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INTEGRATED CONTROL OF POWDERY MILDEW AND RUST OF PEA IN RELATION TO GREEN YIELD

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ABSTRACT

The eight tested pea cultivars showed clear variations in their reaction to powdery mildew and rust diseases. Different fungicides, bioagents and salts were investigated under field conditions singly or alternatively for controlling the two diseases. All treatments were sprayed five times with 10-day-interval 45 days after planting. The fungicides Domark, Topas and Sumi Eight significantly decreased the infection percentage and disease severity of pea powdery mildew and significantly increased the obtained green yield. Concerning pea rust, fungicides Sumi Eight, Plantvax and Saprol were also effective in reducing disease incidence than other fungicides and, therefore, increased both early and total yield. Bioagents (Rizo-N and Promot) were more effective in controlling the two diseases than others and hence, increased early and total green yield. On the other hand, spraying with different salts proved that Kaligreen followed by Sodium bicarbonate were the most effective for controlling the two diseases compared with other salts. Therefore, an integrated management programme was tried by Micronic Sulphur, Topas, Sumi Eight, Sodium bicarbonate and Rizo-N. Rotation spray with these agents resulted in the highest effectiveness for controlling pea powdery mildew and rust diseases as well as the increasing of early and total green yield.

Key Words: Integrated Management, Pea powdery mildew, Pea rust, Fungicides, Bioagents, Salts, *Erysiphe pisi*, *Uromyces pisi*.

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important economic legumes crops in Egypt for local consumption and exportation. It is consumed locally as green and/or dry seeds because of its high protein content (Abdel-Al *et al.*, 1980). Because of its high economic value, the area planted has been increased especially in the newly reclaimed lands.

Pea plants are attacked by different diseases among which powdery mildew and rust caused by *E. pisi* and *Uromyces pisi*, respectively. This fungus attacks leaves, stems and pods resulting in severe damage to the host. Pea rust also have been considered an important and economic disease as the fungus

Uromyces pisi attacks leaves, stems, peduncles and pods causing severe injuries. Pal *et al.* (1980) reported that powdery mildew and rust diseases on pea plants are wide spread and cause severe losses in India. Also, Khafagi *et al.* (1995 a & b) reported that powdery mildew and rust diseases cause high damage for pea plants in Egypt.

The present work was planned to study: a) the varietal reaction of some pea cultivars against powdery mildew and rust diseases. b) investigating the effect of some fungicides, bioagents and salts on the incidence of the two diseases. c) using the integrated management for controlling the diseases.

MATERIALS AND METHODS

I. Varietal reactions:

Eight pea cultivars; i.e. Little Marvel, Master B, Progress No. 9, Victory Freezer, Lincoln, Grant Climbing, Water Top and Perfection were used in this investigation. Seeds of these cultivars were kindly obtained from Vegetable Department, Horticultural Institute, Agricultural Research Center, Giza.

II. Chemical control:

1. Of powdery mildew by fungicides:

Bayfedan Morestan, Triademinal (150 ml/L); Sofril, sulphur (250 g/100 L); Saprol, CELA (150 ml/100 L); Micronic sulphur (250 g/100 L); Domark 10 % EC, Tetraconazole (15 ml/100 L); Topas 100, 10 % EC, Penconazole (25 ml/100 L) and Sumi Eight 5% EC, Diniconazole (35 ml/100 L), Table (1 A).

2. Of rust by fungicides:

Bavistin, Carbendazim (100g/100 L); Sumi Eight 5% EC, Dinicona ZOLE (35 ML/100 L); Tecto 45 % FL, Thiobendazole (150 ml/100 L); Plantvax (100 ml/100 L); Saprol, CELA (150 ml/100 L) and Micronic sulphur (250 g/100 L), Table (1 B).

III. Chemical salts:

The role of Kaligreen (82 % potassium bicarbonate, 1.5 g/ L, Sodium bicarbonate (5 g/L), Potassium nitrate (3 g /L) and Monopotassium sulphate (3 g/L) was tested during the present investigation against mildew ant rust diseases, Table (1 C).

IV. Application of bioagents to control rust and powdery mildew:

Promot, *Trichoderma koningii* + *T. harzianum* (4 g/L); Rizo-N, *Bacillus subtilis* (4 g/L); Plant Guard, *T. harzianum* (3 ml/L) and Biocont, *T. harzianum* (1 g/L) were evaluated in controlling both powdery mildew and rust diseases on pea during the present work, Table (1 D).

