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Sensitivity of *Fusarium oxsporum* Isolates Collected from Strawberry Roots to QoI Fungicides Azoxystrobin and Trifloxystrobin

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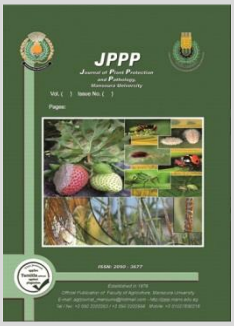

ABSTRACT

Egypt is among the top five countries in strawberry production and leads the Arab world in both production and exportation. More than five thousand hectares of land in Egypt are used to grow strawberries. Fusarium wilt in strawberries caused by *Fusarium oxysporum* can severely decrease production. The essential strategy to control the disease is the application of protective fungicides. Recently, the fungicides commonly used to control the disease lost their efficiency due to the emergency of resistant populations. The current study aims to detect resistance frequency to QoI fungicides azoxystrobin and trifloxystrobin in addition to finding an appropriate control strategy. 113 *F. oxysporum* isolates were collected from four main strawberry-producing governorates (Beheira, Ismailia, Dakahlia and Qalyubia) and subjected to bioassay assessment. The results showed that among 113 isolates collected, only 42 (37.2%) isolates were resistant to azoxystrobin while 36 (31.9%) isolates were resistant to trifloxystrobin. EC_{50} of azoxystrobin and trifloxystrobin were determined for a set of sensitive and resistant isolates using the mycelial growth inhibition technique. The EC_{50} mean value for azoxystrobin-sensitive isolates was 0.0209 µg/ml while, the EC_{50} mean value for azoxystrobin-resistant isolates was 0.4544 µg/ml. For trifloxystrobin, the EC_{50} mean value for sensitive isolates was 0.0174 µg/ml, while the EC_{50} mean value for resistant isolates was 0.2232 µg/ml. The combination of tebuconazole 50% and trifloxystrobin 25% tested with two concentrations 10 and 100 µg/ml showed high ability in the management of azoxystrobin and trifloxystrobin-resistant isolates and exhibited 100% mycelial growth inhibition.

Keywords: *Fusarium oxysporum*, Strawberry, QoI fungicides, Fungicide Resistance, Azoxystrobin

INTRODUCTION

The rose family (Rosaceae) includes many economically important crops such as strawberries which considered one of the most economically significant crops worldwide (Chandler *et al* 2012). Egypt is the fourth-largest producer of strawberries in the world and ranked first among the Arab countries (Eissa 2015). Strawberry root rot is a serious disease in Egypt that can significantly reduce crop yields (El-Shemy *et al* 2013).

In Egypt, common fungi such as *Fusarium spp, Botrytis cinerea, Alternaria spp, Aspergillus spp, Rhizoctonia solani, Phytophthora cactorum, Sclerotinia sclerotiorum, Penicillium spp. and Rhizopus stolonifera* infect strawberry plants and numbers of them can cause root rots (Tarek 2004 and Aye and Matsumoto 2011). The main crops cultivated on older grounds in the Nile Valley are not in competition with this crop, because it is grown on a variety of soils, including recently reclaimed sites. Egypt export earnings increased from 188,52 thousand dollars in 2000 to roughly 73.77 million dollars in 2018 (Shehata *et al* 2020). Quinone outside inhibitors (QoIs) registered in Egypt by many active ingredients such as azoxystrobin, pyraclostrobin, kresoxim-methyl, and trifloxystrobin. Resistance management is indicated by the Fungicide Resistance Action Committee (FRAC) in Europe. The application of QoI fungicides is recommended to prevent or delay the emergence of resistant fungal populations in Egypt. The QoI fungicides prevent plant pathogens by blocking the pathogen's ability to produce energy by blocking the transfer of electrons at the **Q**uinone "**o**utside" site of the bc1 complex (complex III in the electron transport chain). The QoIs are effective against a wide variety of plant diseases, including members of the ascomycetes, basidiomycetes, and oomycetes, three major genera of plant pathogens. Many species of fusarium developed resistance to QoI fungicides Such as *F. fujikuroi* and *F. graminearum*. Andrade *et al* (2022) observed that 28.05% of *F. graminearum* isolates collected from Rio Grande (doSul) RS and 50.01% of those collected from Paraná (PR) were less susceptible to azoxystrobin. Also, resistance to trifloxystrobin was detected in many phytopathogenic fungi, Mondino *et al* 2015 mentioned that 3% to 95% of *Venturia inaequalis* isolates were resistant to trifloxystrobin. Weber (2011) indicated that 76.8% of *Botrytis cinerea* isolates tested were highly resistant to trifloxystrobin. Using fungicide mixtures (the combination of two or more fungicides) considered one of the most common strategies for controlling the pathogen (Ballu *et al* 2021). Both empirical and modeling study results have shown the effectiveness of such methods for preventing or delaying the appearance of resistance and maintaining disease control (Brent and Hollomon 2007, Hobbelen *et al* 2011and van *et al* 2014). In addition, resistance management is indicated by the Fungicide Resistance Action Committee (FRAC) (Anonymous, 2022). The current study's objectives are to detect the frequency of azoxystrobin and trifloxystrobin resistance in *F. oxysporum* isolates obtained from selected Egyptian governorates. To determine the EC_{50} values for the resistant and sensitive isolates. Finally, to explore the effectiveness of certain fungicide mixtures as a fungicide resistance management strategy.

