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Custodia, an effective new molecule fungicide for the management of downy mildew and powdery mildew of grape

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Abstract

The new molecule Azoxystrobin 11% + Tebuconazole 18.3% W/W SC (Custodia) was assessed for its bioefficacy against downy and powdery mildew separately and in large scale investigation against both from 2017-18 and 2018-2019 at Regional Agricultural Research Station, Bijapur, Karnataka, India and grape grower's gardens of Northern Karnataka. The results revealed that, the new fungicide molecule Azoxystrobin 11% + Tebuconazole 18.3% W/W SC (Custodia) @ 1.5 ml/l was equally effective in per se performance as compared to recommended popular check fungicides Metalaxyl MZ-6+64 WP @ 2.5 g/l and Triadimefon 25% WP @ 1 g/l in reducing the severity of both downy mildew and powdery mildew of grape. The results of 2017-18 and 2018-2019 against downy mildew revealed mean severity of 13.1 Percent Disease Index (PDI) with Custodia @ 1.5 ml/l was superior to severity of Metalaxyl MZ-72-WP @ 2.5 g/l (PDI 24.8) and significantly superior over untreated check (PDI 52.9). The pooled results of 2017-18 & 2018-18 against powdery mildew indicated severity of 11.90 PDI with Custodia @ 1.5 ml/l was on par with Triadimefon @ 1 g/liter (PDI 9.99) and significantly lower than untreated check (PDI 79.73). In the large scale field trails in Farmer's fields during 2019 targeting both the mildews revealed downy mildew severity of 10.13 PDI and powdery mildew severity of 11.48 PDI with Custodia @ 1.5 ml/l and found on par with severities noticed with Metalaxyl 6% MZ-64 WP @ 2.5 g/liter + Triadimefon @ 1 g/liter. The untreated checks recorded higher mildews severities (PDI 70.38 of downy mildew & 84.47 of powdery mildew). Application of Custodia @ 1.5 ml/l for mildews management also significantly influenced grape yields in both micro plot and large scale experimentation and found on par with present recommendation of Metalaxyl 6% + MZ 64% WP @ 2.5 g/l and Triadimefon @ 1 g/l. The economics of mildews management showed higher net income in Custodia @ 1.5 ml/l (Rs. 4,05,000) with C:B ratio of 1:2.76 as compared to positive checks Metalaxyl (Rs. 3,19,000) and Triadimefon (Rs. 3,97,275) with C:B ratio of 1:2.27 and 1:2.73 respectively. There were no phytotoxic effects such as leaf epinasty, hyponasty and wilting etc even at higher concentrations of Custodia @ 6 ml/l. The present investigations revealed that Custodia @ 1.5 ml/l as an effective fungicide for the management of both downy mildew and powdery mildew of grape. In the events of higher disease pressure, the new product can effectively be employed in the management of mildews in grape ecosystem and in future to tackle the development of resistance by pathogen to conventional molecules.

Keywords: Azoxystrobin, grapes, management, powdery mildew, downy mildew

Introduction

Grape is an important fruit crop grown in India and liked by all classes of people. The crop is subjected to several diseases among those the diseases such as downy mildew, powdery mildew and anthracnose have become major management targets in the country. Downy mildew and powdery mildew are highly destructive diseases on cultivated grapevine and occur worldwide (Pearson and Goheen 1988) [5]. These two diseases cause considerable quantitative and qualitative losses of fruits if proper management practices are not taken in time. Presently fungicides are playing a major role in managing both the diseases and there is no single molecule effective against both downy mildew and powdery mildew diseases. Hence, management option always includes searching for new molecules. In recent times several of the new fungicides belonging to triazole group have been introduced in India to manage diseases of some fruits and vegetables like apple scab and downy mildew (Gajbhiye *et al.* 1995) [1]. Strobilus groups have been introduced with their eco-friendly and broad spectrum nature and to tackle problem of resistance development by the target pathogens. In Karnataka increasing area under grape cultivation has lead to multifold dynamism in horticultural system. The diseases like downy mildew, powdery mildew and anthracnose have become major management targets in this area. These diseases are often influenced by weather conditions.