Field experiments:

Ten experiments were carried out during the period from 1998 to 2004 under field conditions in Sharkia governorate. Each two couple of seasons' experiments served special aim.

The first two successive seasons, 1998/1999 – 1999/2000:

The experiments of these two seasons aimed to evaluate eight pea cultivars to infection with the two diseases. The seeds were planted in a complete randomized block design; each cultivar was grown in 4 rows, each of 0.6 x 4.5 m and with three replicates.

The second two successive seasons, 2000/2001 – 2001/2002:

Six experiments were carried out during these two seasons to investigate the effect of the tested fungicides, bioagents and chemical salts on the incidence of powdery mildew and rust diseases using cv. Little Marvel. Spray treatments were applied in complete randomized block design with three replicates of 1/100 feddan using each of the tested fungicides, bioagents and salts which were separately sprayed five times with 10 day-intervals after 45 days from planting.

The third two successive seasons, 2002/2003 – 2003/2004:

The experiments of these two seasons aimed to investigate the applying of integrated management using the best treatments resulted from the previous four seasons' experiments. In these experiments, complete randomized block design with three replicates of 1/100 feddan using cv Little Marvel was used. The experiments of these two seasons included the application of the following treatments by spraying each 5 times: Micronic sulphur, Topas, Sumi Eight, Sodium bicarbonate, Promot, as well as 5 alternate sprays with Micronic sulphur, Topas, Sumi Eight, Sodium bicarbonate and Rizo-N with 10 day-intervals beginning at 45 days after planting.

Evaluation of parameters:

Two hundred pea leaves representing each plot were randomly examined for estimating the incidence of powdery mildew and rust diseases as infection percentage (IP) and disease severity (DS) as follows:

$$IP = \frac{\text{No. of infected leaves}}{\text{No. of total leaves}} X100$$

However, disease severity was estimated as the ratio of leaf surface infected by powdery mildew or rust relative to the whole leaf surface area according to Horsfall and Barrat (1945) with the aid of disease index of eleven categories, including a disease free one, and applying the following formula:

$$\text{Disease (\%)} = \frac{\text{Sum (No. of each infection category x Numerical value of infection category)}}{\text{No. of total leaves x The highest numerical value of infection category (11)}} X\ 100$$

Where, the eleven categories were: 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 equal to 1-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-35, 36-40, 41-45 and 46-50 % of leaf surface showing powdery mildew or rust, respectively, as well as zero type category showing no infection.

Table (1): Control agents tested against pea powdery mildew and rust diseases under field conditions during 2000/2004 growing seasons.

Agent common name	Structure	Recommended dose/100L water
A- Fungicides used against powdery mildew;		
Bayfidan Morestan (Bayfidan Mo 200 SC)	Triadimenol: (β-(4-chlorophenoxy)-α-(1,1- dimethyl)-IH-1,2,4-triazole-1-ethanol and Thiomethionate: 6-Methyl-1,3, dithiolo [4,5-b] quinoxalin-2-one.	150 ml
Sofril	Sulphur	250 ml
Saprol	Triforine: (N,N'-[1,4-Piperazinediyl-bis (2,2,2-trichloro-ethylidene)]-bis[formamide].	150 ml
Micronized sulphur	Sulphur	250 ml
Domark 10%	Tetraconazle: 1-[2-2,4-dichlorophenyl]-3- (1,1, 2,2- tetrafluoroethoxy)propyl]-1H-1,2,4-triazole.	15 ml
Topas 100 EC, 10%	Penconazole: 1,2-(2,4-dichlorophenyl)-n-penty]-1 H-1,2,4-triazole.	25 ml
Sumi Eight 5%	Diniconazole-M: (αR, βE)-[2(2,4-dichlorophenyl) methylene]- α-(1,1-dimethylethyl)-1H-1,2,4 triazole-1-ethanol.	35 ml
B- Fungicides used against rust:		
Bavistin	Carbendazim: 2-(Methoxycarbomylamino)-benzimidazole.	100 gm
Sumi Eight 5%	Diniconazole-M: (αR, βE)- β- [(2,4-dichlorophenyl) methylene]- α-(1,1-dimethylethyl)- 1H-1,2,4-triazole-1-ethanol.	35 ml
Tecto 45% FL	Thiabendazole: 2-(4'-Thiazolyl)-benzimidazole.	150 ml
Plantvaz	Oxycarboxin: 5,6-dihydro-2-methyl-N-phenyl-1,4-oxathin-3-carboxamide 4,4-dioxide.	100 ml
Saprol	Triforine:(N,N'-[1,4-Piperazinediyl-bis(2,2,2-trichloro-ethylidene)]-bid[formamide].	150 ml
Micronic sulphur	Sulphur	250 gm
C- Chemical salts used against the two diseases:		
Kaligreen	$KHCO_3$	
Potassium nitrate	KNO_3	300 gm
Monopotassium sulphate	$KHSO_4$	300 gm
D- Bioagents used against the two diseases:		
Promot	*Trichoderma koningii + T. harziamm*	400 gm
Rhiz-N	*Bacillus subtilis*	400 gm
Plant Guard	*T. harzianum*	300 ml
Bicont	*T. harzianum*	100 gm

