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Efficacy of Cyantraniliprole 300 g/L OD against thrips (*Scirtothrips dorsalis*) and flea beetle (*Scelodonta strigicollis*) on grapes.

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ABSTRACT

Thrips, Scirtothrips dorsalis and flea beetle, Scelodonta strigicollis are the two important destructive pest prevailing in the grapes ecosystem in the terms of economic damage is concern. Field studies were conducted during two consecutive seasons of 2022 and 2023 in order to evaluate the field bio-efficacy of a new anthranilic diamide molecule Cyantraniliprole 300 g/L OD (45, 60, 75, 90 and 105 g a.i./ ha) along with Lambda- cyhalothrin 4.90 % CS (12.5 g a.i./ha) and Emamectin benzoate 5% SG (11 g a.i./ha) as standard checks against the thrips (Scirtothrips dorsalis) and flea beetle (Scelodonta strigicollis) in grapes. The two higher doses of Cyantraniliprole 300 g/L OD i.e. 90 and 70 g a.i./ha was found highly effective in managing the population of thrips and flea beetle during both the year compared to Lambda-cyhalothrin and Emamectin benzoate. The highest grapes yield was recorded in plots treated with Cyantraniliprole 300 g/L OD @ 90 g a.i./ha (19.45, 19.61 t/ha respectively) and it was statistically on par with its lower dose of 70 g a.i./ha (19.36, 19.52 t/ha respectively) during first and second field trials. Considering the bio-efficacy and yield, Cyantraniliprole 300 g/L OD @ 70 g a.i./ha is recommended for effective control of thrips and flea beetle pests in grapes ecosystem.

Keywords: *Cyantraniliprole, Grapes, Thrips, Flea beetle, Bioefficacy, Safety, Yield.*

Introduction

Grape (*Vitis vinifera* L.) belonging to Family *Vitaceae* known as the 'queen of fruits' is one of the commercially important fruit crops of the temperate zone, which has acclimatized to sub-tropical and tropical agro-climatic conditions prevailing in the Indian subcontinent [5]. The grape occupies 1.2 % & 2.8% of the total fruit crops under area and production in the country. Production is of total fruits produced in the country [26]. This crop ranks fifth position amongst fruit crops with a production of 3477 metric tonnes from an area of 162 ha with an average productivity of 21.48 metric tonnes/ha in 2021-22 in India [11]. The estimated area for grape production in India during the fiscal year 2022 was approximately 162000 hectares which was increased from the previous fiscal year 2021 (155000 ha). About 80% of the production comes from Maharashtra with a production of 2467 metric tonnes from an area of 118 ha with an average productivity of 20.43 metric tonnes/ha in 2021-22 followed by Karnataka and Tamil Nadu [33].

There are about 132 insect pests attacking grapes in the world [6]. Out of which, 85 species of insect pests have been reported in India [2] but only a few of them pose a serious threat and have gained the major attention due to yield loss caused by them are concerned. The two thrips species, viz., *Scirtothrips dorsalis* and *Rhipiphorothrips cruentatus* attack the growing shoots, flowers, and berries while the third one, *Retithrips syriacus* thrives only on old leaves of table grapes in India. Among them, grape thrips (*Scirtothrips dorsalis* Hood) are the most devastating pest species in which infested grape leaves develop a whitish hue, withered appearance and eventually turn brown (scap formation). Leaves ultimately curl up and fall off. In the recent past, thrips damage has been increasing every year, particularly on Thompson Seedless. The next difficult pest to control is the Flea beetle, *Scelodonta strigicollis*, a regular and serious pest in India that often causes 10 to 30% in damage and up to 50% in yield loss. The adult beetle severely damages buds and tender shoots. Later they attacked the matured leaves causing shot hole appearance or elongated holes in leaves [38].

Generally, conventional insecticides from the class of organophosphates and synthetic pyrethroids are recommended to control the thrips and flea beetle in grapes [34]. Major management of these insects relies heavily upon chemical insecticides. Several insecticides have been reported to be effective in controlling insect pests on grapes. However, in the wake of widespread resistance, cross-resistance to chemical insecticides, and pest resurgence, a need for newer insecticides with novel chemistries and modes of action is increasingly felt due to their effectiveness at lower doses, greater levels of safety, better performance, and reduced environmental impact. In this context, the present study was taken up to evaluate the efficacy of a newer insecticide, Cyantraniliprole 300 g/L OD globally developed by FMC Pvt. Ltd. against insect pests of grapes under field conditions. Cyantraniliprole is a second-generation anthranilic diamide insecticide discovered by DuPont Crop Protection. The chemistry acts as a modulator of the ryanodine receptors, which are ubiquitous calcium channel regulators [1, 14, 18]. Insecticides in this chemistry class have a novel mode of action, selectively activating and binding to the ryanodine receptors in insect-striated muscle cells, provoking calcium release from intracellular stores in the sarcoplasmic reticulum

