disease under field conditions. Disease severity, agronomic traits (yield and yield components), and technological traits were used as criteria for evaluation of the tested fungicides.

Based on disease severity on the tested cultivars in the control treatments, which did not receive fungicides, it was possible to classify the cultivars in 2011 into highly susceptible (Istro and Jiteka), susceptible (Giza 9 and Sakha 4), moderately susceptible (Giza 10), and moderately resistant (Sakha 3). In 2012, they could be classified into highly susceptible (Giza 9 and Sakha 3, Sakha 4, and Jiteka), susceptible (Istro), and moderately susceptible (Giza 10). In general, the mean disease severity in the control treatments of the tested cultivars was 82.39% in 2011 and 93.63% in 2012. The number of the highly susceptible cultivars (100% disease severity) increased from two in 2011 to four in 2012. These results indicate that environmental conditions of 2012 were more favorable for the occurrence of FPM than those of 2011. The results also indicate that the fungicides were tested, for efficiency in controlling FPM under high disease pressure in both years. This high disease pressure is considered a prerequisite condition for any meaningful field evaluation of fungicides. The differences in disease severity among some cultivars in the control treatments varied from one year to another. For example, the difference between Sakha 3 and Sakha 4 was significant in 2011, while it was nonsignificant in 2012. Another example is the difference between Istro and Jiteka was nonsignificant in 2011 and significant in 2012. These results may indicate the occurrence of cultivar x year (environment) interaction.

Giza 10 showed the most stable disease reaction because it was moderately susceptible in both years. On the other hand, Sakha 3 showed unstable disease reaction because it was moderately susceptible in 2011 and highly susceptible in 2012.

Bellis and sulphur were effective in controlling the disease (reducing the disease severity) in 2011 and 2012 on all the tested cultivars (Tables 3 and 4). In 2011, Bellis was more efficient than sulphur in controlling the disease on Giza 9, Sakha 3, Sakha 4 and Istro. On the other hand, sulphur was more effective on Giza 10 and Jiteka (Table 3). In 2012, Bellis was more effective on Giza 10, and Istro, while sulphur was more effective on Giza 9 and Jiteka. Bellis and sulphur were equally effective in controlling the disease on Sakha 3 and Sakha 4 (Table 4).

Efficiency of fungicides (magnitude of reduction in the disease severity) in controlling the disease differed from one cultivar to another. For example, in 2011, the efficiency of Bellis on controlling the disease on Giza 9 (77.02%) was higher than its efficiency on Giza 10 (65.28%). On the other hand, sulphur showed inverted performance in controlling the disease on the two cultivars. Thus, its efficiency on Giza 9 (49.99%) was lower than its efficiency on Giza 10 (79.58%), (Table 3).

Efficiency of fungicides also varied from year to year. For example, the efficiency of Bellis in controlling the disease on Giza 9 decreased from 77.02 in 2011 to 56.77 in 2012. On Giza 10, the efficiency of Bellis increased from 65.28 in 2011 to 76.60% in 2012 (Tables 3 and 4). Efficiency of sulphur in controlling the disease on Giza 9 increased from 49.99 in 2011 to 70.75% in 2012. On Giza 10, its efficiency decreased from 79.58 (in 2011) to 51.05% (in 2012) (Tables 3 and 4).

The effects of cultivar and year (environmental conditions) on efficiency of fungicides in controlling FPM, as we have demonstrated herein, have been previously reported by Aly *et al.* (2000). These results suggest that efficiency of fungicides in controlling FPM should be evaluated in as many years as possible by using as many cultivars as possible as this will improve the chance of identifying fungicides effective in controlling the disease on many cultivars under different environments.