Green Yield:

Early green yield was estimated by adding the harvested yield through the two harvestings together.

Total green yield:

The entire harvested yield from the beginning of the harvesting till the end of the season were calculated. The yield increase (%) was calculated as follows.

$$\text{Yield increase (\%)} = \frac{\text{Treatment yield} - \text{Check yield}}{\text{Check yield}} \times 100$$

Statistical analysis:

The obtained data were subjected to analysis of variance (Steel and Torrie, 1960), whereas the differences between treatments were tested by the calculated least significant differences (LSD) at 5 % level.

RESULTS AND DISCUSSION

I. Varietal Reaction Against:

1. Pea powdery mildew:

Data in Table (2) clearly reveal that all of the tested pea cultivars showed variations in their reactions toward infection by powdery mildew. Giant Climping and Waver Top cultivars showed the least infection as indicated by the early and total yield at 1998/1999 and 1999/2000 growing seasons. In contrast, Progress No. 9, Perfection, Victory Freezer and Little Marvel cvs. were the most susceptible, while the two cvs. Lincoln and Master B were moderately resistant. Percentage of infection and disease severity were higher in 1998/1999 growing season than in 1999/2000 one. These variations in susceptibility of the tested cvs. may be due to the genetic structure of cultivars and environmental conditions. These results are in agreement with those obtained by Utikar (1977), Dixson (1978) and Khafagi *et al.*(1995 b).

2. Pea rust:

Data in Table (3) indicate that all of the tested pea cultivars significantly differed in their reactions to pea rust. Results showed that cvs. Giant Climbing, Waver Top and Master B were the most resistant, as they recorded the least percentages of infection and disease severity. Meanwhile, an increase of the early and total green yield during the two seasons (1998/1999 and 1999/2000) was recorded. On the other hand, cvs. Progress No. 9, Victory Freezer and Little Marvel were highly susceptible for rust disease and gave the lowest early and total green yield. Perfection and Lincoln cvs. were moderately in the same respects of disease incidence and the obtained early and total green yield. These findings are in agreement with those obtained by Shata *et al.* (1984), Sherf & Macnab (1986) and Khafagi *et al.* (1995 a).

Table (2): Evaluation of some pea (*Pisum sativum* L.) cultivars against powdery mildew under field conditions in Sharkia governorate during the two successive seasons, 1998/1999-1999/2000.

Cultivar	Growing season			
	1998 / 1999			
	Infection (%)	Disease severity (%)	Green yield (ton/fed.)	
			Early yield	Total yield
Giant Climbing	20.8	13.8	1.215	3.050
Lincoln	25.0	16.9	1.015	3.015
Little Marvel	45.5	30.2	0.650	1.950
Master B	25.7	17.3	0.960	2.900
Perfection	35.0	23.7	0.850	2.130
Progress No.9	33.8	20.8	0.875	2.625
Victory Freezer	40.3	26.8	0.705	2.110
Waver Top	23.3	15.3	1.020	3.050
L.S.D. at 5%	3.72	2.04	0.350	0.254
1999 / 2000				
Giant Climbing	17.8	11.8	1.750	3.235
Lincoln	22.0	14.6	1.110	3.150
Little Marvel	44.0	29.3	0.705	2.120
Master B	22.3	15.7	1.050	3.120
Perfection	33.5	21.5	0.920	2.335
Progress No.9	27.5	18.8	0.960	2.765
Victory Freezer	37.3	24.3	0.745	2.140
Waver Top	21.5	13.2	1.320	3.190
L.S.D. at 5%	0.57	0.58	0.350	0.534

II. Fungicidal effect on:

1. Pea powdery mildew and green yield:

All of the tested fungicides (Table, 4) realized significant decrease in the infection percentage and disease severity compared with the control treatment through the two successive growing seasons, 2000/2001 and 2001/2002. Out of the six fungicides tested, Topas and Domark were the most effective ones since they reduced the infection percentage and disease severity, being 9.5, 12.5 & 6.8, 8.4 % and 8.3, 10 & 5.5, 6.9 % during the two successive seasons, respectively. Sofril had a considerable potentiality but with the least results recording 26.3 and 16.4 for infection percentage and disease severity, respectively in 2000/2001 season as well as 24.7 and 15.4 infection percentage and disease severity, respectively in 2001/2002 season.