MATERIALS AND METHODS

Isolation and identification: -

In this study, 113 *Fusarium oxysporum* isolates were obtained in 2021 from four governorates in Egypt. The selected

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governorates were Ismailia, Beheira, Dakahlia, and Qaluobia. The samples were taken from diseased strawberry plants that had symptoms of root rot. The diseased roots were cleaned, and surface sterilized for three minutes in a solution of 1% sodium hypochlorite, washed numerous times in sterilized distilled water, and then dried between two sterilized filter papers. Wet blotter-coated plates were aseptically used to transfer the sterilized root fragments. For seven days, plates were incubated at 25 °C. Fungal colonies similar to those of *Fusarium oxysporum* were sub cultured onto new PDA plates. Using the hyphal tip technique, each isolated fungus was purified (Hawker,1956). The isolated fungi were identified based on their cultural and morphological characteristics as described by Leslie and Summerell (2008) in the Mycological Research and Plant Disease Survey Department, Plant Pathology Research Institute, A.R.C., Giza, Cairo, Egypt

Table 1. shows Fungicides and Fungicides mixtures used in the present study. Name, active ingredient percentage and sources of samples are given in table

Fungicide or mixtures	Active ingredient	manufacturer
Azoxystrobin	50% technical grade	Shanghai Heben-Eastsun Medicaments Co. Ltd. -china
Trifloxystrobin	96% technical grade	Hefei Yifeng Chemical Industry Co., Ltd. -china
Nativo	75%WG (trifloxystrobin 25 % + teubaconazole 50 %)	Bayer AG German
Destruwwr	32.5 % SC (difenoconazole12.5% + azoxystrobin 20%)	Jiangsu Lanfeng Biochemical Co., Ltd. -china
Flins	56% sc (chlorothalonil50%+azoxystrobin6%)	shandong Heyi Biological Technology Co., Ltd.-china

Detection of fungicide resistance: -

In this experiment, discriminatory concentrations (concentration that fully inhibits mycelial growth of the sensitive isolates) of azoxystrobin and trifloxystrobin were prepared. The appropriate amount of each fungicide was dissolved in pure acetone to produce a stock solution 100 mg/ml. The discriminatory concentration 1 μg/ml of both fungicides was prepared and used to distinguish between resistant isolates and sensitive ones. Mycelial plugs (five mm in diameter) were cut with a cork borer from the margin of a3-day-old colony of each isolate and placed upside down into the media that amended with the fungicide. The resistant isolate could grow on the modified media. While the sensitive isolates could not grow on the modified medium.

Sensitivity of *Fusarium oxysporum* to fungicides: -

The sensitivity to azoxystrobin was determined by the (EC_{50}) values for 18 $azoxy^R$ and 17 $azoxy^S$ isolates. To test resistant and sensitive isolates, technical grade azoxystrobin (50% active ingredient [a.i.]) was dissolved in 100% acetone, adjusted to a concentration of 100 mg/ml, and added to PDA to produce final concentrations at (0, 0.1, 0.5, 1, 5 and 10 μg/ml) and at (0, 0.001, 0.005, 0.01, 0.05 and 0.075 μg/ml) to test resistant and sensitive isolates, respectively.

Similarly, the sensitivity to trifloxystrobin was determined by evaluating the (EC_{50}) values for 9 $trifloxy^R$ and 11$trifloxy^S$ isolates that were tested in the experiment. Technical grade trifloxystrobin (96% active ingredient [a.i.] was dissolved in 100% acetone, adjusted to a concentration of 100 mg/ml, and added to PDA to produce final concentrations at (0, 0.01, 0.05, 0.1, 0.5, 1 and 5 μg/ml) and (0, 0.001, 0.01, 0.025, 0.05 and 0.075 μg/ml) to test resistant and sensitive isolates, respectively.