The downy mildew caused by *Plasmopara viticola* (Schw.) Burr.) is often influenced by mean temperature as well as humid weather period in Northern Karnataka (Shamarao Jahagirdar *et al.*, 2001) [2]. Hence, management option always includes searching for new molecules. Thus, the present study was taken up to assess the performance of new molecule Custodia against mildews of grape.

Material and Methods

The present field investigations were conducted at Regional Agricultural Research Station Bijapur, Karnataka, India and grape grower’s gardens of Northern Karnataka during 2017-18 to 2018-19 to assess the performance of Custodia @ 1.5 ml/l against downy and powdery mildew of grape. These field trials were conducted in 3 situations *viz.* 1. Targeted against downy mildew only. 2. Targeted against powdery mildew only 3.Targeted against both downy mildew and powdery mildew diseases.

Experimental Situation 1: Targeted against downy mildew only: The experiment was conducted during productive fore pruning periods (October to April) during 2017-18and 2018-19 to assess the efficacy of Custodia against downy mildew with following details.
Design: RBD, Age of the grape crop 8 years, Replications 3, Treatments 7,
Variety Thompson Seedless, Number of Vines /treatment 3, Spacing 2.4 x 1.8 m.
Spray solution used 500 l/ ha/ spray i.e. 215 ml/vine.

Experimental Situation 2: Targeted against powdery mildew only. The experiment was conducted during productive fore pruning period (October to April) during 2017-18 & 2018-19 with following details.
Design: RBD, Age of the grape crop 10 years, Replications 3, Treatments 7,
Variety Thompson Seedless, Number of Vines /treatment 3, Spacing 2.4 x 1.8 m.
Spray solution used 500 l/ ha/ spray i.e. 215 ml/vine.

Experimental Situation 3: Targeted against both downy mildew and powdery mildew: The experiment was conducted during productive fore pruning period (October to April) during 2017-18 & 2018-19 with following details.
Site: Grape gardens of farmers of Northern Karnataka.
Variety; Thompson Seedless. Each treatment plot size: 1000 sq.m.
In all the three situation, the first spray was given immediately after appearance of the disease/diseases followed by two sprays at 10 days interval. The observations on severity of diseases, yield and phytotoxic effect on grape were recorded and the economics of the each trial was also worked out.

Recording of powdery mildew and downy mildew severities on grape
The powdery mildew and downy mildew severities on grape was recorded by following 0 to 9 scale. Fifteen leaves per grape vine were observed for recording severities in the present study. The details of the scale are given below.

The details of the scale are given below.

Range value	Description
0	No disease symptoms on leaf
1	Powdery/downy mildews patches covering 1% or less of the leaf area
3	Typical powdery/downy mildews symptoms covering 1 to 10% of leaf area
5	Typical Powdery/downy mildews symptoms covering 11 to 25% of leaf area
7	Typical Powdery/downy mildews symptoms covering 26 to 50% of leaf area
9	Typical Powdery/downy mildews symptoms covering 51% or more of leaf area and yellowing, necrosis, dropping of leaves, symptoms on fruits.

Further, these scales were converted into severity (Percent Disease Index i.e. PDI) using the formula given by Wheeler (1969).

$$PDI = \frac{\text{Sum of numerical values}}{\text{Number of leaves observed}} \times \frac{100}{\text{Maximum disease rating Value}}$$

The original PDI values were transformed and subjected to

statistical analysis for drawing the conclusions.

Method of observations to record phytotoxicity of fungicides on grape
Two plants were selected at random from each treatment and the total number of leaves and those showing phytotoxicity were counted. The data collected were converted into percentage. The extent of phytotoxicity is recorded based on following score.