Concerning the green yield, data (Table, 4) show that a significant increase was found by each fungicide sprayed if compared to the check yield that was 2.185 and 2.225 ton/feddan in the first and second seasons, respectively. The green yield increase ranged from 41.88 to 120.60 % and 46.97 to 125.17 in the two seasons. Similar findings were recorded by Farahat *et al.*

(1990) and Khafagi *et al* (1995 b) who reported that some fungicides were not effective to control powdery mildew of pea. It could be attributed to host resistance or to the environmental factors affecting the disease incidence. Also, many investigators used various fungicides to control powdery mildew; i.e. Hassan *et al.*(1999), Abd El-Sayed (2000), Jiskani *et al* (2000) and Ibrahim *et al.* (2003).

Table (3): Evaluation of some pea (*Pism sativum* L.) cultivars against rust disease under field conditions in Sharkia governorate during the two successive seasons, 1998/1999-1999/2000.

Cultivar	Growing season			
	1998 / 1999			
	Infection (%)	Disease severity (%)	Green yield (ton/fed.)	
			Early yield	Total yield
Giant Climbing	15.3	10.4	1.275	3.135
Lincoln	27.3	18.5	0.900	2.730
Little Marvel	37.8	25.7	0.675	2.035
Master B	23.0	16.2	1.045	3.030
Perfection	25.7	17.3	1.010	2.730
Progress No.9	30.0	20.1	0.830	2.550
Victory Freezer	32.8	22.1	0.745	2.225
Waver Top	20.8	13.3	1.150	3.115
L.S.D. at 5%	2.27	0.80	0.175	0.660
	1999 / 2000			
Giant Climbing	12.3	9.8	1.450	3.335
Lincoln	25.8	17.2	0.950	2.810
Little Marvel	35.5	24.9	0.715	2.145
Master B	20.5	14.5	1.105	3.140
Perfection	23.0	15.8	1.065	2.825
Progress No.9	28.3	18.3	0.940	2.750
Victory Freezer	30.0	21.1	0.805	2.425
Waver Top	17.8	11.7	1.320	3.230
L.S.D. at 5%	1.36	0.89	0.235	0.271

2. Pea rust and green yield:

Data in Table (5) show that all of the tested fungicides significantly decreased the infection percentage and disease severity of pea rust compared with the control treatment. Moreover, Sumi Eight, Plantvax and Saprol were significantly the most effective fungicides during the two successive seasons, 2000/2001 and 2001/2002. In contrast, Micronic sulphur was the least efficient in controlling pea rust with significant differences in the infection percentage and disease severity and green yield (early and total) during the first and second seasons. Generally, the infection percentage and disease severity were higher in the first season than in the second one. This may be due to the variations in the environmental factors from season to another. Fungicidal control increased the green yield from 44.93 to 121.66 and from 47.98 to 127.96 % in the first and second seasons, respectively. These results are in harmony with those obtained by Shata *et al.* (1984), Youssef *et al.* (1984) and Khafagi *et al* (1995 a).

Table (4): Effect of spraying six fungicides on the incidence of pea (cv. Victory freezer) powdery mildew and green yield during the two successive seasons, 2000/2001-2001/2002 under field conditions.

Treatments	Growing season				
	2000 / 2001				
	Infection (%) Disease	Severity (%)	Green yield (ton / fed.)		Increase (%)
			Early	Total	
Bayfidan MO	20.5	11.2	1.315	3.735	70.39
Domark	12.5	8.4	1.925	4.820	120.60
Micronic sulphur	23.3	14.3	1.220	3.165	44.98
Sofril	26.3	16.4	1.105	3.100	41.88
Sumi Eight	14.8	10.6	1.530	4.305	97.03
Topas	9.5	6.8	1.620	4.610	110.98
Control	45.5	30.5	0.860	2.185	------
L.S.D. at 5%	0.80	0.83	0.169	0.232	
	2001 / 2002				
Bayfidan MO	18.3	10.1	1.410	3.925	76.40
Domark	10.0	6.9	2.015	5.010	125.17
Micronic sulphur	21.3	13.2	1.305	3.335	49.89
Sofril	24.8	15.4	1.225	3.270	46.97
Sumi Eight	12.5	8.1	1.610	4.430	99.10
Topas	8.3	5.5	1.705	4.825	116.85
Control	43.8	28.7	0.890	2.225	------
L.S.D. at 5%	0.78	0.84	0.080	0.169	

Table (5): Effect of spraying six fungicides on the incidence of pea (cv. Victory Freezer) rust and green yield during the two successive seasons, 2000/2001- 2001/2002 under field conditions.