Bellis did not contribute to significant increases in many agronomic and technological traits of the tested cultivars in 2011 and 2012 (Table 3 and 4). This ineffectiveness of Bellis in improving some agronomic traits could be attributed to interplot interference, which obscures the response of some agronomic traits to Bellis (Frank and Ayers, 1986, and Lipps and Madden, 1988). The experimental design of the present study was completely randomized blocks of four replications. In each block (replication), plots of the different treatments were adjacent to one another. Inoculum from heavily infected plants in the control plots would have had an effect on those in the other plots. The ultimate influence would be higher than normal levels of disease and lower agronomic traits responses in treated plots, thus leading to apparent loss of efficiency. In commercial-sized fields, foliar application of Bellis would be expected to control FPM and improve agronomic traits to a greater extent than observed in the present study (Lipps and Madden, 1988).

Table (3). Effect of flax cultivars and fungicides on powdery mildew severity, agronomic, and technological traits under field conditions in 2010/2011 growing season.

No.	Treatment		Disease severity (%)[d]	Agronomic and technological traits							
	Cultivar	Fungicide		Total plant length (cm)	Technical plant length (cm)	Straw yield/plant (g)	Straw yield/fed. (ton)	Fiber yield/fed (ton)	Long fiber percentage	Fiber length (cm)	Fiber fineness (Nm)
1	Giza 9	Control [a]	87.83 b	96.97 f-I	86.77 def	1.022 def	3.684 cde	0.542 gh	14.73 e	85.64 fgh	237.7bcd
2	Giza 9	Bellis [b]	20.18 h*	110.30abc*	98.05 abc*	1.228 bc*	4.421 b*	0.780 cd*	17.66 b*	102.70ab*	281.0ab*
3	Giza 9	Sulphur [c]	43.92 ef*	115.60a*	101.80a*	1.433 a*	5.266 a*	1.033 a*	19.63 a*	108.20a*	295.1a*
4	Giza 10	Control	79.44 cd	94.38 ghi	81.16 fgh	0.957 efg	3.529 def	0.478 hij	13.54 fg	79.46 ij	226.0cd
5	Giza 10	Bellis	27.58 g*	102.90b-g	91.32 b-e*	1.148 b-e	4.232 bc*	0.686 def*	16.24 c*	95.28 cde*	269.0abc
6	Giza 10	Sulphur	16.22 h*	107.00bcd*	94.83 a-d*	1.339 ab*	4.938 a*	0.910 b*	18.44 b*	102.80ab*	290.6a*
7	Sakha 3	Control	41.37 f	88.20 i	85.23 d-g	0.836 f-i	3.172 ef	0.430 ijk	13.52 fg	80.48 hij	225.9cd
8	Sakha 3	Bellis	13.40 h*	105.70b-f*	90.21 b-f	1.002 def	3.683 cde	0.597 fg*	16.21 c*	96.50 cd*	266.9abc
9	Sakha 3	Sulphur	28.48 g*	111.40ab*	99.15 ab*	1.169 bcd*	4.391 b*	0.796 c*	18.12 b*	100.80bc*	276.9ab*
10	Sakha 4	Control	85.67 bc	93.47 hi	81.90 efg	0.739 hij	3.158 ef	0.378 k	11.99 hi	75.76 jk	217.7d
11	Sakha 4	Bellis	3.60 i*	100.10d-h	89.21 c-f	0.886 fgh	3.797 cd*	0.549 gh*	14.38 ef*	90.84 def*	257.1a-d
12	Sakha 4	Sulphur	19.13 h*	106.00b-e*	94.80 a-d*	1.034 c-f*	4.369 b*	0.696 de*	15.89 cd*	96.77 cd*	268.8abc*
13	Istro	Control	100.00a	91.03 i	75.91 gh	0.661 ij	3.028 fg	0.346 kl	11.30 ij	74.72 jk	216.3d
14	Istro	Bellis	40.27 f*	97.16 e-i	85.02 e-g	0.792 g-j	3.631 de*	0.493 hi*	13.55 fg*	89.58 efg*	243.4bcd
15	Istro	Sulphur	74.36 d*	101.50c-h*	91.28 b-e*	0.924 fgh*	4.086 bcd*	0.616 efg*	15.09 de*	91.24 def*	266.0abc*
16	Jiteka	Control	100.00a	89.44 i	72.85 h	0.602 j	2.523 g	0.269 l	10.74 j	70.64 k	215.2d
17	Jiteka	Bellis	74.92 d*	95.25 ghi	84.37 efg*	0.722 hij	3.025 fg	0.391 jk*	12.88 gh*	84.34 ghi*	240.0bcd
18	Jiteka	Sulphur	50.33 e*	100.20d-h*	85.36 d-g*	0.843 f-i*	3.867 bcd*	0.552 gh*	14.18 ef*	92.66 de*	256.9a-d

