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EFFECTIVENESS OF AZOXYSTROBIN IN THE CONTROL OF *ERYSIPHE CICHORACEARUM* AND *PSEUDOPERONOSPORA CUBENSIS* ON CUCUMBER

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Abstract: The bioefficacy of azoxystrobin (Amistar 25 SC) was tested against cucumber downy mildew and powdery mildew diseases. The two season trials of field studies revealed that the disease progression of cucumber downy mildew and powdery mildew was successfully arrested by azoxystrobin. Spraying of azoxystrobin at various doses (31.25, 62.50 and 125 g a.s./ha) revealed that 125 g a.s./ha (500 ml/ha) was considered as the optimum dose for the control of these diseases of cucumber. The treatment also recorded the highest yield of 13.23 and 14.46 tonnes/ha in the first and second season, respectively. No phytotoxic effect of azoxystrobin was observed in the both field trials even at four times of the recommended dose 125 g a.s./ha. The persistence of azoxystrobin at 250 and 500 g a.s./ha was observed up to seven days after last spraying. However, the persistence of azoxystrobin at 31.25, 62.50 and 125 a.s./ha was observed up to three to five days after last spraying. The safe waiting period for the harvest of cucumber fruits was 1.53 days in the first field trial and 2.37 days in the second field trial, respectively at azoxystrobin 125 g a.s./ha. The residues of azoxystrobin were at below detectable level (BDL) in the harvested cucumber fruits.

Key words: bioefficacy, cucumber, persistence, phytotoxicity, residues

INTRODUCTION

Cucumber (*Cucumis sativus* L.), a popular fresh market vegetable prepared as salads, is cultivated throughout India. The total area under cucumber cultivation in

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India was reported around 0.02 million ha and its production was 0.12 million tonnes (Anonymous 2004). The major constraint to cucumber production in India is downy mildew and powdery mildew caused by *Pseudoperonospora cubensis* DC and *Erysiphe cichoracearum* DC, respectively. Protective spray schedules require frequent application of fungicides as the disease cycle is completed in 3–7 days and several quick cycles cause widespread infection within a short period. Furthermore, the successive use of systemic fungicides such as fenarimol, triadimefon and bupirimate to control these diseases has led to the development of tolerant strains (Gupta and Shyam 1996). Frequent sprays of copper containing fungicides (Bordeaux mixture and copper oxychloride) and certain other groups of fungicides are required to check the diseases, which increase the cost of cultivation besides posing residue problem.

Hence, newer fungicides are needed for downy mildew and powdery mildew disease management in cucumber. Azoxystrobin (Amistar 25 SC) possesses a novel biochemical mode of action. Its fungicidal activity results from the inhibition of mitochondrial respiration in fungi. This is achieved by the prevention of electron transfer between cytochrome b and cytochrome c. Because of its novel mode of action, azoxystrobin is effective against pathogens which have developed reduced sensitivity to other fungicides (Hewitt 1998). Azoxystrobin shows a unique spectrum of disease control and is active against Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. No current commercial fungicide combines this breadth of spectrum with high levels of intrinsic activity at low rates.

Azoxystrobin is the only currently available fungicide to provide effective control of downy mildew and powdery mildew, which are the two most important fungal diseases of grapevine (Baldwin *et al.* 1996; Wilcox *et al*. 1999). The protectant, post infection, post symptom, translaminar and vapor activities of azoxystrobin provided 100 per cent disease control of grapevine downy mildew (Hewitt 1998). The present study was undertaken to study the bioefficacy, phytotoxicity and persistence of azoxystrobin against cucumber downy mildew and powdery mildew diseases.

MATERIALS AND METHODS

Source of fungicides

The chemicals *viz*., azoxystrobin, mancozeb and carbendazim were obtained from M/S Syngenta Pvt. Ltd., India.