Treatments	Growing season :				
	2000 / 2001				
	Infection (%)	Disease Severity (%)	Green yield (ton / fed.)		Increase (%)
			Early	Total	
Folicur	15.5	10.6	1.920	3.905	79.95
Micronic Sulphur	19.0	13.9	1.515	3.145	44.93
Plantvax	10.5	6.9	1.915	4.615	112.67
Saprol	12.8	8.3	1.805	4.225	94.70
Sumi Eight	8.0	5.7	2.010	4.810	121.66
Topsin M 70%	17.3	12.4	1.720	3.725	71.66
Control	38.5	26.2	0.890	2.170	------
L.S.D. at 5%	1.31	1.10	0.323	0.308	
	2001 / 2002				
Folicur	13.8	9.1	1.025	4.015	80.04
Micronic Sulphur	17.5	12.6	1.625	3.300	47.98
Plantvax	9.0	6.5	2.025	4.825	116.33
Saprol	10.8	6.1	1.915	4.420	98.21
Sumi Eight	7.3	5.2	2.120	5.120	127.96
Topsin M 70%	15.5	10.4	1.815	4.125	85.00
Control	35.3	24.7	0.930	2.230	------
L.S.D. at 5%	1.33	0.49	0.138	0.474	

III. Effect of the tested bioagents on:

1. Pea powdery mildew and green yield:

The tested bioagents (Table, 6) show variable significant levels of reducing powdery mildew incidence as infection percentage and disease severity. Rizo-N was the best during the two successive seasons, 2000/2001 and 2001/2002, as the disease incidence reached 9.0 and 8.8 %, while the disease severity recorded 6.2 and 5.1 % for the two seasons, respectively. Plant Guard was the least effective as relevant successive records were 18.5, 16.8, 12.8 and 10.5 % for the infection percentage and disease severity in the two growing seasons, respectively. Promot gave intermediate effectiveness but with significant lower potentiality than Rizo-N in case of the infection percentage, being 15.8 % in the first season and 12.3 % in the second one.

Concerning the green yield, data in Table (6) also show that all of the tested bioagents significantly increased the green yield (early and total). Rizo-N was the superior in this respect giving increase of 72.28 and 74.17 % during the two successive seasons, respectively. These bioagents were effective against powdery mildew as reported by Abd El-Sayed (2000), Ibrahim *et al.* (2003) and Seif El-Eslam *et al.* (2003).

Table (6): Effect of four bioagents on the incidence of pea (cv. Victory Freezer) powdery mildew and green yield during the two successive seasons, 2000/2001 – 2001/2002 under field conditions.

Treatments	Growing season				
	2000 / 2001				
	Infection (%)	Disease Severity (%)	Green yield (ton / fed.)		Increase (%)
			Early	Total	
Biocont	16.3	10.4	1.305	3.830	59.92
Plant Guard	18.5	12.8	1.220	3.800	58.66
Promot	15.8	9.5	1.515	3.910	63.26
Rhizo-N	9.0	6.2	1.710	4.125	72.28
Control	47.3	32.6	0.980	2.395	----
L.S.D. at 5%	0.49	0.72	0.084	1.070	
	2001 / 2002				
Biocont	14.5	9.2	1.420	3.920	62.00
Plant Guard	16.8	10.5	1.305	3.875	60.12
Promot	12.3	8.3	1.600	4.065	67.98
Rhizo-N	8.8	5.1	1.805	4.215	74.17
Control	45.5	30.2	1.025	2.420	------
L.S.D. at 5%	0.81	0.41	0.146	0.842	

2. Pea rust and green yield:

Data in Table (7) show that all of the tested bioagents caused variable levels of reducing the disease incidence and severity Rizo-N was the best for the two successive seasons, 2000/2001 and 2001/2002 as the disease incidence

recorded 6.8 and 5.3 %, while the disease severity reached 4.1 and 3.7 % in the two seasons, respectively. Plant Guard was the least effective as the relevant successive records were 12.5, 11.0; 8.3 and 8.1 %. The effect of Promot and Biocont was intermediate on the infection percentage and disease severity.