Assessment of fungicides mixtures efficacy in controlling resistant isolates: -

The efficacy of three different commercial fungicide mixtures was investigated against *F. oxysporum* by poisoned food technique. The mixtures tested were Destruwwr mixture 32.5 % SC (difenoconazole 12.5 % + azoxystrobin 20%), Flins mixture56%sc (chlorothalonil50%+azoxystrobin6%) and Nativo mixture 75%WG (trifloxystrobin 25 % +tebuconazole 50%). Appropriate amounts of each mixture were dissolved in sterilized distilled water to produce a stock solution of 100mg/ml. Final concentrations 10 and 100 μg/ml were prepared in PDA medium and added to sterilized petri dishes. Each dish was inoculated in the centre with a mycelial disc (5-mm diameter) of *F. oxysporum*. The plates were incubated at (25°C) and the inculated plates untreated controls were used for comparison. Isolates that were able to grow on the amended PDA were designated as resistant isolates and the unable to grow designated as sensitive.

RESULTS AND DISCUSSION

Qualitative Fungicide Sensitivity Assay at Discriminatory Concentrations: -

The present sampling strategy resulted in 113 isolates from the four investigated governorates. The discriminatory concentration of 1μg/ml of azoxystrobin or trifloxystrobin allowed to identify the resistant and sensitive strains. From the screened isolates, 42(37.2%) isolates were resistant to azoxystrobin fungicide as they were able to grow on media amended with discriminatory concentration, while 71(62.8%) isolates were sensitive as they were unable to grow. The frequency distribution of resistant and sensitive isolates to the Qoi fungicide azoxystrobin (table2) indicated that 34.61% (nine out of 26) resistant isolates were detected in population of Beheria, 7.1% (one out of 14) in Ismailia, 52.17% (12 out of 23) in Qalyubia and 40.00% (20 out of 50) in Dakahlia. The present results are in harmony with those of Andrade *et al* (2022) who studied the response of 225 *F. graminearum* isolates obtained from two states in southern Brazil to azoxystrobin and the results showed that 28.05% and 50.01% of *Fusarium graminearum* isolates collected from Rio Grande (doSul) RS and Paraná (PR) were less susceptible, respectively. Furthermore, the above-mentioned results clearly showed that the highest percentages of azoxystrobin-resistant isolates were detected in Dakahlia governorate, while the lowest was detected in Ismailia. This variation between governorates could be attributed to a high selection pressure that occurred as a result of using the fungicide extensively in the Dakahlia control programme.

Table 2. Information about the sensitivity against azoxystrobin of 113 Fusarium oxysporum isolates collected from strawberry fields in Egypt.

Location	Year of collection	No. of isolates	No and (%) $azoxy^S$	No and (%) $azoxy^R$
Beheria	2021	26	17 (65.34)	9 (34.61)
Ismailia	2021	14	13 (92.85)	1(7.1)
Qalyubia	2021	23	11 (47.82)	12 (52.17)
Dakahlia	2021	50	30 (60.00)	20 (40.00)
Total		113	71 (62.8)	42 (37.2)

azoxyS = sensitive to azoxystrobin azoxyR = resistant to azoxystrobin

As for trifloxystrobin, among the 113 isolates that were collected during this study, 36 (31.9%) could grow in media that had been modified with a discriminatory concentration of 1 μg/ml, whereas 77 (68.1%) were sensitive to the fungicide. The frequency distribution of resistant and sensitive isolates (table 3) indicated that 26.9, 0, 52.2 and 34% of the isolates showed resistance in Beheira, Ismailia, Qalyubia and Dakahlia governorates, respectively. According to the earlier findings, it was clear that Qalyubia governorate had the highest percentage of trifloxystrobin-resistant isolates, whereas Ismailia governorate had the lowest percentage. This can be attributed to the high selection pressure that resulted from the extensive use of the fungicide in the control strategies in the Qalyubia governorate. Resistance to trifloxystrobin ranged between 0-52.2 % in the current study similar results found in different pathogens such as *Venturia inaequalis* where the incidences of trifloxystrobin resistance ranged from 3% to 95% (Mondino *et al* 2015). Moreover, 353 *Botrytis cinerea* isolates, collected from twenty-three Northern German fields (highbush blueberry, strawberry, redcurrant and raspberry) and tested for sensitivity to trifloxystrobin and the results illustrated that 76.8% of the tested isolates were highly resistant Weber (2011). Moreover, Weber and Entrop (2017) determined the sensitivity of 323 *Botrytis cinerea* isolates obtained from visible cane lesions in twenty-two batches of long-cane raspberries. The results showed that most isolates (87.3 %) were resistant to trifloxystrobin

Table 3. Information about the sensitivity against trifloxystrobin of 113 Fusarium oxysporum isolates collected from strawberries fields in Egypt.