Bioefficacy of azoxystrobin

A field experiment was conducted with cucumber cv. Malini during February–May, 2004 in the farmer's holding at Bolluvampatti, Coimbatore, Tamil Nadu, India to study the bioefficacy of azoxystrobin against downy mildew and powdery mildew diseases. The experiment was laid out in randomized block design with four replications and a plot size of 5 x 4 m (20 m^2). Regular agronomic practices were followed according to the Tamil Nadu Agricultural University crop production guide. The treatments of the experiment were T_1 – Azoxystrobin 25 SC @ 31.25 g a.s./ha, T_2 – Azoxystrobin 25 SC @ 62.50 g a.s./ha, T_3 – Azoxystrobin 25 SC @ 125 g a.s./ha, T_4 – Mancozeb @ 1kg/ha, T_5 – Carbendazim @ 500 g/ha and T_6 – Control.

Two sprays were performed with azoxystrobin 35 days after sowing along with the standard checks at 15 days interval using a high volume ASPEE backpack sprayer with a spray fluid volume of 500 l/ha. Downy mildew and powdery mildew incidence were recorded at 7 and 15 days after each spray. The intensity of downy mildew and powdery mildew diseases was assessed using the score chart of 0 to 5 scale (0 – No infection, 1–0 to 10, 2–10.1 to 15, 3–15.1 to 25, 4–25.1 to 50 and 5 – More than 50 per cent leaf area covered with mildew growth) as described by Jamadar and Desai (1997). The per cent disease index (PDI) was calculated with the following formula (Mckinney 1923).

$$PDI = \frac{\text{Sum of numerical ratings}}{\text{Total number of leaves observed}} \times \frac{100}{\text{Maximum category value}}$$

Another field experiment was conducted during August–November, 2004 in a farmer's field at Alandurai, Coimbatore, Tamil Nadu, India using cv. Malini cucumber in the same way to confirm the results obtained in the field experiment I. The weight of fruits from each plot during harvest was recorded and the average yield per treatment was calculated.

Phytotoxic effect of azoxystrobin

To study the phytotoxic effect of azoxystrobin on cucumber field experiments were laid out (*vide* bioefficacy trials). The treatments of the experiment were T_1 – Azoxystrobin 25 SC @ 31.25 g a.s./ha, T_2 – Azoxystrobin 25 SC @ 62.50 g a.s./ha, T_3 – Azoxystrobin 25 SC @ 125 g a.s./ha, T_4 – Azoxystrobin 25 SC @ 250 g a.s./ha, T_5 – Azoxystrobin 25 SC @ 500 g a.s./ha and T_6 – Control. Plants were observed on 1, 3, 5, 7, 10 and 20 days after spraying for the phytotoxic symptoms such as injury to leaf tips, leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty. Leaf injury was graded based on visual rating on a 1–10 scale (1–1 to 10; 2–11 to 20; 3–21–30; 4–31 to 40; 5–41 to 50; 6–51 to 60; 7–61 to 70; 8–71 to 80; 9–81 to 90; 10–91 to 100 per cent leaf injury) (CIB 1989).

Harvest time residues of azoxystrobin

Two field experiments were conducted to determine the persistence of azoxystrobin in cucumber fruits. The field experiment was conducted during February–May, 2004 and August–November, 2004 in the farmer's holding at Bolluvampatti and Alandurai, Coimbatore, Tamil Nadu, India, respectively. The treatments of the experiments were as given above.

Analytical methodology

Sampling

Fruit samples were collected from all concentrations of azoxystrobin treated and untreated plots after last round of spraying to determine the harvest time residues. Samples were collected for dissipation studies at 0 (1 h after spray), 1, 3, 5, 7, 10 and 14 days after application. Fruits (500 g each) were collected from each replication, pooled and after quartering, 25 g of laboratory analytical samples in duplicates were drawn in wide mouth containers having extraction solvent, acetonitrile: doubled distilled water (9 : 1 v/v). The working samples were transported in an ice box and stored at –70°C in a deep freezer in the laboratory.

Extraction

The laboratory samples were homogenized with acetonitrile: water (9:1 v/v). The extract was filtered under vacuum through a buchner funnel overlaid with Whatman No. 1 filter paper into a round bottom flask. For further extraction, the residues were washed with the same solvent. All the aliquots were evaporated to near dryness on rotary evaporator at < 40°C and redissolved in dichloromethane: ethyl acetate mixture (95:5) for silica gel column clean up.