The extent of phytotoxicity is recorded based on following score

Score	Phytotoxicity (%)	Score	Phytotoxicity (%)
0	No phytotoxicity	6	41-50
1	0-10	7	61-70
3	11-20	8	71-80
4	21-30	9	81-90
5	31-40	10	91-100

Results and Discussion

The results on bio-efficacy of Custodia (Azoxystrobin 11% + Tebuconazole 18.3% W/W SC) against downy mildew and grape yield are presented in table 1. The pooled results of the two years 2017-18 and 2018-19 for downy mildew

management indicated that the minimum severity of 12.9 Percent Disease Index (PDI) was recorded with Custodia @ 2.0 ml/l and it was statistically on par with 13.1 PDI noticed with Custodia @ 1.5 ml/l and recommended check Azoxystrobin @ 1 ml/l 14.9 PDI and significantly superior

over check Metalaxyl MZ 68 WP @ 2.5 g/l (24.8 PDI). The maximum severity of 52.9 PDI was recorded with untreated check. The maximum grape yield of 36.0 t/ha was recorded with Custodia @ 2.0 ml/l, it was followed by Custodia @ 1.5 ml/l (34.2 t/ha) and Azoxystrobin @ 1ml/l (31.75 t/ha) and superior over Metalaxyl MZ 72WP (27.53 t/ha). The minimum yield 13.7 t/ha was recorded with untreated check. Similar trends were observed between the results of the two individual years 2017-18 and 2018-19 for reducing the severity of downy mildew of grape. The economics for the management of downy mildew through Custodia, Amistar and Metalaxyl are presented in table 2. The maximum net returns of Rs 4,52,000 / ha and highest C:B ratio of 1:2.95 were realized with Custodia @ 1.5 ml/l. Where as Rs 4,05,000 / ha and C:B ratio of 1:2.75 and Rs. 3,19,600 and CB ratio of 1:2.38 were noticed with the positive check Azoxystrobin 23 SC @ 1ml/l and Metalaxyl MZ 72 WP @ 2.5 g/l respectively. The results on bio-efficacy of Custodia against powdery mildew and grape yield are presented in table 3. The pooled results of the two years 2017-18 and 2018-19 for powdery mildew management indicated that the minimum severity of 8.41 PDI was recorded with Custodia @ 2.0 ml/l and it was statistically on par with 9.99 PDI noticed with recommended check Triadimefon @ 1 g/l and Custodia @ 1.5 ml/l (11.90 PDI). Further, the severity noticed with Custodia @ 1.5 ml/l was significantly lower than severities observed with Custodia @ 1.5 ml/l. The maximum severity of 79.73 PDI was recorded with untreated check. The highest grape yield of 32.29 t/ha was recorded with Custodia @ 2.0 ml/l and it was followed by 31.32 t/ha with Triadimefon @ 1 g/l and Custodia @ 1.5 ml/l (30.655 t/ha). The minimum yield 14.32 t/ha was recorded with untreated check. Similar trends were observed between the results of the two individual years 2017-18 and 2018-19 for reducing the severity of powdery mildew of grape as well as grape yields. The economics for the management of powdery mildew through Custodia @ 2.0 ml/l and Triadimefon are presented in table 4. The highest net amount of Rs 4,11,900 / ha and highest C:B ratio of 1:2.76 were realized with Custodia @ 2.0 ml/l. Whereas Rs 3,97,275 / ha and C:B ratio of 1:2.73 were noticed with the positive check Triadimefon 25 WP @ 1 gm per litre.

The results of effectiveness of Custodia @ 1.5 ml/l against

both the diseases and economics are presented in table 5. The minimum severity of 10.13 PDI of downy mildew, 11.48 PDI of powdery mildew with highest net returns of Rs. 4,51,250 /ha and maximum C:B ratio of 1:2.29 were observed with Custodia @ 1.5 ml/l. Where as downy mildew PDI of 12.84 and powdery mildew PDI of 14.43 were noticed with recommended check treatment Metalaxyl MZ 72 WP @ 2.5 g/l + Triadimefon @ 1 g/l with net returns of 3,72,250. These severities were on par with severities noticed with Custodia @ 1.5 ml/l and significantly superior in yield. The C:B ratio of 1:2.60 noticed with recommended check is lower than C:B ratio noticed with new molecule Custodia @ 1.5 ml/l. Significantly highest severities of downy mildew (PDI of 70.38) and powdery mildew (PDI of 85.47) were noticed with untreated check.