Location	Year of collection	No. of isolates	Noand (%)	
			tri^S	tri^R
Beheria	2021	26	19 (73.07)	7 (26.92)
Ismailia	2021	14	14 (100)	0 (0.00)
Qalyubia	2021	23	11 (47.82)	12 (52.17)
Dakahlia	2021	50	33 (66)	17 (34.00)
Total		113	77 (68.1)	36 (31.9)

triS = sensitive to trifloxystrobin triR = resistant to trifloxystrobin

Determination of EC_{50} of *F.oxysporum* sensitive and resistant isolates to azoxystrobin.

17 $azoxy^S$ and 18 $azoxy^R$ isolates obtained in the study, randomly selected, were used to determine the EC_{50}'s for azoxystrobin sensitive and resistant isolates using mycelial growth inhibition assay. The EC_{50} values of azoxystrobin-sensitive isolates ranged from 0.001 to >0.03 µg/ml with a mean of 0.0209 µg/ml and the highest values EC_{50} of isolates (70.6%) ranged from 0.01 to 0.0299µg/ml (Fig 1). The EC_{50} values of azoxystrobin-resistant isolates (Fig 1) ranged from 0.01 to > 1 µg/ml with a mean of 0.4544 µg/ml. and the highest values EC_{50} of isolates (61.1%) ranged from 0.1 to 0.99 µg/ml. RF (Resistance Factor) values for resistant isolates differed among the isolates and ranged between 2.87 to 101.84 (table 4). the current results agreed with previous studies of Avozani *et al* (2014a) who determined the inhibitory concentration of 50% (IC_{50}) for conidial germination and the IC_{50} for azoxystrobin was 0.21mg/L. Song *et al* (2022) studied the baseline sensitivity of *F. fujikuroi* to azoxystrobin (AZO). The activity of AZO against the 100 *F. fujikuroi* isolates was strong with EC_{50} values of 0.822 ± 0.285. Duan *et al* (2020) tested the sensitivity of thirty-two *F. graminearum* and *F. asiaticum* strains to six QoIs and the EC_{50} value of azoxystrobin ranged from 0.2739 to 1.2403 µg mL^{-1}. Amini and Sidovich (2010) tested azoxystrobin *in vitro*. The median effective concentration (EC_{50}) value of azoxystrobin was 1.56 µg/ml and the average of (EC_{50}) values of azoxystrobin was 0.4µg/ml. In contrast, Sameer (2018) calculated the EC_{50} values of certain fungicides and azoxystrobin had a moderate value of 17.38 µg /ml.

Table 4. Sensitivity EC50's of Fusarium oxysporum isolates collected from strawberry rot roots to azoxystrobin

Azoxystrobin EC_{50}				
Sensitive		Resistant		
Isolate	EC50	Isolate	EC50	RF
H27	0.0044±0.0001	B21	0.0602±0.0006	2.87
E4	0.0181±0.0005	D56	0.4581±0.0007	21.88
H26	0.0265±0.0003	D27	0.08±0.0378	3.82
D43	0.0156±0.0006	H19	0.1361±0.0001	6.50
H23	0.0268±0.0003	B25	0.0904±0.0003	4.32
E1	0.0188±0.0002	D41	1.3348±0.0003	63.74
H10	0.014±0.0062	D21	2.1327±0.0001	101.84
D2	0.0303±0.0004	D18	0.1259±0.0005	6.01
E7	0.0073±0.0006	D32	0.3065±0.0002	14.64
E2	0.0166±0.0002	D20	0.1623±0.0006	7.75
D42	0.0292±0.0002	D39	0.1921±0.0002	9.17
B13	0.0151±0.0001	D40	0.2248±0.0001	10.73
B29	0.0317±0.0006	B17	0.1751±0.0001	8.36
D10	0.0177±0.0003	D3	0.2284±0.0002	10.91
H4	0.0143±0.0001	H8	0.4497±0.0003	21.47
E6	0.0446±0.0001	H1	1.7214±0.0003	82.20
H9	0.025±0.0001	H22	0.0979±0.0001	4.68
		H2	0.2035±0.0003	9.72

