Eco. Env. & Cons. 30 (1) : 2024; pp. (315-320)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i01.057

Field appraisal of Picarbutrazox 9.53 % w/w (100 SC) against downy mildew of grapes

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(Received 18 August, 2023; Accepted 9 October, 2023)

ABSTRACT

Grape is an important fruit crop of India, which belongs to the family *Vitaceae*. Downy mildew caused by pathogen *Plasmopara viticola* is a fungal disease which is of global concern. Picarbutrazox 9.53 % w/w (100 SC) was evaluated against downy mildew disease at field conditions for two seasons at two locations viz., Nashik and Sangli districts of Maharashtra in 2017-18 and 2018-19. Based on the favorable weather conditions four foliar sprays (one preventive + three curative) were applied as soon as first symptoms were observed in experimental plot. Picarbutrazox 9.53 % w/w (100 SC) @ 1250 ml/ha was most effective in controlling the disease at both locations. At Sangli, Picarbutrazox 9.53 % w/w (100 SC) @ 1000 and 1250 ml/ha were at par with each other for both the seasons. However in Nashik, Picarbutrazox 9.53% w/w (100 SC) @ 1250 ml/ha was significantly superior over all treatments. Pooled data for both locations showed the same trend according to respective locations. Pooled Percent Disease Index of Picarbutrazox 9.53 % w/w (100 SC) @ 1250 ml/ha on leaves was 9.31 and 7.13 in Nashik and Sangli respectively which was significantly less than rest of the treatments. Picarbutrazox 9.53 % w/w (100 SC) @ 1250 ml/ha showed highest marketable yield i.e. 24.87 and 25.31 t/ha in Nashik and Sangli respectively. The chemical was not phytotoxic at 2500 ml/ha. Hence, Picarbutrazox 9.53 % w/w (100 SC) 1000-1250 ml/ha can be recommended for the control of downy mildew.

***Key words**: Bioefficacy, Grape, Picarbutrazox, Downy mildew, Phytotoxicity*

Introduction

Grape (*Vitis vinifera*) is a commercially important and popular fruit crop grown in India which includes Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. India has produced 3490 thousand MT from an acreage 162000 ha in the year 2020-21 (Anonymous, 2021). Several reports indicated that <"72 million tons of grapes were produced worldwide every year (Sawant *et al.,* 2017). Along with economic value grapes are also endowed with several nutritional attributes. Grape is a rich source of bioactive molecules including phenolic acids, flavonoids, anthocyanins, stilbenes and lipids. Reports suggested that grapes had various antioxidant, antimicrobial, anti-inflammatory and anti-carcinogenic activities and had a wide applications in food and nutraceutical industries (Sabra *et al.,* 2021).

Grape production is hampered by several biotic and abiotic stresses. The common biotic stresses in-

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cluded diseases such as downy mildew, powdery mildew, anthracnose and bacterial leaf spot. These diseases cause major economic losses in grape cultivation (Rienth *et al.,* 2021). Downy mildew is one of the most prevalent and ubiquitous disease of grapevine, caused by the obligate fungal pathogen, *Plasmopara viticola* (Berk. & Curt). *P. viticola* mainly infected leaves and clusters of young berries and produces oil spot lesions on the adaxial leaf surface accompanied by massive sporulation on the abaxial surface (Fig 1) (Perazzolli *et al.,* 2012).

a) b)

Fig. 1. Downy mildew symptoms on a) Berries b) Leaf

Downy mildew is considered to have a high destructive potential causing 60-70% of crop loss (Sawant *et al.* 2016). Downy mildew management requires intensive use of fungicides. Conventionally disease was controlled by frequent application of fungicides with various active ingredients such as Quinone outside Inhibitors (QoI), Carboxylic Acid Amide (CAA), phenyl amide (PA) etc. (Massi, *et al.,* 2021). Several fungicides like Propineb, Mancozeb, Fosetyl Al, Dimethomorph, Mandipropamid and Cyazofamid were reported to control the disease (Ghule *et al.,* 2018). Continuous application of fungicide generated fungicide resistant strains and to overcome the disease caused by the resistant strains, there is a need for a large number of new effective molecules that can be incorporated in the control measures (Sawant *et al.*, 2016).