Table (3). Cont.

No.	Treatment		Agronomic and technological traits							
	Cultivar	Fungicide	No. of fruiting branches/pl	No. of capsules Per plant	No. of seeds / capsule	1000 seed weight (g)	Seed yield / plant (g)	Seed yield / fed (kg)	Oil percentage	Oil yield/fed (kg)
1	Giza 9	Control [a]	9.720 cde	9.19 e	7.31 cd	5.690 c-g	0.446 cd	416.6 cd	31.03 e	129.2def
2	Giza 9	Bellis [b]	10.460 bc	11.02 cd*	8.76 ab*	6.823 ab*	0.535 ab*	499.5 b*	37.01 abc*	184.7b*
3	Giza 9	Sulphur [c]	11.460 a*	12.97 a*	9.12 a*	7.340 a*	0.566 a*	569.3 a*	38.37 a*	224.8a*
4	Giza 10	Control	7.850 gh	8.62 efg	7.10 cd	5.450 efg	0.408 def	357.5 d-g	30.28 e	108.2fgh
5	Giza 10	Bellis	9.413 de*	10.34 d*	8.40 b*	6.533 a-d*	0. 489bc*	428.7 c*	36.11 a-d*	154.3c*
6	Giza 10	Sulphur	10.050 cd*	12.15 ab*	8.99 ab*	6.923 ab*	0.526 ab*	505.9 b*	37.54 ab*	189.8b*
7	Sakha 3	Control	8.320 fg	8.87 ef	7.32 cd	5.120 fgh	0.348 ghi	349.0 efg	29.29 e	102.2gh
8	Sakha 3	Bellis	9.980 cd*	10.64 cd*	8.78 ab*	6.140 b-e*	0.417 de*	418.5 cd*	35.13 bcd*	148.1cd*
9	Sakha 3	Sulphur	11.150 ab*	12.43 a*	9.16 a*	6.620 abc*	0.460 cd*	506.6 b*	37.32 ab*	189.0b*
10	Sakha 4	Control	7.520 ghi	7.86 gh	7.05 cd	4.750 gh	0.321 hi	326.2 efg	29.08 e	94.75h
11	Sakha 4	Bellis	9.020 ef*	9.43 e*	8.45 b*	5.700 c-g	0.385 efg*	391.2 cde	34.87 bcd*	136.3cde*
12	Sakha 4	Sulphur	10.010 cd*	11.46 bc*	8.75 ab*	6.520 a-d*	0.441 cde*	425.4 c*	36.25 a-d*	154.5c*
13	Istro	Control	6.140 j	6.61 i	6.70 de	4.370 h	0.252 jk	258.4 h	28.51 e	73.0 i
14	Istro	Bellis	7.360 hi*	7.92 fgh*	6.84 de	5.640 d-g*	0.302 hij	309.9 fgh	33.99 d*	104.4gh*
15	Istro	Sulphur	8.130 gh*	8.61 efg*	7.50 c*	5.750 c-f*	0.357 fgh*	371.7 c-f*	35.65 a-d*	131.9cde*
16	Jiteka	Control	5.070 k	5.29 j	5.18 f	4.270 h	0.218 k	253.3 h	28.38 e	72.37i
17	Jiteka	Bellis	6.080 j*	6.34 i*	6.21 e*	5.400 efg*	0.261 jk	303.8 gh	33.63 d*	100.8gh*
18	Jiteka	Sulphur	6.780 ij*	7.02 hi*	6.83 de*	5.650 d-g*	0.296 ij*	357.6 d-g*	34.11 cd*	121.3efg*