As for the green yield, all of the tested bioagents significantly increased the green yield. Rizo-N was the best in this respect, resulting in an increase of 72.0 and 73.43 % in the two seasons, respectively. The other three bioagents were also of great importance on disease spread and severity as previously recorded by Abd El-Sayed (2000), Ibrahim *et al.* (2003) and Seif El-Eslam *et al.* (2003).

Table (7): Effect of four bioagents on the incidence of pea (cv. Victory Freezer) rust and green yield during the two successive seasons, 2000/2001 – 2001/2002 under field conditions.

Treatments	Growing season				
	2000 / 2001				
	Infection (%)	Disease Severity (%)	Green yield (ton / fed.)		Increase (%)
			Early	Total	
Biocont	10.3	6.7	1.235	4.175	67.00
Plant Guard	12.5	8.3	1.120	4.125	65.00
Promot	8.5	5.2	1.300	4.250	70.00
Rhizo-N	6.8	4.1	1.515	4.300	72.00
Control	35.8	24.3	0.865	2.500	-----
L.S.D. at 5%	0.71	0.47	0.103	0.119	
	2001 / 2002				
Biocont	9.3	6.5	1.325	4.300	68.95
Plant Guard	11.0	8.1	1.210	4.215	65.62
Promot	7.5	5.2	1.515	4.360	71.32
Rhizo-N	5.3	3.7	1.705	4.410	73.43
Control	33.8	22.6	0.965	2.545	------
L.S.D. at 5%	1.19	0.52	0.120	0.504	

IV. Effect of chemical salts on:

1. The incidence of powdery mildew and green yield:

Results presented in Table (8) illustrate that Kaligeen was the most effective against both disease incidence and severity. Infection and severity percentages were 10.3 and 6.5 % in 2000/2001 season, while they were 9.0 and 5.1 in 2001/2002 growing season. Sodium bicarbonate came in the second situation of potentiality as the corresponding figures were 13.0, 12.8, 8.7 and 8.2 % . The effect of other salts was not at the same level, but significantly reduced the disease incidence and severity if compared with those of the control treatment. Disease infection in the check was 47.8 and 46.3 % in the two growing seasons, respectively. Potassium nitrate and monopotassium sulphate were the least effective on the disease incidence and severity during the two seasons.

Table (8): Effect of four salts on the incidence of pea (cv. Victory Freezer) powdery mildew and green yield during the two successive seasons, 2000/2001 – 2001/2002 under field conditions.

Treatments	Growing season				
	2000 / 2001				
	Infection (%)	Disease Severity (%)	Green yield (ton / fed.)		Increase (%)
			Early	Total	
Kaligreen	10.3	6.5	1.510	3.950	84.15
Monopotassium sulphate	15.3	10.9	1.020	3.595	67.60
Potassium nitrate	14.8	9.5	1.115	3.780	76.22
Sodium bicarbonate	13.0	8.7	1.325	3.920	82.75
Control	47.8	31.6	0.810	2.145	-----
L.S.D. at 5%	0.67	0.79	0.133	0.381	
	2001 / 2002				
Kaligreen	9.0	5.1	1.615	4.165	87.19
Monopotassium sulphate	14.8	10.4	1.115	3.805	71.10
Potassium nitrate	13.8	9.1	1.235	3.965	78.20
Sodium bicarbonate	12.8	8.2	1.425	4.135	85.84
Control	46.3	30.5	0.860	2.225	------
L.S.D. at 5%	0.54	0.51	0.103	0.189	

The green yield in the two successive seasons was consequently increased in a significance reflecting the various potentiality of the salts themselves. Thus, Kaligreen gave the highest green yield, 3.950 and 4.165 ton/feddan in the two successive seasons, respectively. In the meantime, yield of check treatment recorded 2.145 and 2.225 ton/feddan, respectively. Figures expressing increases of 84.15 and 87.19 %, respectively. The other salts behaved almost in a similar manner matching their rates of potentiality against the disease infection and severity. Yet, Sodium bicarbonate affected the yield, that was increased almost to a grade very close to that expressed by Kaligreen and the differences among the three salts were not significant in this respect as well as on the other disease variants; incidence and severity. Napier and Oosthnyse (1999) and Ibrahim *et al.* (2003) found that potassium salts alone or with oil gave good results for controlling powdery mildew and yield increase underwent (McGarth and Shishkoff, 1999).