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and causing gradual muscle contraction, impairing regulation and feeding and ultimately leading to paralysis and death. [8, 14, 15, 16, 17, 18, 21, 35, 40]. Cyantraniliprole, a xylem systemic insecticide with translaminar activity and having root systemicity and foliar penetration, is the first to control a cross spectrum of chewing (Lepidoptera) and sucking (Hemiptera) pests [4, 18, 37]. Hence considering the importance of these pests, the present study was carried out to generate information about the newer diamide molecule against the insect pests of grapes.

Materials and Methods

Chemicals and reagents

The Experimental formulation of Cyantraniliprole 300 g/L OD was obtained from FMC India Pvt. Ltd., Maharashtra, India. Lambda-cyhalothrin 4.9% CS and Emamectin benzoate 5% SG formulations were purchased from a local pesticide outlet.

Field experiments

Supervised field experiments were conducted at chinnamanur, Theni, India for two seasons. First season field trial conducted with grapes cv. *Paneer* under the irrigated condition from June 2022 to August 2022 and second season field trial conducted from November 2022 to January 2023 with cv. *Paneer* in a randomized block design with seven treatments and replicated thrice. The experimental plots of 30 m^2 were marked for each replication and grapes were raised following standard agronomic practices except insect pest management. The first foliar spray was applied at 50% flowering-cap falling stage and subsequent spray was done 10 days after the first spray at pin head stage starting from the ETL of pest population @ 1000 L spray fluid /ha. The treatments for the management of *Scirtothrips dorsalis* and *Scelodonta strigicollis* comprised Cyantraniliprole 300 g/L OD @ 30, 50, 70, and 90 g a.i./ha along with Lambda-cyhalothrin 4.9% CS @ 12.5 g a.i./ha and Emamectin benzoate 5 % SG@ 11g a.i./ha.

Bioefficacy of Cyantraniliprole 300 g/L OD against *S. dorsalis* and *S. strigicollis* in grapes

The observations on grapes, *Scirtothrips dorsalis,* and *Scelodonta strigicollis* population were recorded at 0, 3, 7, and 10 days after each spray. The count of *Scirtothrips dorsalis* was recorded on 3 fully expanded leaves from the upper canopy and represented as a number per plant. The adult count of flea beetle was recorded on 10 randomly selected shoots per plot. The pest population was transformed into the square root of the x+1 transformation before statistical analysis. Per cent berry damage was recorded from 25 randomly selected bunches at the full berry stage and at the time of harvest. Per cent berry damage was assessed by counting number of berries damaged and total berries per bunch. Per cent damage was transformed to arc sine for statistical analysis. Plot-wise marketable grapes yield was recorded at each picking and combined on a per-plot basis. The obtained grapes yield was further converted into tonnes per hectare (t/ha). The yield data were subjected to statistical analysis for comparison of means.

Phytotoxicity of Cyantraniliprole 300 g/L OD on grapes

Phytotoxicity caused by Cyantraniliprole 300 g/L OD on grapes was evaluated in field experiments and the treatments used in bio-efficacy studies were used along with a dose of 70 g a.i./ha, 140 g a.i./ha which was replicated three times. Five plants were selected in each plot at random and examined for phytotoxicity symptoms viz., chlorosis, stunting, epinasty, hyponasty and necrosis on 3, 7, and 10 days after each application. The per cent injury on leaves was calculated using the following formula,

$$\text{Percent injury} = \frac{\text{Total grade points}}{\text{Maximum grade x No. of leaves observed}} \times 100$$

The phytotoxicity symptoms were graded by per cent injury on leaves as specified by Central Insecticide Board and Registration Committee (CIBRC, India) grade scale. The observed data were converted into percentages and reported on a scale of 0-100% for chlorosis, epinasty, hyponasty, necrosis, and stunting; where 0 means 'no phytotoxicity' and 100 means 'death of plant'. The 0 - 100% scale is subdivided into 10 equivalent grades of 0 to 10 *viz*., no phytotoxicity grade 0; 1-10% grade 1; 11-20%......90-100% grade 10.