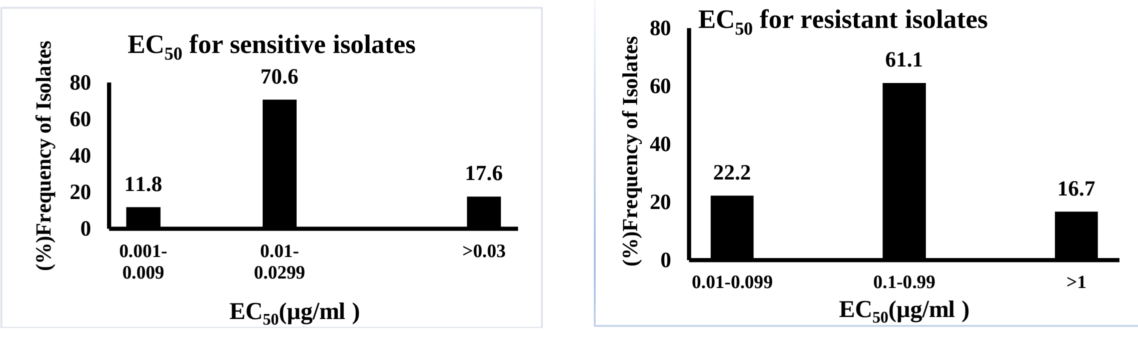


Fig. 1. Frequency distribution of effective concentration (EC_{50}) of azoxystrobin to inhibit 50% of mycelial growth.

Determination of EC50 of *f.oxysporum* sensitive and resistant isolates to trifloxystrobin

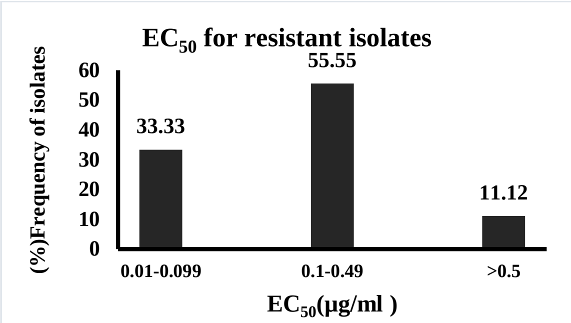
To determine the sensitivity of *F.oxysporum* sensitive and resistant isolates to trifloxystrobin 11 tri^S and 9 tri^R isolates were randomly selected and tested using mycelial growth inhibition assay. The EC_{50} values of trifloxystrobin-sensitive isolates ranged from 0.001 to > 0.03 µg/ml with a mean of 0.0174 µg/ml and the highest values EC_{50} of isolates (63.6%) ranged from 0.01 to 0.029 µg/ml. While, the EC_{50} values for resistant isolates ranged between 0.01 to >0.5 µg/ml with a mean of 0.2232 µg/ml. and the highest values EC_{50} of isolates (55.55%) ranged from 0.1 to 0.49µg/ml (Fig 2). RF (Resistance Factor) values for resistant isolates differed among the isolates and ranged between 3.68 to 45.99(Table 5). In harmony with our results, Avozani *et al* (2014b) evaluated the EC_{50} of trifloxystrobin (QoI fungicide) against *Fusarium graminearum* isolates collected from wheat kernel.

Table 5. Sensitivity of *Fusarium oxysporum* isolates collected from strawberry roots to trifloxystrobin.

Trifloxystrobin EC_{50}				
Sensitive		Resistant		
Isolate	EC50	Isolate	EC50	RF
H9	0.0323±0.0001	H8	0.3428±0.0002	19.67
H5	0.0188±0.0004	D4	0.224±0.001	12.85
D43	0.0041±0.0004	B1	0.0641±0.0003	3.68
D10	0.0201±0.0003	B27	0.1073±0.0003	6.16
D20	0.029±0.001	H1	0.8016±0.0004	45.99
B11	0.0061±0.0003	B21	0.0912±0.0001	5.23
B29	0.029±0.0041	B2	0.1037±0.0003	5.95
H27	0.014±0.001	B25	0.0957±0.0002	5.49
D50	0.0068±0.0003	D41	0.1784±0.0005	10.24
B13	0.0139±0.0001			
D31	0.0177±0.0004			

The results showed that the IC_{50} value was 0.28 mg/L. moreover, Avozani *et al* (2014a) determined (IC_{50}) for trifloxystrobin against *Fusarium graminearum* isolates collected from different crops. They reported that the IC_{50} was 1.33 mg/L.