[a] Plants were sprayed with water
[b] Bellis was applied as foliar spray at a rate of 50 ml/100 liters of water.
[c] Sulphur was applied as foliar spray at a rate of 250 g/100 liters of water.
[d] In columns, means followed by the same letter(s) are not significantly ($P < 0.05$) different according to Duncan's multiple range test.
* Significant difference from the respective control.

Table (3). Cont.

No.	Treatment		Agronomic and technological traits							
	Cultivar	Fungicide	No. of fruiting branches/pl	No. of capsules Per plant	No. of seeds / capsule	1000 seed weight (g)	Seed yield / plant (g)	Seed yield / fed (kg)	Oil percentage	Oil yield/fed (kg)
1	Giza 9	Control [a]	9.720 cde	9.19 e	7.31 cd	5.690 c-g	0.446 cd	416.6 cd	31.03 e	129.2def
2	Giza 9	Bellis [b]	10.460 bc	11.02 cd*	8.76 ab*	6.823 ab*	0.535 ab*	499.5 b*	37.01 abc*	184.7b*
3	Giza 9	Sulphur [c]	11.460 a*	12.97 a*	9.12 a*	7.340 a*	0.566 a*	569.3 a*	38.37 a*	224.8a*
4	Giza 10	Control	7.850 gh	8.62 efg	7.10 cd	5.450 efg	0.408 def	357.5 d-g	30.28 e	108.2fgh
5	Giza 10	Bellis	9.413 de*	10.34 d*	8.40 b*	6.533 a-d*	0. 489 bc*	428.7 c*	36.11 a-d*	154.3c*
6	Giza 10	Sulphur	10.050 cd*	12.15 ab*	8.99 ab*	6.923 ab*	0.526 ab*	505.9 b*	37.54 ab*	189.8b*
7	Sakha 3	Control	8.320 fg	8.87 ef	7.32 cd	5.120 fgh	0.348 ghi	349.0 efg	29.29 e	102.2gh
8	Sakha 3	Bellis	9.980 cd*	10.64 cd*	8.78 ab*	6.140 b-e*	0.417 de*	418.5 cd*	35.13 bcd*	148.1cd*
9	Sakha 3	Sulphur	11.150 ab*	12.43 a*	9.16 a*	6.620 abc*	0.460 cd*	506.6 b*	37.32 ab*	189.0b*
10	Sakha 4	Control	7.520 ghi	7.86 gh	7.05 cd	4.750 gh	0.321 hi	326.2 efg	29.08 e	94.75h
11	Sakha 4	Bellis	9.020 ef*	9.43 e*	8.45 b*	5.700 c-g	0.385 efg*	391.2 cde	34.87 bcd*	136.3cde*
12	Sakha 4	Sulphur	10.010 cd*	11.46 bc*	8.75 ab*	6.520 a-d*	0.441 cde*	425.4 c*	36.25 a-d*	154.5c*
13	Istro	Control	6.140 j	6.61 i	6.70 de	4.370 h	0.252 jk	258.4 h	28.51 e	73.0 i
14	Istro	Bellis	7.360 hi*	7.92 fgh*	6.84 de	5.640 d-g*	0.302 hij	309.9 fgh	33.99 d*	104.4gh*
15	Istro	Sulphur	8.130 gh*	8.61 efg*	7.50 c*	5.750 c-f*	0.357 fgh*	371.7 c-f*	35.65 a-d*	131.9cde*
16	Jiteka	Control	5.070 k	5.29 j	5.18 f	4.270 h	0.218 k	253.3 h	28.38 e	72.37i
17	Jiteka	Bellis	6.080 j*	6.34 i*	6.21 e*	5.400 efg*	0.261 jk	303.8 gh	33.63 d*	100.8gh*
18	Jiteka	Sulphur	6.780 ij*	7.02 hi*	6.83 de*	5.650 d-g*	0.296 ij*	357.6 d-g*	34.11 cd*	121.3efg*