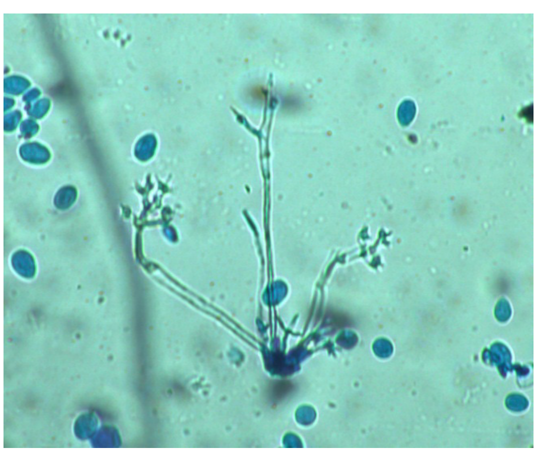

Fig. 2. Spore of Downy Mildew

A new active ingredient from a novel chemical class i.e. Picarbutrazox was developed by Nippon Soda Co Ltd., Japan. Picarbutrazox belongs to the tetrazolyloxime group of FRAC category U17. Picarbutrazox is an oxime O-ether that is the (Z)-oxime derivative of 1-methyl-1H-tetrazol-5-yl phenyl ketone in which the hydrogen of the hydroxy group has been replaced by the N-tert-butoxycarbonyl derivative of a [6-(Boc-amino) pyridin-2-yl]methyl group (Fig. 3). It is a carbamate ester, a member of tetrazoles, a member of pyridines, an oxime O-ether and a carbamate fungicide. It can be used to control diseases caused due to oomycetes such as *Bremia*, *Pythium, Peronospora, Pseudoperonspora* and *Phytophthora* sp. with a unique mode of action. Picarbutrazox is globally recognized to be one of the most effective fungicides to control downy mildew (Anonymous, 2017).

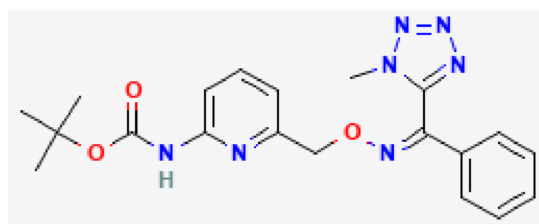

Fig. 3. Chemical structure of Picarbutazox

Source: Pub Chem

In the quest to find newer and more efficacious molecules, the present investigation was planned to evaluate the efficacy of Picarbutrazox 9.53 % w/w (100 SC) to control downy mildew disease of grapes during 2017-2019, which covered two vegetative and two fruiting seasons at two different locations.

Materials and Methods

The bio efficacy of fungicide Picarbutrazox 100 SC @500, 750, 1000 and 1250 ml/ha (supplied by Biostadt India Limited, Mumbai) was evaluated against downy mildew infection on grape leaves and berries. The field trial was conducted at two different locations in Maharashtra i.e.

Dhondgavanwadi, Nashik (20°.2550" N and 73°.8964" E, mean sea level 584m) and Borgaon, Sangli (17°.0448" N and 73°.8964" E, mean sea level 570m) during two consecutive seasons (2017-2018 & 2018-2019). The varieties used for the study at Nashik and Sangli were Super Sonaka and Thompson Seedless respectively. The vines were grown at spacing of 10' between rows and 6' between vines. The vines were trained on extended 'Y' trellises system. Methods of fertilization, irrigation, and other cultural practices were carried out as per regular commercial practices. Dimethomorph 50% WP @1000g/ha and Kresoxim-methyl 44.3% SC @600ml/ha were used as Standard check fungicides. Except, the test fungicide, all formulations were used at their recommended doses. Water volume used for spray was calculated based on requirement of 1000 L/ha at full canopy. To avoid spray drift to neighboring plots, sprayings were carried out with knapsack sprayers. Trials were conducted in randomized block design with four replications that composed of two vines each. The treatment vines were surrounded by guard vines.