The results of farm trials and large scale field verification trials conducted in farmer's fields for the management of both downy and powdery mildew are presented in table 6. The results revealed that lower severities of both the diseases with higher grape yields were recorded with Custodia @ 1.5 ml/l than recommended check Metalaxyl MZ 72 WP @ 2.5 g/l + Triadimefon @ 1 g/l. Thus, the results of investigations spread over different growing environments in dollar earning crop showed superiority of new molecule Custodia @ 1.5 ml/l over the existing positive checks in terms of its bioefficacy and economics. The phytotoxicity trial revealed that there were no phototoxic symptoms at all the tested concentration levels (Table7). The symptoms of leaf necrosis, epinasty, fruit injury etc. were not noticed even at increased concentrations. In management of downy mildew Varalakshmi *et al.*, (1999) [3] reported effectiveness hexaconazole on downy mildew of grape and Jamadar *et al.* (2004) [4] reported effectiveness of Amistar on downy mildew and powdery mildew of grape. In the events of higher disease pressure, the new product can effectively be employed in management of downy mildew and in future, to tackle the resistant development by pathogen to old molecules. Thus, it can be concluded that the new molecule Azoxystrobin 11% + Tebuconazole 18.3% SC be recommended for management of mildews in grape growing areas of subcontinent with better bioefficacy and realization of higher net income.

Table 1: Bio efficacy of Azoxystrobin 11% + Tebuconazole 18.3% SC against Downy Mildew of Grape during October 2017 to April 2018 & October 2018 to April 2019.

Tr. No	Treatment	Formulated Product (ml or g/ lit)	Percent Disease Index (PDI) of Downy mildew After 10 days of III Spray			Grape yield t/ha		
			2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
1	Azoxystrobin 11% + Tebuconazole 18.3% SC	1.0 ml / l	14.4 (22.3)	19.6 (26.3)	18.4 (25.4)	30	33.5	31.8
2	Azoxystrobin 11% + Tebuconazole 18.3% SC	1.5 ml/ l	13.6 (21.6)	15.1 (23.1)	14.9 (22.7)	32.4	36	34.2
3	Azoxystrobin 11% + Tebuconazole 18.3% SC	2.0 ml / l	13.5 (21.6)	11.0 (19.4)	12.9 (21.0)	34	38	36.0
4	Metalaxyl MZ 72 WP	2.5 g / l	21.8 (27.8)	25.5 (30.3)	24.8 (29.8)	30.5	36.5	32.0
5	Mancozeb 75 WP	2.5 / l	20.3 (26.7)	25.8 (30.5)	23.7 (29.1)	29.8	28.6	29.0
6	Azoxystrobin	1.0 ml/l	14.1 (22.1)	9.8 (18.2)	13.1 (21.2)	32	35.5	33.5
7	Check (Untreated)	-	55.9 (48.4)	51.7 (45.9)	52.9 (47.1)	13.3	14.1	13.7
S.Em ±			0.43	1.44	2.22	1.50	1.14	2.06
CD at 5%			1.34	4.46	7.68	4.65	3.51	7.83
CV %			9.93	9.09	11.63	17.24	11.63	14.41

Figures in parentheses indicate arcsine values.