Safety of Cyantraniliprole 300 g/L OD to natural enemies

Safety of Cyantraniliprole 300 g/L OD to natural enemies of the grapes ecosystem was evaluated concerning spiders and coccinellids which were recorded on each plot in ten randomly selected plants before application of insecticides, 3, 7, and 10 days after each application. These groups were chosen because they were the most abundant, other groups being present in too low numbers for table data.

Data analysis: The design followed for the conducting field experiment was a randomized block design (RBD). For the field experiment, the significant effects (P<0.05) of Cyantraniliprole 300 g/L OD on the population and damage parameters were determined by analysis of variance (ANOVA) using SPSS Statistics for Windows, Version 23.0. The data were subjected to statistical analysis after transforming the percentage data to arcsine valueand square root for population data to ensure homogeneity of variance.

Results and discussion

Bio efficacy of Cyantraniliprole 300 g/L OD against Thrips (*Scirtothrips dorsalis*) population

Before imposing insecticidal treatments there was no significant difference among thrips population in experimental plots. After the first spray, Cyantraniliprole 300 g/L OD @ 90, 70 g a.i./ha significantly reduced thrips and were on par with each other at 3, 7, and 10 DAS. All the insecticide treatments were found to be effective in reducing the pest population. Cyantraniliprole 300 g/L OD @ 90g a.i./ha treated plots recorded the lowest mean population (3.81 thrips/ 3 leaves) which was on par with its lower dose Cyantraniliprole 300 g/L OD @ 70 g a.i./ha (3.95 thrips/ 3 leaves) at 10 days after second application. The effect of cyantraniliprole 300 g/L OD was followed by the standard checks of Lambda-cyhalothrin 4.90 % CS at 12.5g a.i./ha (4.98 thrips/ 3 leaves) and Emamectin benzoate 5% SG at 11 g a.i./ha (6.90 thrips/ 3 leaves) while untreated control showed the highest mean population (22.02 thrips/ 3 leaves) at 10 days after second application. After two sprays at a 10 days interval, based on the per cent reduction in thrips population over untreated control, the order of efficacy of cyantraniliprole 300 g/L OD treatment was as follows: Cyantraniliprole 300 g/L OD @ 90 g a.i./ha (82.69%) > Cyantraniliprole 300 g/L OD @ 70 g a.i./ha (82.06%) > Cyantraniliprole 300 g/L OD @ 50 g a.i./ha (78.92%) > Lambda-cyhalothrin 4.90 % CS @ 12.5 g a.i./ha (77.38%), Cyantraniliprole 300 g/L OD @ 30 g a.i./ha (69.98%) whereas the Emamectin benzoate 5% SG @ 11 g a.i./ha gave the lowest per cent reduction (68.66%) over control (Table 1). In the second field trial, a similar trend in the reduction of the *Scirtothrips dorsalis* thrips population was observed, based on the per cent reduction over the untreated control (Table 2). The present research results accorded with those of [9, 10, 12] who showed that cyantraniliprole was effective against other insect pests of various host plants. They are also in conformity with the results of [3, 22, 24, 32] who stated that cyantraniliprole 10 OD is effective in thrips population reduction in gherkins, potato and capsicum. Cyantraniliprole applied as foliar sprays (100 OD) or soil treatments (200 SC) provided excellent control of adult whitefly, and reduced oviposition and nymph survival in tomato comparable to current standards [7].

Berry damage by thrips (*Scirtothrips dorsalis)*

The lowest percent berry damage (22.60%) due to *Scirtothrips dorsalis* attack was recorded in plots treated with Cyantraniliprole 300 g/L OD @ 90 g a.i./ha which was on par with Cyantraniliprole 300 g/L OD @ 70 g a.i./ha, (22.76 %) followed by Cyantraniliprole 300 g/L OD @ 50 g a.i./ha (28.20%), Lambda-cyhalothrin 4.90% CS @ 12.50 g a.i./ha (28.62%), Cyantraniliprole 300 g/L OD @ 30 g a.i./ha (32.75%) and Emamectin benzoate 5% SG @ 11 g a.i./ha (33.10 %) at full berry stage. At harvest stage, similar trend was observed in plots treated with Cyantraniliprole 300 g/L OD @ 90 g a.i./ha (15.56%) which was on par with Cyantraniliprole 300 g/L OD @ 70 g a.i./ha (15.72%) followed by Cyantraniliprole 300 g/L OD @ 50 g a.i./ha (21.16%), Lambda-cyhalothrin 4.90% S CS @ 12.50 g a.i./ha (21.58%), Cyantraniliprole 300 g/L OD @ 30 g a.i./ha (25.71%) and Emamectin benzoate 5% SG @ 11 g a.i./ha (26.06%) (Table 3). Cyantraniliprole 10.26% w/w OD @ 90 g a.i. ha^{-1} is effective in reducing leafhopper, whitefly, and thrips populations as well as the damage caused by shoot and fruit borer in brinjal and it can be suggested in an integrated pest management program of brinjal for the control of insect pests and harnessing higher yield [30]. According to [27], cyantraniliprole 10% OD was found to be quite effective in controlling the populations of aphids, thrips, and whiteflies in cotton at two higher doses of 90 and 105 g a.i./ha. According to [234], The cyantraniliprole doses at 105 and 90 g a.i./ha were similarly effective against tomato plants infested with *T. tabaci*. This is in agreement with the present finding.