To get the EC50 value for each isolate, the Hangzhou Reifeng Information Technology Ltd., Hangzhou, China-developed Data Processing System (DPS) program was utilized. For each isolate, the average of the EC50 values from the two trials was used in the data analysis because there was no significant difference (P>0.05) between both experiments (Hamada *et al* 2011).



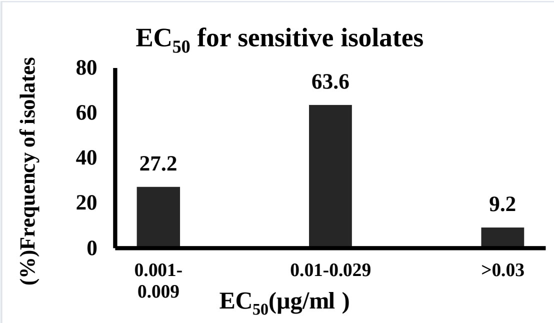


Fig. 2. EC_{50} of *Fusarium oxysporum*-resistant and sensitive isolates which tested by using trifloxystrobin fungicide.

The efficiency of some mixture of fungicides in controlling some resistant isolates: -

(Table 6) shows mycelia growth inhibition percentages resulted from using different mixtures of Qoi fungicides. The combination of tebuconazole 50% and trifloxystrobin 25% showed high ability in management of azoxystrobin and trifloxystrobin-resistant isolates where mycelial growth inhibition reach 100% when it was tested with two concentrations of 10 and 100 µg/ml.

Table 6. Mycelial growth inhibition percentages resulted from using different mixtures to control Qoi resistant isolates.

Name of the isolates	AZO	Tri	Fungicide mixtures: Destruwwr (azo+dif)		Flins (chlor+azo)		Nativo (tri+tubac)	
	Concentrations (µg/ml)							
	1	1	10	100	10	100	10	100
B15	21.36	36.18	52.99	71.41	57.21	81.71	100	100
B27	16.80	31.54	49.57	69.37	55.50	77.24	100	100
H1	20.21	28.96	44.99	65.78	52.10	71.41	100	100
H15	15.60	26.52	43.02	61.22	51.25	75.30	100	100
D39	22.50	24.64	38.05	60.40	52.12	72.83	100	100

Chlor: chlorothalonil, azo: azoxystrobin, dif: difenoconazole, tri: trifloxystrobin, tubac: tebuconazole

In other hand, both mixtures containing (difenoconazole+azoxystrobin) and a mixture containing (chlorothalonil +azoxystrobin), showed low ability. The results observed in this study were in harmony with the previous reports of Patón *et al* (2017) who evaluated three commercial fungicides from different chemical groups for their ability to suppress the mycelial growth of *F. proliferatum* in vitro. The mixture of tebuconazole 50 % + trifloxystrobin 50 % was highly effective in reducing the mycelial development of *F. proliferatum*. Similarly, Ponnusamy et al (2021) showed the efficacy of several fungicides against Fusarium wilt of carnation in vitro. Among the fungicides, tebuconazole 50% + trifloxystrobin 25% WG and azoxystrobin 23% EC completely inhibited (100% inhibition) the mycelial growth of the fungus in vitro therefore suggestion was made to use the mixture of fungicide tebuconazole 50% + trifloxystrobin 25% WG for controlling the wilt disease in carnation. Also, Shankar et al (2016) evaluated the efficiency of several fungicides against the most virulent *Fusarium oxysporum f.sp. ricini* isolates *in vitro* using the poisoned food method. Among these fungicides tebuconazole + trifloxystrobin inhibited the fungal growth at 50 ppm. According to the above mentioned results one may suggest that quinone outside inhibitor fungicides with fungicides from other mode of action can be used as a strategic approach in fungicide resistance management when resistance to QoI's has been detected.

CONCLUSION AND RECOMMENDATION

Extensive usage of QOI fungicides to control fusarium root rot in strawberry caused by *Fusarium oxysporum* led to development of resistant populations. High frequencies of resistance to QOI fungicides trifloxystrobin and azoxystrobin were detected in the most of the governorates tested. 37.2% of the total isolates collected were resistant to azoxystrobin while, 31.9% of the total isolates were resistant to trifloxystrobin. In the current study, the Nativo mixture 75%WG (trifloxystrobin 25 % + teubaconazole 50 %) was the most effective fungicide mixture tested against the resistant *F.oxysporum* isolates.