Table 2: Economics of Azoxystrobin 11% + Tebuconazole 18.3% SC for the management of Downy Mildew of Grape

Sl. No	Treatments	Yield t/ha	Gross returns Rs/ha	Cost of cultivation Rs/ha	Net returns Rs/ha	C: B ratio
1	Azoxystrobin 11% + Tebuconazole 18.3% SC	34.2	6,84,000	2,31,750	4,52,250	1:2.95
2	NM : Azoxystrobin (Amistar) @ 1 ml/liter	31.75	6,35,000	2,29,500	4,05,500	1:2.75
3	RC : Metalaxyl MZ 72 WP @ 2.5 g/liter	27.53	5,50,600	2,31,000	3,19,600	1:2.38
4	UC: Untreated Check	13.7	2,74,000	2,25,000	49,000	1:1.21

Grape Rs 20/kg Custodia : Rs 3000 /litre Azoxystrobin Rs. 3000/liter Metalaxyl MZ Rs. 1600/kg
Custodia 2.25 litre=6750 Azoxystrobin 1.5 liter = Rs.4500 Metalaxyl 3.75 kg = Rs. 60004
Spray solution/spray 500 liters No. of sprays 3 Untreated Check only these 3 sprays were not taken.
Average Cost of production : 2,25,500 per ha

Table 3: Bioefficacy of Azoxystrobin 11% + Tebuconazole 18.3% SC against Powdery Mildew of Grape during October 2017 to April 2018 & October 2018 to April 2019.

Tr. No	Treatment	Formulated Product (ml or g/ lit)	Percent Disease Index (PDI) of Powdery mildew After 10 days of III Spray			Grape yield t/ha		
			2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
1	Azoxystrobin 11% + Tebuconazole 18.3% SC	1.0 ml / l	15.54 (23.22)	18.60 (25.55)	17.09 (24.39)	26.21	31.84	29.025
2	Azoxystrobin 11% + Tebuconazole 18.3% SC	1.5 ml / l	9.70 (18.12)	14.18 (22.12)	11.90 (20.12)	27.89	33.42	30.655
3	Azoxystrobin 11% + Tebuconazole 18.3% SC	2.0 ml / l	7.43 (15.77)	9.39 (17.84)	8.41 (16.90)	28.44	36.15	32.295
4	Triadimefon 25% WP (Bayleton)	1.0 g / l	7.93 (16.18)	12.36 (20.58)	9.99 (18.37)	28.10	34.54	31.32
5	Penconazole 10% EC Topas 10% EC	1.0 ml / l	10.41 (18.81)	14.61 (22.47)	12.44 (20.64)	27.28	32.84	30.06
6	Carbendazim 50% WP (Bavistin)	1.0 g / l	19.32 (26.08)	24.89 (29.94)	22.07 (28.01)	25.67	30.99	28.33
7	Check (Untreated)	-	72.54 (58.41)	86.07 (68.08)	79.73 (63.25)	15.59	13.02	14.32
S Em ±			1.87	1.73	1.71	0.49	0.94	0.66
CD at 5%			5.76	5.32	5.27	1.54	2.88	2.03
CV %			12.84	10.12	10.83	5.34	10.16	7.10

Figures in parentheses indicate arcsine values.

Table 4: Economics of Azoxystrobin 11% + Tebuconazole 18.3% SC for the management of Powdery Mildew of Grape

Sl. No	Treatments	Yield t/ha	Gross returns Rs/ha	Cost of cultivation Rs/ha	Net returns Rs/ha	C : B ratio
1	Azoxystrobin 11% + Tebuconazole 18.3% SC @2 ml/l	32.295	6,45,900	2,34,000	4,11,900	1:2.76
2	Triadimefon 25% WP (Bayleton) @ 1 g/liter	31.32	6,26,400	229125	397275	1:2.73
3	UC: Untreated Check	14.32	2,86,400	225000	61400	1:1.27

Grape Rs 20/kg Custodia : Rs 3000 /litre Triadimefon Rs. 2750/kg
Spray solution/spray 500 liters No. of sprays 3
Custodia 3.0 litre=9000 Triadimefon 1.5 kg = Rs. 4125
Untreated Check only these 3 sprays were not taken.
Average Cost of production : 2,25,500 per ha

Table 5: Bioefficacy of Azoxystrobin 11% + Tebuconazole 18.3% SC against Downy Mildew and Powdery Mildew of Grape. During October 2017 to April 2018 & October 2018 to April 2019.