Bio efficacy of Cyantraniliprole 300 g/L OD against Flea beetle (*Scelodonta strigicollis*) population

The experimental results after the spray showed that all the test doses of Cyantraniliprole 300 g/L OD and other treatments were significantly superior in the reduction of the pest population. The adult count of *Scelodonta strigicollis*, before imposing treatment ranged from 4.84 to 4.91 adults per ten shoots, which was statistically non-significant. The treatments of Cyantraniliprole 300 g/L OD @ 90 g a.i./ha and 70 g a.i./ha were recorded as lowest population i.e. 2.78 and 2.84 adults /10 shoots respectively and were significantly superior to untreated control (4.97 adults /10 shoots) at 3 DAS. At 7 DAS, Cyantraniliprole 300 g/L OD @ 90 g a.i./ha recorded the lowest population (2.35 adults /10 shoots) which was at par with Cyantraniliprole 300 g/L OD @ 70 g a.i./ha (2.41 adults /10 shoots). A similar trend was noticed at 10 DAS with a slight increase in an overall infestation. After the imposition of treatments for the second time at 10 DAS, the infestation came down again (Table 4) in a similar trend with the lowest adult population in Cyantraniliprole 300 g/L OD @ 90 g a.i./ha, 70 g a.i./ha (0.89 and 0.92 adults /10 shoots respectively). The highest adult population was noticed in the untreated control (6.17 adults /10 shoots) which was significantly inferior to the chemical pesticides (Table 4). With respect to the second field trial, a similar trend in the pest population reduction was observed (Table 5), Cyantraniliprole 300 g/L OD @ 90 g a.i./ha recorded the highest per cent reduction over untreated control of 85.57% followed by Cyantraniliprole 300 g/L OD @ 70 g a.i./ha of 85.09% per cent reduction. To control a wide range of lepidopteran and coleopteran pests in maize and soybean such as armyworms and white grubs, seed treatments with cyantraniliprole have been developed [19, 29, 31, 36, 42]. [41] also reported that cyantraniliprole @ 80 g a.i./ha resulted in the highest leaf damage reduction by flea beetle, *Scelodonta strigicollis* in grapes. [37] acknowledged that foliar application of cyantraniliprole reduced numbers of *Diaphorina citri* adults and nymphs in citrus. [24] revealed that cyantraniliprole @ 105 and 90 g a.i. ha^{-1} to be most effective against red pumpkin beetles *Aulacophora foveicollis* on gherkins. The findings of the present study on the efficacy of diamide insecticide were similar to that of [25, 13, and 20] for the management of *L. orbonalis* in brinjal.

Safety of Cyantraniliprole 300 g/L OD to spiders and coccinellids in grapes

Major predators in the grape ecosystem during the period of observation in two field trials were coccinellids comprising *Coccinella septempunctata* and spiders comprising mainly *Oxyopes salticus*. The coccinellids and spider population before treatment was varying between 4.66 to 5.99 / five plants and 3.99 to 4.99 / five plants with no significant differences between plots (Table 6 & 7). At 3 DAS after the first spray, a decrease in coccinellids and spider population was observed among the treated plots. The reduction in the mean coccinellids and spider population was found to be directly proportional to the Cyantraniliprole 300 g/L OD test dose. However, recovery of coccinellids and spider population was observed in Cyantraniliprole 300 g/L OD treated plots (90, 70, 50 and 30 g a.i. ha^{-1}) at 7 and 10 days after the second spray. According to the [23], Cyantraniliprole is an effective insecticide safe for coccinellid predators where higher tomato fruit yield (16.65 t ha^{-1}) was obtained by using a higher dose of Cyantraniliprole (105 g ai. ha^{-1}) followed by 16.26 t ha^{-1} (90 g ai. ha^{-1}) with yield increase (48.90-52.49%) over untreated control. The results of this study about the safety of cyantraniliprole to predatory coccinellids are consistent with other reports in the tomato ecosystem. [28] reported that a study on the response of natural enemies to cyantraniliprole 10 OD applied against insect pests of cotton revealed that the population of coccinellids, spiders, and green lacewings did not significantly differ from that of control after applications indicating the safety of cyantraniliprole 10 OD (45, 60, 75, 90 and 105 g a.i. ha-1) to these predators.