REFERENCES

Amini, J., and Sidovich, D. (2010). The effects of fungicides on *Fusarium oxysporum f. sp. lycopersici* associated with Fusarium wilt of tomato. Journal of plant protection research 50: 172–178.

Andrade, S. M., Augusti, G. R., Paiva, G. F., Feksa, H. R., Tessmann, D. J., Machado, F. J., ... and Del Ponte, E. M. (2022). Phenotypic and molecular characterization of the resistance to azoxystrobin and pyraclostrobin in *Fusarium graminearum* populations from Brazil. Plant Pathology, 71(5):1152-1163.

Anonymous, FRAC Code List (2022): Fungal control agents sorted by cross resistance pattern and mode of action (including coding for FRAC Groups on product labels).

Avozani, A., Reis, E. M., and Tonin, R. B. (2014b). In vitro sensitivity reduction of *Fusarium graminearum* to DMI and QoI fungicides. Summa Phytopathologica, 40: 358-364.

Avozani, A., Tonin, R. B., Reis, E. M., Camera, J., and Ranzi, C. (2014a). In vitro sensitivity of *Fusarium graminearum* isolates to fungicides. Summa Phytopathologica, 40:231-247.

Aye, S. S. and Matsumoto, M. (2011). Effect of some plant extract on *Rhizoctonia ssp*. And *Sclerotium hydrophilum*. J. of Medicinal Plants Res. Vol. 5(16): pp. 3751-3757

Ballu, A., Deredec, A., Walker, A. S., and Carpentier, F. (2021). Are efficient-dose mixtures a solution to reduce fungicide load and delay evolution of resistance? An experimental evolutionary approach. Microorganisms, 9(11): 2324.

Brent, K.J. and Hollomon, D.W. (2007) Fungicide Resistance in Crop Pathogens: How Can It Be Managed? FRAC Monograph; GIFAP: Brussels, Belgium; ISBN 90-72398-07-6.

Chandler, C. K., Folta, K., Dale, A., Whitaker, V. M., and Herrington, M. (2012). Strawberry. Fruit breeding: 305-325.

Duan, Y., Lu, F., Zhou, Z., Zhao, H., Zhang, J., Mao, Y., ... and Zhou, M. (2020). Quinone outside inhibitors affect DON biosynthesis, mitochondrial structure and toxisome formation in *Fusarium graminearum*. Journal of Hazardous Materials, 398:122908.

Eissa M.F. and Abd-Elgawad M.M. (2015) Nematophagous bacteria as biocontrol agents of phytonematodes. In: Askary TH, Martinelli PRP (eds) Biocontrol agents of phytonematodes. CAB International, Wallingford, pp 217–243

El-Shemy AA, Khafagy YS and Al-Genteery AMM (2013) Cultivation and production of strawberry. Techn issue no. 9/2013, General Directorate of Agricultural Culture, Egyptian Ministry of agriculture, Giza, 135 p. (in Arabic).

Hamada, M.; Yin, Y. and Zhonghua, M. (2011) Sensitivity to iprodione, difenoconazole and fludioxonil of *Rhizoctonia cerealis* isolates collected from wheat in China. Crop Protec., 30: 1028-1033.

Hawker, L.E. (1956). Physiology of Fungi. Univ. of London Press, Ltd, War-Witch Square, London, 452 pp.

Hobbelen, P.H.F.; Paveley, N.D. and van den Bosch, F. (2011) Delaying Selection for Fungicide Insensitivity by Mixing Fungicides at a Low and High Risk of Resistance Development: A Modeling Analysis. Phytopathology 101: 1224–1233.

Leslie, J. F., & Summerell, B. A. (2008). The Fusarium laboratory manual. 388 pp John Wiley & Sons.

Mondino, P., Casanova, L., Celio, A., Bentancur, O., Leoni, C., and Alaniz, S. (2015). Sensitivity of *V. Inaequalis* to trifloxystrobin and difenoconazole in uruguay. J. Phytopathol. 163: 1–10. doi: 10.1111/jph.12274.

Patón, L. G., Marrero, M. D. R., and Llamas, D. P. (2017). In vitro and field efficacy of three fungicides against *Fusarium bulb* rot of garlic. European Journal of Plant Pathology, 148:321-328.