Tr. No.	Treatment	Downy mildew PDI 10 days after III spray	Powdery mildew PDI 10 days after III spray	Yield t/ha	Gross returns Rs/ha	Cost of cultivation Rs/ha	Net returns Rs/ha	B:C ratio
1	I, II, & III Sprays with Azoxystrobin 11% + Tebuconazole 18.3% SC @1.5 ml/l	10.13 (18.55)	11.48 (19.81)	34.15	6,83,000	2,31,750	4,51,250	1:2.90
2	I Spray with Metalaxyl MZ 72 WP @ 2.5 g/liter, II Spray with Metalaxyl MZ 72 WP @ 2.5 g/liter + Triadimefon 25% WP (Bayleton) @ 1 g/liter & III Spray with Triadimefon 25% WP @ 1 g/liter	12.84 (20.99)	14.43 (22.32)	28.88	5,77,600	2,31,750	345850	1:2.49
3	UC: Untreated Check (Only these 3 Sprays were avoided)	70.38 (57.02)	85.47 (67.60)	11.27	225400	225000	400	1:1.01
S.Em. ±		1.47	1.86	0.534	-	-	-	-

CD at 5%	4.54	5.72	1.645			
CV %	12.10	13.43	9.03			

Grape Rs 20/kg Custodia : Rs 3000 /litre Metalaxyl 1600/kg Triadimefon Rs.2750/kg
 Spray solution/spray 500 liters No. of sprays 3
 Custodia : 2.25 liter = Rs.6750 Metalaxyl 2.5 kg = Rs. 4000 Triadimefon 1 kg = Rs. 2750
 Untreated Check only these 3 sprays were not taken.
 Average Cost of production : 2,25,500 per ha

Table 6: Bioefficacy of Azoxystrobin 11% + Tebuconazole 18.3% SC against Downy Mildew and Powdery Mildew of Grape Results of Farm Trials and Large Scale Demonstration Trials

Sl. No	Name of the trial	Treatments	2017-18			2018-19			Average		
			PDI		Yield t/ha	PDI		Yield t/ha	PDI		Yield t/ha
			DM	PM		DM	PM		DM	PM	
1	Farm Trials	T1	-	-	21.15	18.7	-	17.26	-	-	19.21
		T2	-	-	20.50	24.77	-	16.23	-	-	18.36
2	Large scale demonstrations	T1	11.82	7.78	21.80	13.89	9.82	22.43	12.85	8.80	22.12
		T2	13.48	12.68	19.75	15.54	14.62	21.15	14.51	13.65	20.45
Average		T1	-	-	21.47	17.12	-	19.85	-	-	20.67
		T2	-	-	20.12	19.33	-	18.69	-	-	19.40

Note:

T1 = Azoxystrobin 11% + Tebuconazole 18.3% SC @ 1.5 ml/liter

T2 = Metalaxyl MZ 72 WP @ 2.5 g/liter + Triadimefon 25% WP @ 1 g/liter

Table 7: Evaluation of phytotoxicity of Azoxystrobin 11% + Tebuconazole 18.3% SC @1.5 ml/l (Custodia) on Grapevine

During fore pruning period October 2018 to April 2019									
Product	Dosage g a.i./ha	Phytotoxicity parameters under 0-9-Scale							
		Injury on leaf tips	Injury on leaf surface	Vein clearing	Necrosis	Leaf epinasty	Injury on fruits	Wilting	
Azoxystrobin 11% + Tebuconazole 18.3% SC @1.5 ml/l	250	0	0	0	0	0	0	0	
Azoxystrobin 11% + Tebuconazole 18.3% SC @3.0 ml/l	300	0	0	0	0	0	0	0	
Azoxystrobin 11% + Tebuconazole 18.3% SC @6.0 ml/l	350	0	0	0	0	0	0	0	
Water spray	-	0	0	0	0	0	0	0	

0 to 9 Scale where 0 = No phytotoxicity and 9 = 90-100% phytotoxicity

All phytotoxicity parameters showing zero level indicating safe nature of Azoxystrobin 11% + Tebuconazole 18.3% SC at different tested dosages mentioned above on grapevines.

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