Clean up

For column chromatography, 1.5 cm (dia) x 50 cm (length) glass columns were used. The drip tips of the columns were plugged with cotton wool and packed up to 6 cm height with activated silica gel sandwitched between 2 cm height layers of anhydrous sodium sulphate on either side. The packed column was prewetted with dichloromethane.

To elute the compound, 25 ml of dichloromethane and ethyl acetate (7:3 v/v) was used after loading the condensed extract. Eluate was concentrated to near dryness and the residue was redissolved in 5–10 ml of HPLC grade acetonitrile for final determination using HPLC, Hitachi model L 6200 [Mobile phase – Acetonitrile (HPLC grade): water (HPLC grade) (80:20 v/v), Column – ODS 2, Flow rate – 1 ml/min, Wave length – 245 ηm, Quantity injected – 20 µl (fixed loop), Attenuation – 3]. The amount of residue present in the fruits was calculated by comparing the sample response with the response of standard by using the formula

$$\text{Residue (ppm)} = \frac{\text{Sample peak height (cm)}}{\text{Standard peak height (cm)}} \times \frac{\text{Weight of standard } (\eta g)}{\text{Weight of sample (g)}} \times \frac{\text{Volume of final extract (ml)}}{\text{Volume of sample injucted } (\mu l)}$$

RESULTS

Bioefficacy against downy mildew

In the first season trial, the results revealed that azoxystrobin tested at all concentrations was effective against both diseases (Tables 1 and 2). The efficacy increased with increase in the concentration but the rate of progression of the disease was found to decrease in treated plots. In the control plots 5.02 PDI was initially recorded which progressed up to 44.55 PDI as observed at the end of the experiment. Azoxystrobin at 31.25, 62.50 and 125 g a.s./ha sprayed plots recorded 80.07, 83.57 and 90.08 per cent disease reduction over control, respectively, when compared to mancozeb (79.30%) and carbendazim (54.12%) (Table 1).

A similar trend was observed in the second season and 125 g a.s./ha was found to be the best among the doses of azoxystrobin recording the lowest PDI of 2.92. This treatment showed the highest per cent disease reduction (92.59%) followed by other doses *viz.*, 62.50 g a.s./ha (86.18%) and 31.25 g a.s./ha (81.74%).

Table 1. Effect of azoxystrobin on downy mildew of cucumber

Treatments	Trial I						Trial II					
	Per cent disease index											
	Before spray	1st Spray		2nd Spray		Per cent reduction over control	Before spray	1st Spray		2nd Spray		Per cent reduction over control
		7 DAS	15 DAS	7 DAS	15 DAS			7 DAS	15 DAS	7 DAS	15 DAS	
Azoxystrobin 31.25 g a.s./ha	7.74 (16.15) a	8.98 (17.44) b	9.24 (17.70) c	9.20 (17.65) c	8.88 (17.33) c	80.07	5.02 (12.94) ab	7.84 (16.26) c	7.86 (16.28) c	7.64 (16.15) d	7.20 (15.56) d	81.74
Azoxystrobin 62.50 g a.s./ha	7.50 (15.89) a	8.54 (16.94) c	8.50 (16.95) d	7.92 (16.34) d	7.32 (15.69) d	83.57	6.24 (14.46) a	6.36 (14.60) d	6.40 (14.65) d	6.04 (14.23) e	5.45 (13.50) e	86.18
Azoxystrobin 125 g a.s./ha	6.78 (15.10) a	6.97 (15.31) d	6.85 (15.17) e	5.90 (14.05) e	4.42 (12.62) e	90.08	4.64 (12.48) b	4.70 (12.52) e	4.35 (12.04) e	3.42 (10.66) f	2.92 (9.83) f	92.59
Mancozeb @ 1 kg/ha	7.90 (16.32) a	9.93 (18.37) b	10.26 (18.68) c	10.56 (18.96) c	9.22 (17.68) c	79.30	6.10 (14.29) a	8.62 (17.07) b	8.78 (17.24) c	9.07 (17.57) c	8.52 (16.97) c	78.39
Carbendazim @ 500 g/ha	7.88 (16.30) a	10.72 (19.11) b	14.35 (22.26) b	16.36 (20.86) b	20.44 (26.88) b	54.12	4.82 (12.68) b	8.92 (17.37) b	12.48 (20.69) b	17.63 (24.83) b	19.08 (25.90) b	51.62
Control	5.02 (13.21) b	12.88 (21.03) a	25.77 (30.84) a	43.64 (41.34) a	44.55 (49.22) a	–	4.50 (12.24) b	10.88 (19.26) a	20.79 (27.12) a	31.58 (34.19) a	39.44 (38.90) a	–