Assessment of downy mildew on leaves and bunches in the field

Downy mildew incidence on leaves was recorded visually adopting the 0-4 scale, where 0 = nil, 1 = trace to 25, 2 = 26 to 50, 3 = 51 to 75 and 4 = more than 75 leaf area infected (Horsfall and Heuberger 1942). Percent Disease Index (PDI) was calculated by using following formula:

$$\text{PDI} = \frac{\text{Sum of numerical ratings} \times 100}{\text{Number of leaves observed} \times \text{Maximum of rating scale}}$$

The ratings on ten leaves were recorded on randomly selected canes. Ten such canes per vine were observed and 100 disease observations were recorded per replicate. Four replications for each treatment were considered. Only actively growing downy mildew lesions were considered for recording ratings. The marketable yield from all the treatments was recorded at harvest and expressed in kg /vine and further extrapolated to yield/ha basis.

The per cent disease control over control was calculated by using following formula.

$$\text{PDC} = \frac{\text{PDI in control} - \text{PDI in treatment} \times 100}{\text{PDI in control}}$$

The mean of PDI of both the seasons was calculated and percent disease control was tabulated using the formula of Vincent (1947)

I= C-T/C ×100

Where,

I=percent disease control; C=PDI in untreated control; T= PDI in fungicide treatment

All data obtained were subsequently analyzed statistically after PDI data of both seasons were pooled for convenience and significant interpretation.

Statistical analysis

The PDI data was transformed by using arcsine transformation for leaves and analyzed statistically following Randomized Block Design (RBD) using Statistical Analysis System (SAS software 9.3). The yield data was analyzed without transformation. Means were compared using Least Significant Difference (LSD) test. Compatibility data were analyzed in Completely Randomized Design (CRD) with Analysis of Variance (ANOVA) using SAS (ver. 9.3; SAS Institute Inc., Cary, North Carolina, USA). Means were compared by the Tukey's test ($P < 0.05$).

Phytotoxicity

Phytotoxicity experiment was conducted at the same plot and the vines treated with sprays of different doses of Picarbutrazox 100 SC viz., 2000 & 2500 ml/ha.. Vineyards were critically observed for presence of phytotoxic effects such as chlorosis, tip burning, necrosis, epinasty, vein clearing, hyponasty etc. on leaves and necrosis, russeting on berries up to fifteen days after each spray of the fungicides. Observations were recorded at 0, 1, 3, 5, 7 and 10 days after spray of fungicides in the form of visual ratings in 0-10 scale where, 0=No phytotoxicity, 1=0-10%, 2=11 – 20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%.

Results and Discussion

Experiment details indicated that all treatments were found significantly superior over untreated control for PDI on leaves and enhanced marketable yield/vine. There was gradual reduction in PDI in all the fungicidal treatments after each spray treatment but an increase was recorded in untreated control (Fig. 4).

The bio efficacy of Picarbutrazox 100 SC @500, 750, 1000 and 1250 ml/ha was evaluated against

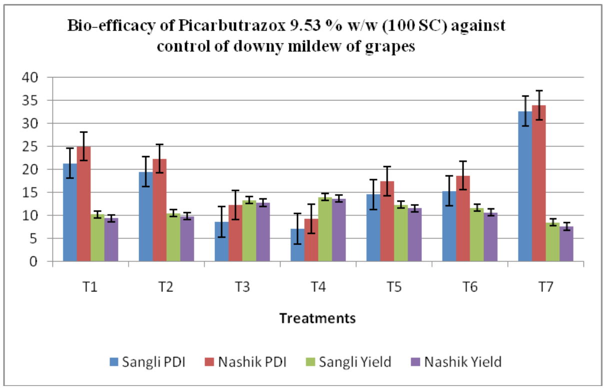

Fig. 4. Bio-efficacy of Picarbutrazox 9.53 % w/w (100 SC) against control of downy mildew of grapes