2. The incidence of pea rust and green yield:

Data in Table (9) show that Kaligreen was the most effective against both disease infection and severity. Infection and severity percentages were 9.0 and 5.8 % in the first season and 8.3 and 4.3 % in the second one. Sodium bicarbonate came in the second rank, recording 11 3, 6.1 and 10.0, 5.6 % for disease infection and severity in the two successive seasons, respectively. Potassium nitrate and monopotassium sulphate significantly reduced the disease

incidence and severity with least effective if compared with those of the check treatment. Disease infection in the control treatment recorded 37.3 and 35.8 %, while severity reached 24.7 and 26.8 % in the two seasons, respectively.

The green yield obtained during the two seasons was consequently increased significantly reflecting the various potentialities of the salts themselves. Thus, Kaligreen gave the highest green yield, being 4.420 and 4.675 ton/feddan in the two seasons, respectively. In the meantime, yield of the check treatment was successively 2.375 and 2.485 ton/feddan through the two seasons, respectively. The other salts behaved almost in a similar manner matching their rates of potentiality against disease infection and severity. These results are in agreement with those obtained by Abada *et al.* (1997) and Khafagi (2002).

Table (9): Effect of four salts on the incidence of pea (cv. Victory Freezer) rust and green yield during the two successive seasons, 2000/2001 – 2001/2002 under field conditions.

Treatments	Growing season				
	2000 / 2001				
	Infection (%)	Disease Severity (%)	Green yield (ton / fed.)		Increase (%)
			Early	Total	
Kaligreen	9.8	5.8	1.935	4.420	86.11
Mono potassium sulphate	14.8	9.6	1.125	4.050	70.53
Potassium nitrate	13.5	8.5	1.625	4.275	80.0
Sodium bicarbonate	11.3	6.1	1.845	4.335	82.85
Control	37.3	24.7	1.045	2.375	-------
L.S.D. at 5%	0.84	0.67	0.133	0.304	
	2001 / 2002				
Kaligreen	8.3	4.3	2.015	4.675	88.13
Mono potassium sulphate	13.0	8.3	1.255	4.335	74.40
Potassium nitrate	11.5	7.4	1.720	4.530	82.30
Sodium bicarbonate	10.0	5.6	1.910	4.590	84.71
Control	35.8	26.8	1.075	2.485	-------
L.S.D. at 5%	0.52	0.43	0.881	0.377	

V. The role of Micronic sulphur, Topas, Sumi-Eight, Sodium bicarbonate and Rizo-N singly and as integrated measure of the two diseases control:

Results tabulated in Table (10) show that the effectiveness of the three fungicides, the salt and the bioagent was successfully significant for all of the studied parameters, i.e. disease incidence, disease severity and the green yield. The relevant data here are not vary than those recorded in the aforementioned experiments as shown in Tables (4, 5, 6, 7,8 & 9). These were true when they were applied separately for six sprays. The case was greatly differed when the five materials were applied in such a sequence of Micronic sulphur in the first

spray, Topas in the second, Sumi Eight in the third, Sodium bicarbonate in the fourth, Rizo-N in the fifth and Micronic sulphur in the sixth spray. This subsequent application gave higher effectiveness than the single fungicide application.

Table (10): Effect of Micronic sulphur, Topas, Sumi Eight, Sodium bicarbonate and Rhizo-N separately and alternatively (IPM) for controlling powdery mildew and rust of pea (cv. Victory Freezer) and total green yield during the two successive seasons, 2002/2003 – 2003/2004.

Treatments	Growing season :						
	2002 / 2003						
	Powdery mildew		Rust		Green yield (ton / fed.)		Increase (%)
	Infection (%)	Disease severity (%)	Infection (%)	Disease severity (%)	Early	Total	
Micronic sulphur (A)	24.0	16.3	19.3	13.4	1.050	2.300	44.67
Topas (B)	9.3	6.1	7.5	4.9	2.015	4.345	165.43
Sumi Eight (C)	12.5	8.3	10.8	6.7	1.820	4.410	152.0
Sodium bicarbonate (D)	13.8	9.1	12.3	8.2	1.610	3.625	107.14
Rhizo-N (E)	15.8	10.6	13.5	9.3	1.035	2.915	66.60
A,B,C,D and E (alternatively)	6.8	4.5	4.5	3.2	2.220	5.215	198.0
Control	55.5	36.8	34.3	22.7	0.750	1.750	-----
L.S.D. at 5%	0.56	0.76	0.57	0.42	0.914	0.133	
	2003 / 2004						
Micronic sulphur (A)	22.5	15.1	17.8	12.1	1.110	2.650	48.04
Topas (B)	8.5	5.2	6.8	4.2	2.250	5.370	168.72
Sumi Eight (C)	11.0	7.4	10.3	5.2	1.915	4.925	158.38
Sodium bicarbonate (D)	12.3	8.3	11.3	7.3	1.725	3.405	112.85
Rhizo-N (E)	13.8	9.2	12.5	8.5	1.115	3.125	74.58
A,B,C,D and E (alternatively)	5.3	4.1	4.3	3.2	2.325	5.910	184.30
Control	53.3	35.5	32.0	20.5	0.765	1.790	-----
L.S.D. at 5%	0.56	0.50	0.88	0.60	0.707	0.141	