In a column, means followed by the same letters are not significantly different at the 5% level
Values in parentheses are arcsine transformed values,
DAS – days after spraying

Table 2. Effect of azoxystrobin on powdery mildew of cucumber

Treatments	Trial I						Trial II					
	Per cent disease index											
	Before spray	1st Spray		2nd Spray		Per cent reduction over control	Before spray	1st Spray		2nd Spray		Per cent reduction over control
		7 DAS	15 DAS	7 DAS	15 DAS			7 DAS	15 DAS	7 DAS	15 DAS	
Azoxystrobin 31.25 g a.s./ha	10.36 a (18.77)	12.43 c (20.64)	12.32 d (20.54)	12.10 d (20.35)	11.95 d (20.22)	70.75	3.73 a (11.13)	5.95 b (14.11)	6.34 d (14.58)	6.30 d (14.53)	5.98 d (14.15)	83.93
Azoxystrobin 62.50 g a.s./ha	10.22 a (18.64)	10.60 d (19.00)	10.44 e (18.85)	10.08 e (18.51)	9.69 e (18.13)	76.28	3.44 ab (10.68)	4.33 b (12.01)	4.40 e (12.10)	4.00 e (11.53)	3.88 e (11.36)	89.58
Azoxystrobin 125 g a.s./ha	9.96 a (18.40)	10.10 d (18.54)	9.88 e (18.32)	9.00 e (17.45)	7.94 f (16.36)	80.56	2.96 b (9.90)	3.10 bc (10.14)	3.10 e (11.14)	2.42 f (8.94)	1.92 f (7.90)	94.84
Mancozeb @ 1 kg/ha	10.78 a (19.16)	12.36 b (20.58)	15.02 c (22.80)	14.90 c (22.70)	14.52 c (22.39)	64.45	3.33 ab (10.51)	5.90 b (13.43)	8.16 c (16.59)	9.10 c (17.55)	9.26 c (17.71)	75.12
Carbendazim @ 500 g/ha	8.72 b (17.18)	12.08 b (20.34)	18.66 b (25.59)	17.66 b (24.85)	17.28 b (24.56)	57.70	4.58 a (12.35)	6.28 b (14.51)	9.27 b (17.72)	10.79 b (19.17)	11.88 b (20.16)	68.08
Control	9.75 a (18.19)	16.18 a (23.71)	24.77 a (29.84)	39.73 a (39.10)	40.85 a (42.78)	–	5.10 a (13.05)	10.90 a (19.28)	18.99 a (25.83)	29.89 a (33.14)	37.22 a (37.59)	–

In a column, means followed by the same letters are not significantly different at the 5% level
Values in parentheses are arcsine transformed values,
DAS – days after spraying