Ponnusamy, R., Pasuvaraji, A., Suppaiah, R., and Sundaresan, S. (2021). Molecular characterization of *Fusarium oxysporum* f. sp. dianthi and evaluation of fungicides against Fusarium wilt of carnation under protected cultivation. Indian Journal of Experimental Biology (IJEB), 59(11):770-775.

Sameer, W. M. (2018). Control of the root rot diseases of wheat using fungicides alone and in combinations with selenium. Al-Azhar Bulletin of Science, 29(2-C):27-37.

Shankar, V. G., Priya, M. N., and Shanker, A. S. (2016). In vitro evaluation of fungicides and bio-control agents against *Fusarium oxysporum f. Sp. ricini*. Progressive Research Journal. 11: 4775-4779.

Shehata, H., Soliman, M. A., and Ewis, D. M. (2020). An Analytical Study of Strawberry Crop in Egypt. Assiut J. Agric. Sci., 51 (3) :115-126

Song, Y., Chen, X., Sun, J., Bai, Y., Jin, L., Lin, Y., ... and Chen, Y. (2022). In Vitro Determination of Sensitivity of *Fusarium fujikuroi* to Fungicide Azoxystrobin and Investigation of Resistance Mechanism. Journal of Agricultural and Food Chemistry, 70(31):9760-9768.

Tarek, S.S.S. (2004). Integrated control for minimizing post-harvest diseases of strawberry. MSc. Thesis, Fac. of Agric., Ain Shams Univ. 165pp.

Van den Bosch, F.; Oliver, R.; van den Berg, F. and Paveley, N (2014) Governing Principles Can Guide Fungicide-Resistance Management Tactics. Annu. Rev. Phytopathol., 52:175–195.

Weber, R. W. (2011). Resistance of *Botrytis cinerea* to multiple fungicides in Northern German small-fruit production. Plant Disease, 95(10):1263-1269.

Weber, R. W., and Entrop, A. P. (2017). Recovery of Botrytis strains with multiple fungicide resistance from raspberry nursery plants. European Journal of Plant Pathology, 147(4): 933-936.

حساسية عزلات الفيوزاريوم اوكسسبوريوم التي تم تجميعها من الفراولة لمبيدات من مجموعه الQOI (الازوكسي استروبين والتراي فلوكسي استروبين)

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الملخص

تعد مصر من بين الدول الخمسة الاولي عالميا في إنتاج الفراولة وتتصدر الدول العربية في كل من الإنتاج والتصدير.5245هكتار من الأراضي في مصر تستخدم لزراعه الفراولة. يعتبر فطر الفيوزاريوم أحد الفطريات التي تسبب اعفان الجذور في الفراولة ويؤدي الي تقليل الإنتاج بشده. الاستراتيجية الأساسية لمكافحه الامراض الفطريه هي تطبيق المبيدات الفطريه الوقائيه لكن في الاونه الاخيره فقدت معظم مبيدات الفطريات المستخدمه قدرتها في السيطره على الامراض بسبب ظهور السلالات المقاومه. في هذه الدراسه تم عزل والتعرف على 113 عزله لفطر الفيوزاريوم اوكسسبوريوم حيث تم تجميعها من 4 محافظات في مصر وهي الدقهليه، الإسماعيلية، البحيره والقليوبيه. في هذه الدراسه تم استخدام عدد من مبيدات ال QoI لاختبار كفائتها ضد عزلات الفيوزاريوم.واوضحت النتائج ان37.2%من العزلات مقاومه للازوكسي استروبين و31.9%من العزلات مقاومه للتراي فلوكسي استروبين .تم اختيار عدد من العزلات الحساسه والمقاومه لكلا من المبيدان لتقدير قيمه ال EC_{50}ومعرفه مستوي المقاومه باستخدام طريقه تثبيط النمو الميسليومي .فكان متوسط قيمه ال EC_{50}للعزلات الحساسه للازوكسي استروبين 0.0209وللعزلات المقاومه 0.4544 بينما للتراي فلوكسي استروبين فكان متوسط قيمه ال EC_{50} للعزلات الحساسة للتراي فلوكسي استروبين0.0174بينما للعزلات المقاومه 0.2232.يعتبر استخدام مخاليط المبيدات احد الاستراتيجيات للحد من ظهور وتطور ظاهره المقاومه.حيث تم اختبار عدد من المخاليط واثبت مخلوط Nativo الذي يتكون من (التراي فلوكسي استروبين +والتيوباكونازول) كفاءه عاليه في السيطره علي العزلاتت المقاومه.