downy mildew during two consecutive seasons. It was compared with Dimethomorph 50% WP @1000g/ha, Kresoxim-methyl 44.3% SC @600 ml/ha and untreated control. The findings (Table 1) revealed that all treatments were significantly superior over untreated control at both the locations. It was observed that Picarbutrazox 100 SC @ 1000 and 1250 ml/l water gave remarkable control of the disease with PDC 73.75 and 78.14 respectively at Sanglias compared to untreated control and standard fungicides. It was recorded that Dimethomorph 50% WP @1000g/ha (55.38), Kresoxim-methyl 44.3% SC @600 ml/ha (52.92) were significantly superior over Picarbutrazox 100 SC @ 500 (34.37) and 750 ml/l (40.54) (Table 1).

At Nashik district similar trend was observed as Sangli where PDC of Picarbutrazox 100 SC @ 1250ml/ha (72.54) and @1000 ml/ha (63.77) were at par with each other as well as significantly superior over control treatment. Dimethomorph 50% WP (17.44) and Kresoxim-methyl 44.3% SC (18.69) recorded highest PDI and was similar to PDI of Picarbutrazox 100 SC at 750 ml/ha (22.34) (Table 2).

All fungicides manifested increased yield as compared to untreated control. The productivity of grape was recorded maximum in Picarbutrazox 9.53 % w/w (100 SC)@1250 ml/l treatment followed by 1000 ml/l at both the locations. The yield recorded for Picarbutrazox 9.53 % w/w (100 SC) @1250 ml/l at Sangli and Nashik were 14.00 and 13.75 respectively. Yield of grapes with standard fungicides were at par with Picarbutrazox 9.53 % w/w (100 SC) @1000ml/l and @ 750 ml/l. Significantly lower yield of 8.52 and 7.66 t/ha was noted for untreated control at Sangli and Nashik respectively (Table 1, 2).

The phytotoxicity studies of Picarbutrazox 9.53 % w/w (100 SC) was conducted on same two field locations viz. Sangli and Nashik. The observations on the leaf tip, surface injury, wilting, vein clearing, necrosis, epinasty, hyponasty and fruit injury were recorded during both the seasons and there were no visual symptoms of phytotoxicity noticed on grape.

Picarbutrazox was registered in June 2017 in Japan. It belongs to the tetrazolyloxime class, controlling oomycete diseases such as downy mildew and

Table 1. Bio-efficacy of Picarbutrazox 9.53 % w/w (100 SC) against control of downy mildew of grapes at Sangli.

	Treatments	Dosage/ha		PDI of downy mildew of leaves		Pooled Data		
		a.i (g)	Formulation (ml)	2017-18	2018-19	Pooled PDI	Pooled PDC	Pooled Yield (t/ha)
T1	Picarbutrazox 9.53 % w/w (100 SC)	50	500	17.75 (24.88)	25.06 (30.03)	21.41 (27.54)e	34.37 (35.84)e	10.27e
T2	Picarbutrazox 9.53 % w/w (100 SC)	75	750	15.38 (22.85)	23.56 (29.02)	19.47 (26.14)d	40.54 (39.52)d	10.52e
T3	Picarbutrazox 9.53 % w/w (100 SC)	100	1000	4.88 (12.65)	12.88 (20.81)	8.63b (16.97)	73.75 (59.28)b	13.37b
T4	Picarbutrazox 9.53 % w/w (100 SC)	125	1250	4.06 (11.54)	9.88 (18.27)	7.13 (15.47)a	78.14 (62.13)a	14.00a
T5	Dimethomorph 50% WP	500	1000	10.50 (18.87)	18.69 (25.59)	14.59 (22.44)c	55.38 (48.09)c	12.37c
T6	Kresoxim-methyl 44.3% SC	300	600	11.06 (19.39)	19.56 (26.23)	15.31 (23.03)c	52.92 (46.68)c	11.75d
T7	Untreated control	-	-	31.06 (33.86)	34.25 (35.78)	32.66 (34.84)f	-	8.52f
	CD @ 5 %	-	-	3.24	2.70	1.75	4.21	1.65

Table 2. Bio-efficacy of Picarbutrazox 9.53 % w/w (100 SC) against control of downy mildew of grapes at Nashik.