[a] Plants were sprayed with water
[b] Bellis was applied as foliar spray at a rate of 50 ml/100 liters of water.
[c] Sulphur was applied as foliar spray at a rate of 250 g/100 liters of water.
[d] In columns, means followed by the same letter(s) are not significantly ($P < 0.05$) different according to Duncan's multiple range test.
* Significant difference from the respective control.

Table (4). Effect of flax cultivars and fungicides on powdery mildew severity, agronomic, and technological traits under field conditions in 2011/2012 growing season.

No.	Treatment		Disease severity (%)[d]	Agronomic and technological traits							
	Cultivar	Fungicide		Total plant length (cm)	Technical plant length (cm)	Straw yield/plant (g)	Straw yield/fed. (ton)	Fiber yield/fed (ton)	Fiber percentage	Fiber length (cm)	Fiber fineness (Nm)
1	Giza 9	Control [a]	100.00a	89.75 efg	80.70 fgh	0.939 cde	3.569 cd	0.5047fg	14.12 cd	83.83 fg	233.9 cde
2	Giza 9	Bellis [b]	43.23 de*	107.60ab*	96.76 ab*	1.126 abc	4.279 b*	0.7240cd*	16.93 b*	100.50b*	276.5 abc
3	Giza 9	Sulphur [c]	29.25 h*	112.10a*	100.30a*	1.325 a*	5.015 a*	0.9290a*	18.55 a*	107.5 a*	290.6 a*
4	Giza 10	Control	68.03 c	88.08 efg	79.43 fgh	0.796 def	3.488 cde	0.4487gh	12.87 def	77.80 hij	222.5 de
5	Giza 10	Bellis	15.92 i*	99.62 cd*	90.65 bcd*	0.954 cde	4.182 b*	0.6457de*	15.43 c*	93.28 cd*	264.8 a-d
6	Giza 10	Sulphur	33.30 gh*	105.1 abc*	93.16 abc*	1.285 ab*	4.856 a*	0.8283b*	17.05 b*	100.20b*	288.6 ab*
7	Sakha 3	Control	100.00a	86.02 fg	81.71 e-h	0.786 def	3.017 efg	0.3897hi	12.89 def	76.35 ij	221.2 de
8	Sakha 3	Bellis	32.47 gh*	103.10bc*	89.98 bcd*	0.942 cde	3.918 bc*	0.6090e*	15.45 c*	91.55 de*	252.2 a-e
9	Sakha 3	Sulphur	29.75 h*	108.6 ab*	96.20 ab*	1.005 bcd	4.275 b*	0.7460bc*	17.43 ab*	98.23 bc*	271.4 abc*
10	Sakha 4	Control	100.00a	83.63 gh	77.29 ghi	0.646 fg*	2.798 fgh	0.3127ijk	11.17 gh	72.92 jk	215.3 e
11	Sakha 4	Bellis	30.33 h*	97.88 cd*	86.49 c-f*	0.774 ef*	3.355 de*	0.4493gh*	13.39 de*	87.43 ef*	244.1 b-e
12	Sakha 4	Sulphur	33.25 gh*	103.90bc*	92.59 bc*	0.948 cde*	4.192 b*	0.6433de*	15:35 c*	93.55 cd*	265.3 a-d*
13	Istro	Control	93.75 b	84.14 gh	74.15 hi	0.570 fg	2.654 gh	0.2740jk	10.38 h	70.35 k	213.9 e
14	Istro	Bellis	18.02 i*	94.89 de*	84.32 d-g*	0.683 efg	3.182 def*	0.3963hi*	12.45 efg*	83.15 fgh*	240.5 cde
15	Istro	Sulphur	38.73 ef*	99.86 cd*	89.23 b-e*	0.842 def	3.964 bc*	0.5857ef*	14.78 c*	91.45 de*	261.3 a-*d*
16	Jiteka	Control	100.00a	77.45 h	71.69 i	0.489 g	2.359 h	0.2333k	9.91 h	67.74 k	212.1 e
17	Jiteka	Bellis	44.93 d*	92.87 def*	83.17 d-g*	0.586 fg	2.829 fgh	0.3370ij*	11.88 fg*	81.22 ghi*	236.4 cde
18	Jiteka	Sulphur	36.50 fg*	98.21 cd*	86.30 c-f*	0.755 efg	3.625 cd*	0.4817gh*	13.28 de*	88.50 def*	255.2 a-e