In this respect, the alternative treatments, in which control agents were sprayed alternatively, recorded percentages of powdery mildew infection and severity, being 6.8 & 4.5 % and 5.3 & 4.1 %, whereas those of rust were 4.5 & 3.2 % and 4.3 & 3.2 % during 2002/2003 and 2003/2004 growing seasons,

respectively. As for control treatments, these measurements were 55.5 & 36.8% and 53.3 & 35.5 % in addition to 34.3 & 22.7 % and 32.0 & 20.5 % for concerning the two diseases through the two successive seasons, respectively.

Such potentiality was reflected in correspondence with the green yield during the two successive seasons. Thus, the alternative sprays gave the best yield, being 5.215 and 5.910 ton/feddan during the first and the second growing seasons, respectively. Thus, the green yield was more double of the check treatment, recording 1.75 and 1.79 ton/feddan during the two successive seasons, respectively.

Therefore, it could be concluded that the alternative sprays programme, whether with different fungicides or with different groups of materials such as fungicides, bioagents and salts was more or less the best way of competing the pea powdery mildew and rust. The superiority of this programme may be due to the camping different mode of action for the tested materials. Ibrahim *et al.* (2003) stated that the antifungal mechanisms were very diversable and the target ranges from structural components to energy evaluation, biosynthesis process and regulatory pathways. These different modes of action played meaningful roles in the differences took place among the tested materials.

Hence, it could be advised to use such a programme of an alternative sprays for each of the best effective fungicide, bioagent and salt to fulfill high disease management and to avoid the hazardous risk of the toxic fungicides on the public health and the environment as well.

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المكافحة المتكاملة للبياض الدقيقى والصدأ فى البسلة وعلاقة ذلك بالمحصول الأخضر

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أظهرت الأصناف الثمانية المختبرة للبسلة تباينات واضحة فى رد فعلها تجاه كل من البياض الدقيقى والصدأ. تم اختبار تأثير مبيدات فطرية مختلفة، ومبيدات حيوية، وأملاح معدنية على حدوث كل من البياض الدقيقى والصدأ فى البسلة تحت ظروف الحقل إما بصورة فردية مطلقة أو فى صورة متتابعة.

تم رش كل المعاملات خمسة مرات بعد خمسة وأربعين يوما من الزراعة بمسافة زمنية مقدارها عشرة أيام. وقد أدى كل من المبيدات الفطرية دومارك، توباس، سومى إيت إلى حدوث نقص معنوى لكل من نسبة وشدة الإصابة للبياض الدقيقى. كما أدت هذه المبيدات إلى زيادة المحصول الأخضر الناتج.

بالنسبة لصدأ البسلة، فقد كانت المبيدات سومى إيت، وبلانتفاكس، وسابرول أيضا مؤثرة فى خفض الإصابة بالأمراض موضع الدراسة مقارنة مع المبيدات الفطرية الأخرى، مما أدى إلى زيادة المحصول الأخضر المبكر والكلى. وكانت المبيدات الحيوية (ريزو-ن، وبلانت جارد) الأكثر تأثيرا فى مقاومة هذين المرضين مقارنة مع المبيدات الأخرى، مما أدى إلى زيادة المحصول الأخضر المبكر والكلى. ومن ناحية أخرى، فإن الرش بالأملاح المختلفة أثبت أن كالبجرين متبوعا ببيوكربونات الصوديوم كانت الأكثر تأثيرا فى مقاومة المرضين موضع الدراسة، مقارنة مع غيرها من الأملاح.

وعلى ذلك، فإن برنامج المكافحة المتكاملة تم تجريبه بكل من الكبريت الميكرونى، والمبيد توباس والمبيد سومى-إيت، بيكربونات الصوديوم، والمبيد الحيوى ريزو-ن. إن تبادل الرش بتلك العناصر أظهر التأثير الأعلى فى مقاومة البياض الدقيقى والصدأ فى البسلة، كما أدى إلى زيادة المحصول الأخضر المبكر.