Treatments		Dosage/ha		PDI of downy mildew of leaves		Pooled Data		
		a.i (g)	Formulation (ml)	2017-18	2018-19	Pooled PDI	Pooled PDC	Pooled Yield (t/ha)
T1	Picarbutrazox 9.53 % w/w (100 SC)	50	500	25.31 (30.14)	24.69 (29.74)	25.00 (29.95)e	26.50 (30.65)e	9.42e
T2	Picarbutrazox 9.53 % w/w (100 SC)	75	750	24.13 (29.40)	20.56 (26.94)	22.34 (28.20)d	34.15 (35.74)d	9.87e
T3	Picarbutrazox 9.53 % w/w (100 SC)	100	1000	13.06 (21.78)	11.50 (19.82)	12.28 (20.51)b	63.77 (53.00)b	12.76b
T4	Picarbutrazox 9.53 % w/w (100 SC)	125	1250	9.69 (18.12)	8.94 (17.37)	9.31 (17.77)a	72.54 (58.40)a	13.75a
T5	Dimethomorph 50% WP	500	1000	17.50 (24.68)	17.38 (24.62)	17.44 (24.65)c	48.75 (44.28)c	11.54c
T6	Kresoxim-methyl 44.3% SC	300	600	19.06 (25.85)	18.31 (25.31)	18.69 (25.61)c	44.95 (42.10)c	10.72d
T7	Untreated control	-	-	34.06 (35.70)	33.88 (35.57)	33.97 (35.64)f	-	7.66f
	CD @ 5 %	-	-	2.46	1.75	1.61	4.63	2.11

late blight. Uses of Picarbutrazox include seed treatment of corn and soybean to control *Pythium* and *Phytophthora* and turf treatment to control *Pythium* diseases (Anonymous, 2023). These fungi can cause foliar blight, damping-off and root dysfunction, which in turn can cause significant yield losses. The mode of action of this compound is unknown, but it seems to have a new one, since the treatment of Picarbutrazox causes swelling and hyperbranching of mycelia and inhibits zoospore formation, zoospore encystment, and cystospore germination (Umetsu *et al.,* 2020). It is theorized that Picarbutrazox works by affecting the biosynthesis of phospholipids, which disrupts the normal function of the pathogen's cellular membrane. Picarbutrazox has translaminar activity and no known cross resistance between it and other oomycete chemistries like phenyl amides, carboxylic acid amides and quinone outside inhibitors (Anonymous, 2023). It is hypothesized that Picarbutrazox blocks the phosphatidylcholine pathway, which affects the biosynthesis of phospholipids. This leads to leaky cells and disruption of the normal functioning of the pathogen and affects the cell membrane and cell organelles. In the present investigation it was noted that Picarbutrazox 100 SC @ 1000 and 1250 ml/ha was effective in controlling downy mildew without any symptoms of phytotoxicity with significant increase in yield of grape.

Conclusion

Picarbutrazox 100 SC @ 1000 and 1250 ml/ha as a foliar spray manifested significantly higher disease control of downy mildew in grapes over its solo doses, increased the yield and were devoid of any phytotoxic effects on grapes. Thus, these combinations at above doses may be recommended for the management of downy mildew of grapes.

Acknowledgements

The authors are grateful to the Director, ICAR-NRCG, Pune, (India) for his keen interest during the study and providing the facilities for research. Authors are also grateful to Nisso Chemical India LLP, Gurugram, Haryana and Biostadt India Limited, Mumbai for providing the samples.

Declarations

Ethical approval: NA

Consent to publish: All authors agree to publish the paper in Ecology, Environment and Conservation. Research content: The research content is original and has not been published or submitted for publication elsewhere.

Conflict of interest: The authors declare no potential conflicts of interests

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