Table (4). Cont.

No.	Treatment		Agronomic and technological traits							
	Cultivar	Fungicide	No. of fruiting branches/pl	No. of capsules Per plant	No. of seeds / capsule	1000 seed weight (g)	Seed yield / plant (g)	Seed yield / fed (kg)	Oil percentage	Oil yield/fed (kg)
1	Giza 9	Control [a]	8.94 def	9.06 bc	7.14 bc	5.573 d-g	0.438 cd	385.5 cde	30.07 d	115.8 efg
2	Giza 9	Bellis [b]	10.12 abc*	10.86 a*	8.56 a*	6.690 ab*	0.525 ab*	462.2 ab*	35.86 abc*	143.5 bcd*
3	Giza 9	Sulphur [c]	11.00 a*	11.25 a*	8.92 a*	7.250 a*	0.548 a*	518.3 a*	37.12 a*	195.7 a*
4	Giza 10	Control	7.69 gh	7.96 def	6.82 cd	5.300 e-h	0.386 def	302.6 fgh	29.56 d	89.29 hij
5	Giza 10	Bellis	9.22 cde*	9.55 b*	8.18 ab*	6.350 a-d*	0.463 bcd	362.8 def	35.25 abc*	128.2 cde*
6	Giza 10	Sulphur	9.85 bcd*	10.98 a*	8.64 a*	6.627 ab*	0.508 abc*	428.5 bc*	36.96 ab*	157.2 b*
7	Sakha 3	Control	8.69 efg	7.66 def	7.19 bc	4.890 f-i	0.344 efg	277.4 ghi	29.98 d	83.05 hij
8	Sakha 3	Bellis	9.22 cde	9.18 b*	8.62 a*	5.860 d-e*	0.412 de	332.6 efg	35.75 abc*	118.9 def*
9	Sakha 3	Sulphur	10.66 ab*	10.62 a*	8.95 a*	6.520 abc*	0.452 bcd*	388.4 cde*	36.66 ab*	142.5 bcd*
10	Sakha 4	Control	6.78 hij	7.14 ef	6.89 cd	4.700 ghi	0.296 ghi	281.0 ghi	29.16 d	81.95 hij
11	Sakha 4	Bellis	8.13 fg*	8.56 bcd*	8.26 ab*	5.640 c-f*	0.355 efg	336.9 efg	34.76 abc*	117.0 efg*
12	Sakha 4	Sulphur	9.55 cde	10.54 a*	8.65 a*	6.460 abc*	0.422 de*	416.3 bcd*	35.15 abc*	149.2 bc*
13	Istro	Control	5.740 jk	5.99 gh	5.61 de	4.630 hi	0.240 ij	229.6 i	28.14 d	64.85 j
14	Istro	Bellis	6.88 hi*	7.18 ef*	6.73 cd	5.350 e-h	0.288 g-j	275.3 ghi	33.54 c*	92.37 ghi*
15	Istro	Sulphur	7.96 fg*	8.14 cde*	7.18 bc*	5.560 dg*	0.326 fgh*	348.6 ef*	34.77 abc*	121.5 def*
16	Jiteka	Control	4.85 k	5.12 h	4.94 e	4.190 i	0.207 j	247.3 hi	27.75 d	68.67 ij
17	Jiteka	Bellis	5.82 ijk	6.14 g*	5.92 cde	4.830 f-i	0.248 hij	296.5 fgh	32.88 c*	97.64 fgh*
18	Jiteka	Sulphur	6.42 ij*	6.95 fg*	6.74 cd*	5.370 f-h*	0.275 g-j	316.9 fg*	33.74 bc*	107.20e-h*