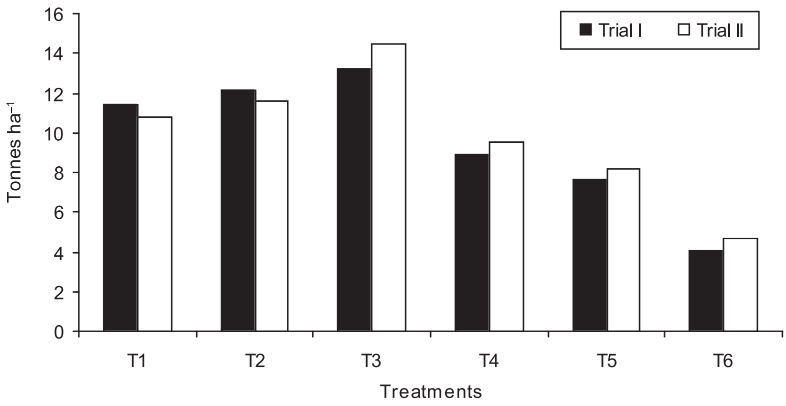
Bioefficacy against powdery mildew

The results revealed that all fungicides were significantly effective against cucumber powdery mildew 15 days after second spray when compared to untreated control (Table 2). The highest dose of azoxystrobin (125 g a.s./ha) was found to be superior to other treatments in reducing the disease incidence to the level of 5.22 PDI followed by other doses at 62.50 g a.s./ha (9.69 PDI) and 31.25 g a.s./ha (11.95 PDI). The efficacy of azoxystrobin increased with the increase in concentrations. Among the treatments, carbendazim at 500 g/ha was less effective against cucumber powdery mildew than azoxystrobin. The control plots recorded the PDI of 9.75 initially and then it increased up to 40.85 PDI.

Similar results were also observed from the second field trial, the lowest disease incidence was recorded for azoxystrobin at 125 g a.s./ha (1.92 PDI) followed by other doses *viz*., 62.50 g a.s./ha (3.88 PDI) and 31.25 g a.s./ha (5.98 PDI). All the treatments were significantly different from each other and control plots recorded the maximum per cent disease index of 37.22. The standard checks *viz*., mancozeb and carbendazim recorded 7.38 and 9.09 PDI on 15 days after second spray.

Yield

The highest yield was recorded in azoxystrobin 125 g a.s./ha (13.23 tonnes/ha) followed by the same chemical at 62.50 g a.s./ha and significantly higher than the yield obtained from untreated plots (4.08 tonnes/ha). In the second season, similar trend of results was obtained, in which the highest dose of azoxystrobin recorded the maximum yield of 14.46 tonnes/ha followed by the same chemical at 62.50 (11.63 tonnes/ha) and 31.25 g a.s./ha (10.81 tonnes/ha). Carbendazim treated plots recorded the lowest yield of 8.22 tonnes/ha (Fig. 1). From the yield data of two trials with cucumber, azoxystrobin @ 125 g a.s./ha was found to be the optimum dose for the management of downy mildew and powdery mildew.



T1 – azoxystrobin 31.25 g a.s./ha; T2 – 62.50 g a.s./ha; T3 – 125 g a.s./ha; T4 – 250 g a.s./ha; T5 – 500 g a.s./ha; T6 – Control

Fig. 1. Effect of azoxystrobin on fruit yield of cucumber

Phytotoxicity

No phytotoxicity symptoms were observed in all the tested concentrations of azoxystrobin.

Persistence

In the field trial I, azoxystrobin at doses: 31.25, 62.50, 125, 250 and 500 g a.s./ha left initial deposits of 1.0253, 1.6650, 2.0541, 2.9204 and 4.2001 µg/g, respectively, on cucumber fruits. One day after treatment, the initial deposits dissipated by 20.98 to 34.56 per cent and reached below detectable level (BDL) after third DAS in azoxystrobin 31.25 g a.s./ha, after fifth DAS at 62.50 and 125 g a.s./ha and seven DAS at the dose of 250 and 500 g a.s./ha (Table 3). In the field trial II, spraying of azoxystrobin at 31.25, 62.50, 125, 250 and 500 g a.s./ha left initial deposits of 0.7944, 2.0142, 2.4532, 3.0464 and 3.8582 µg/g, respectively, on cucumber fruits. One day after treatment, the initial deposits dissipated by 24.32 to 47.88 per cent and reached BDL after 3 DAS at 31.25 g a.s./ha, after fifth day at 62.50 and 125 g a.s./ha and after seventh DAS at 250 and 500 g a.s./ha as in the field experiment I.

The best fit observed in cucumber was first order kinetics in both the trials and also followed the inverse power law (Table 4). Various statistical parameters like intercept (a), slope (b) of regression line and half life ($T_{0.5}$) with their confidence limits for the best fit function in cucumber are presented in Table 4. The half life values worked out for different doses *viz*., 31.25, 62.50, 125, 250 and 500 g a.s./ha were 0.7966, 1.0507, 1.1802, 1.1568 and 1.7933 days, respectively. Considering the maximum permissible residue limit (MRL) of 1.0 µg/g for cucumber, the suggested waiting period after spraying of azosytrobin at 31.25, 62.50, 125, 250 and 500 g a.s./ha was 0.0654, 1.1386, 1.5260, 2.4142 and 4.2324 days, respectively. In the field trial II, the half life values were 0.9349, 1.3089, 1.5590, 1.1488 and 1.4448 days and the suggested waiting period would be 1.7409, 2.3652, 2.5168 and 3.4822 days for azoxystrobin at 62.50, 125, 250 and 500 g a.s./ha, respectively.

Harvest time residues

The residues of azoxystrobin at different concentrations were found at BDL in the harvested fruits of cucumber.

DISCUSSION

In the present study, azoxystrobin was highly effective against the mildews of cucumber at 125 and 62.50 g a.s./ha followed by 31.25 g a.s./ha. From this study it is evident that 125 g a.s./ha (500 ml) of azoxystrobin was considered as the optimum dose to combat the downy mildew and powdery mildew of cucumber. The optimum dose of azoxystrobin (125 g a.s./ha) sprayed plots recorded about 90 and 80 per cent reduction of downy mildew and powdery mildew, respectively, in first season trials. From the second season trials conducted against cucumber downy mildew and powdery mildew the optimum dose of azoxystrobin (125 g a.s./ha) recorded more than 90 per cent disease reduction.

Azoxystrobin at dose of 125 g a.s./ha in the first season trials with cucumber recorded 224.54 per cent increase in yield over control. In the second season cucumber trials also the same dose of azoxystrobin recorded a maximum yield of 14.46 tonnes/ha and 212.31 per cent increase over control. The results are in accordance with excellent

Table 3. Persistence and dissipation of azoxystrobin in cucumber fruits

Days after spraying	Trial I											
	azoxystrobin residues [µg /g]						dissipation [%]					
	31.25 g a.s./ha	62.50 g a.s./ha	125 g a.s./ha	250 g a.s./ha	500 g a.s./ha	Control	31.25 g a.s./ha	62.50 g a.s./ha	125 g a.s./ha	250 g a.s./ha	500 g a.s./ha	Average dissipation [%]
0	1.0253	1.6650	2.0541	2.9204	4.2001	BDL	–	–	–	–	–	–
1	0.6814	1.0895	1.4603	1.9423	3.3189	BDL	33.54	34.56	28.91	33.49	20.98	30.30
3	0.0357	0.5415	0.8207	1.2633	2.1893	BDL	96.52	67.48	60.05	56.74	47.88	65.73
5	BDL	0.0542	0.0968	0.4248	0.9428	BDL	100.0	96.74	95.29	85.45	77.55	91.01
7	BDL	BDL	BDL	0.0312	0.2556	BDL	100.0	100.0	100.0	98.93	93.91	98.57
10	BDL	BDL	BDL	BDL	BDL	BDL	100.0	100.0	100.0	100.0	100.0	100.0
14	BDL	BDL	BDL	BDL	BDL	BDL	100.0	100.0	100.0	100.0	100.0	100.0
	Trial II											
0	0.7944	2.0142	2.4532	3.0464	3.8582	BDL	–	–	–	–	–	–
1	0.4143	1.5100	1.8543	2.2006	2.9196	BDL	47.88	25.03	24.41	27.76	24.32	29.88
3	0.0091	0.8590	1.0858	1.3056	1.8971	BDL	98.85	57.35	55.74	57.14	50.83	63.98
5	BDL	0.1302	0.2485	0.4408	0.9359	BDL	100.0	93.54	89.87	85.53	75.74	88.94
7	BDL	BDL	BDL	0.0330	0.0984	BDL	100.0	100.0	100.0	98.12	97.45	99.11
10	BDL	BDL	BDL	BDL	BDL	BDL	100.0	100.0	100.0	100.0	100.0	100.0
14	BDL	BDL	BDL	BDL	BDL	BDL	100.0	100.0	100.0	100.0	100.0	100.0