[a] Plants were sprayed with water

[b] Bellis was applied as foliar spray at a rate of 50 ml/100 liters of water.

[c] Sulphur was applied as foliar spray at a rate of 250 g/100 liters of water.

[d] In columns, means followed by the same letter(s) are not significantly ($P < 0.05$) different according to Duncan's multiple range test.

* Significant difference from the respective control.

Sulphur is a constituent of the amino acids cysteine and methionine. Cysteine is important in regulating the structure and function of protein. Sulphur is also a component of several coenzymes and plant hormones, a constituent of many active groups involved in oxidation-reduction reactions, and a component of sulfolipids, which are structural constituents of all biological membranes (Kirkpatrick and Rothrock, 2001). Therefore, it was not surprising to find significant increases in almost all the tested agronomic and technological traits, with few exceptions, by the foliar application of sulphur (Tables 3 and 4). Our results are in agreement with those of Chourasia *et al.* (1992), who reported beneficial effects of sulphur on growth, yield, and quality of linseed.

Both Bellis and sulphur were effective in reducing disease severity; however sulphur surpassed Bellis in improving the agronomic and the technological traits. These results suggest that sulphur is a better choice than Bellis for controlling the disease.

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مكافحة البياض الدقيقى على الكتان برش المطهـرات الفطريـة علـى المجمـوع الخضرى

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أجريت تجربة حقلية لمدة عامين بمحطة البحوث الزراعية بالإسماعيلية ، وذلك لتقييم المبيدين بيليز والكبريت الميكرونى من حيث الفاعلية فى مقاومة مرض البياض الدقيقى ، على ستة أصناف من الكتان (جيزة ٩ وجيزة ١٠ وسخا ٣ وسخا ٤ وإسترو وجيتيكا) تتباين فيما بينها من حيث القابلية للإصابة بالمرض. إستعملت شدة المرض والصفات المحصولية والتكنولوجية كمعايير لتقييم أداء المبيدين. أظهر المبيدان فاعلية فى مقاومة المرض (تقليل شدة الإصابة) على جميع الأصناف المختبرة ، خلال عامى ٢٠١١ و ٢٠١٢ ، إلا أن كفاءة المبيدين (حجم النقص فى شدة الإصابة) فى مقاومة المرض إختلفت باختلاف الصنف و**المبيد**. لم يترتب على استعمال بيليز حدوث زيادات معنوية فى الكثير من الصفات المحصولية والتكنولوجية موضع الدراسة ، بعكس الكبريت الميكرونى الذى أدى إستعماله إلى تحسن ملموس فى جميع الصفات تقريباً ، مع وجود إستثناءات قليلة. تخلص الدراسة الحالية إلى أن المبيدين أظهرا **فعاليه فى** الحد من شدة الإصابة ، إلا أن الكبريت الميكرونى تفوق على بيليز فى القدرة على تحسين الصفات المحصولية والتكنولوجية ، وعلى ذلك يمكن القول بأن الكبريت الميكرونى هو الاختيار الأفضل لمكافحة المرض.

قام بتحكيم البحث

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