BDL – Below Detectable Level, Determinability: 0.004 µg/g

Table 4. Intercepts, slope and half life of azoxystrobin residues in cucumber fruits

Treatments	A	LL	UL	B	LL	UL	$T_{0.5}$	LL	UL	Waiting period (days)	Predicted equation
Trial – I											
T1	4.6621	2.3920	6.9322	–0.8707	–1.6376	–0.1027	0.7966	0.0940	1.4992	0.0654	Y = 4.6621 – 0.8701X
T2	5.3563	3.5852	7.1274	–0.6597	–1.2585	–0.0609	1.0507	0.0971	2.0042	1.1386	Y = 5.3563 – 0.6597X
T3	5.5680	3.8277	7.3083	–0.5873	–1.1756	–0.1010	1.1802	0.1221	2.3625	1.5260	Y = 5.5680 – 0.5873X
T4	6.0518	4.4337	7.6698	–0.5992	–0.9940	–0.2044	1.1868	0.3947	1.9189	2.4142	Y = 6.0518 – 0.5992X
T5	6.2411	5.5448	6.9373	–0.3865	–0.5564	–0.2167	1.7933	1.0052	2.5814	4.2324	Y = 6.2411 – 0.3865X
Trial – II											
T1	4.4184	4.2591	4.5777	–0.7415	–0.7953	–0.6676	0.9349	0.8669	1.0028	–	Y = 4.4184 – 0.7415X
T2	5.5271	4.0222	7.0320	–0.5296	–1.0383	–0.0208	1.3089	0.0574	2.5664	1.7409	Y = 5.5271 – 0.5296X
T3	5.6568	4.5943	6.7193	–0.4446	–0.8038	–0.0854	1.5590	0.2995	2.8184	2.3652	Y = 5.6568 – 0.4446X
T4	6.1237	4.5398	7.7076	–0.6034	–0.9898	–0.2169	1.1488	0.4130	1.8846	2.5168	Y = 6.1237 – 0.6034X
T5	6.2758	4.8840	7.6676	–0.4798	–0.8193	–0.1402	1.4448	0.4222	2.4673	3.4822	Y = 6.2758 – 0.4798X

T1 – azoxystrobin (25 SC) 31.25 g a.s./ha; T2 – 62.50 g a.s./ha; T3 – 125 g a.s./ha; T4 – 250 g a.s./ha; T5 – 500 g a.s./ha
A – Intercepts; LL – Lower Limit; UL – Upper Limit; B – Slope; T 0.5 – Half Life

control, curative, translaminar and systemic properties of azoxystrobin which enables it to be used efficiently against downy mildew of grapevine and leaf blight of tomato at very low application rates (Hewitt 1998; Mejia Arreaza and Hernandez 2001; Ranganathan 2001).

Azoxystrobin provides an effective control of downy mildew and powdery mildew disaeses (Baldwin *et al*. 1996; Hansen 2000; Wong and Wilcox 2001; Schwartz and Gent 2005). Grover and Boal (1998) found that the compound was effective against powdery mildew of sweet cherry at Oronda. Wicks and Hitch (2002) evaluated the strobilurin fungicide, azoxystrobin for the control of powdery mildew and downy mildew of grapes and found that azoxystrobin @ 0.5 g/l was more effective than Flint® and Thiovit® in controlling these diseases. Azoxystrobin was found to be highly effective and reduced the disease severity of grapevine downy mildew and powdery mildew (Jamadar *et al*. 2004; Sendhil Vel *et al*. 2004a). The results from early and the present study showed that azoxystrobin is an effective compound for controlling downy mildew and powdery mildew of cucumber. Azoxystrobin is of great advantage to the growers since they can use this systemic fungicide for all the dreaded diseases.

All concentrations of azoxystrobin did not cause any phytotoxicity symptoms. This is an additional advantage in azoxystrobin spray indicating its safety to cucumber crop. Ranganathan (2001) reported that there was no phytotoxic sysmptoms throughout the cropping season due to azoxystrobin application. Sendhil Vel *et al*. (2004b) also found that there was no leaf injury on grapevine at a higher concentration of azoxystrobin.

Persistence of protective fungicide on the surface of the plant parts plays an important role in determining the disease reduction potential and was highly useful in developing spray schedules. The results of persistence of azoxystrobin in the both field experiments with cucumber revealed that azoxystrobin at 31.25, 62.50, 125, 250 and 500 g a.s./ha left an initial deposit ranged from 1.0253 to 4.2001 μg/g and 0.7944 to 3.8582 μg/g in the first and second field trial, respectively. The residues reached BDL after third day at 31.25 g a.s./ha, fifth day at 62.50, 125 g a.s./ha and seventh day at 250 and 500 g a.s./ha in the both field trials. Considering the maximum permissible residue limit of 1.0 ppm for cucumber, the suggested waiting period after spraying of azoxystrobin at different concentrations ranged from 0.0654 to 4.2324 days and 1.7409 to 3.4822 days, respectively, in the field experiment I and II. The effect of azoxystrobin residues on grapes from treatment to harvest and their fate in dried berries, wine and alcoholic beverages were reported. The disappearance rate (half life period $T_{0.5}$) was 3–4 days. In the wines no detectable residues were found at the end of fermentation (Cabras and Angioni 2000). Sendhil Vel (2003) also reported that azoxystrobin residues were recorded from grapevine fruits up to seven days and after that the residues were at below detectable level. He also stated that the half life ($T_{0.5}$) for fruit was 2 to 3 days and 1.5 to 2 days for leaves after spraying.

The azoxystrobin residues at five different concentrations were found at below detectable level in the harvested fruits of cucumber. The minimum detectable level in cucumber was 0.004 μg/g in the sample weight of 25 g of fruits. In cucumber fruits, the MRL for azoxystrobin was 1.0 mg/kg (http://www.hmso.gov.uk/legislation/ scotland/ ssi 2002). Sendhil Vel *et al.* (2004b) also reported that the residues of azoxystrobin were at BDL in harvested fruits of grapevine. Hence, the fungicide can be safely used even up to 500 g a.s./ha for the management of cucumber downy mildew and powdery mildew diseases.

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POLISH SUMMARY

EFEKTYWNOŚĆ AZOKSYSTROBINY W ZWALCZANIU *ERYSIPHE CICHORI ACEARUM* I *PSEUDOPERONOSPORA CUBENSIS* NA OGÓRKU

Przeprowadzono badania nad bioefektywnością azoksystrobiny (Amistar 25 SC) przeciwko mączniakowi rzekomemu i mączniakowi prawdziwemu ogórka. Badania wykonane w dwóch sezonach wegetacyjnych wykazały, że azoksystrobina efektywnie ograniczała rozwój tych chorób. Opryskiwanie roślin ogórka zróżnicowanymi dawkami azoksystrobiny (31,25; 62,50 i 125 g s.a./ha) wykazało, że dawka wynosząca 125 g s.a./ha (500 ml/ha) jest optymalną do zwalczania tych chorób. Stosując tę dawkę uzyskano najwyższy plon ogórków wynoszący 13,23 i 14,46 t/ha, odpowiednio w pierwszym i drugim sezonie prowadzenia badań. W żadnym z tych doświadczeń nie zaobserwowano fitotoksyczności azoksystrobiny, nawet przy zastosowaniu poczwórnej zalecanej dawki (4 x 125 g s.a./ha). Gdy stosowano dawki azoksystrobiny wynoszące 250 i 500 g s.a./ha, wykrywano ją w ogórkach w okresie do 7 dni po ostatnim zabiegu opryskiwania. Jednak gdy stosowano dawki 31,25; 62,50 i 125 g s.a./ha, wykrywano ją w ogórkach w okresie od 3 do 5 dni po ostatnim zabiegu. Przy zastosowaniu dawki 125 g s.a./ha bezpieczny okres prewencji wynosił w pierwszym doświadczeniu polowym 1, 53 dni, natomiast w drugim doświadczeniu 2, 37 dni. W zebranych ogórkach poziom pozostałości azoksystrobiny był niższy od poziomu jej wykrywalności.