Phytotoxicity of Cyantraniliprole 300 g/L OD on grapes

Phytotoxicity caused by Cyantraniliprole 300 g/L OD on grapes was evaluated in field experiments with Cyantraniliprole 300 g/L OD @ 70 g a.i./ha and Cyantraniliprole 300 g/L OD @ 140 g a.i./ha. No phytotoxicity symptoms (chlorosis, stunting, necrosis, epinasty and hyponasty) were observed on the crop after 3, 7, and 10 days after each spray in plots treated with Cyantraniliprole 300 g/L OD @ 70 g a.i./ha and Cyantraniliprole 300 g/L OD @ 140 g a.i./ha (Table 8 & 9). This is in line with research by [39] who observed that all test doses of cyantraniliprole were relatively safe to coccinellids in the potato ecosystem and that cyantraniliprole 10 OD at 75, 150 and 300 g a.i. ha^{-1} did not cause any visible phytotoxic symptoms in potato plants.

Grape Yield

In the present study, the highest grapes yield was recorded in plots treated with Cyantraniliprole 300 g/L OD @ 90 g a.i./ha (19.45, 19.61 t/ha respectively) and it was statistically on par with its lower dose of 70 g a.i./ha (19.36, 19.52 t/ha respectively) (Table 10) during first and second field trials respectively. These two treatments were superior to the rest of the treatments in both trials. The results are consistent with the recent study conducted by [12] in which he reported that foliar application of Cyantraniliprole had greatly reduced feeding injury by related species of thrips (*Frankliniella occidentalis* Pergande) in chilli (*Capsicum annum* L.) due to rapid cessation of feeding and cyantraniliprole at 105 g a.i./ha gained highest yield (33.33 q/ha) and was at par with cyantraniliprole @ 90 g a.i./ha (31.97 q/ha). [28] recorded increasing yield over control in cyantraniliprole @ 90 and 105 g a.i./ha was ranged from 50.80 - 52.81% which was higher than the standard check i.e. endosulfan 35 EC (37.73%) and indoxacarb 14.5 SC (24.08%) in cotton. Cyantraniliprole 10 OD @ 90 and 75 g a.i. ha^{-1} as foliar application recorded the least mean population of sucking pests (aphids, whiteflies and thrips) and armyworm larvae after two rounds of spray at ten days interval in potato crops and Cyantraniliprole 10 OD at 90 and 75 g a.i. ha^{-1} recorded 34.11 and 32.42 % increased yield over untreated control [39].

Conclusion

The test chemical Cyantraniliprole 300 g/L OD @ 90 g a.i./ha, Cyantraniliprole 300 g/L OD @ 70 g a.i./ha were found effective in reducing major insect pests *viz., Scirtothrips dorsalis* and *Scelodonta strigicollis* in grapes during both seasons. The highest grapes yield was obtained in Cyantraniliprole 300 g/L OD @ 90 g a.i./ha and it was on par with Cyantraniliprole 300 g/L OD @ 70 g a.i./ha and No phytotoxicity was found in any of the treatments during both seasons. Therefore, Cyantraniliprole 300 g/L OD @ 70 g a.i./ha can be recommended for controlling major insect pests of grapes *viz., Scirtothrips dorsalis*, *Scelodonta strigicollis* and for getting increased grapes yield without affecting the natural enemies.

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Conflict of interest: The authors declare that they have no conflict of interest.

Table 1. Efficacy of Cyantraniliprole 300 g/L OD against Thrips, Scirtothrips dorsalis in grapes during first season

Tr. No.	Treatments	Dose g a.i./ha	Dose Formulation g or ml/ha	Before spray	1st spray 3DAS	1st spray 7DAS	1st spray 10DAS	2nd spray 3DAS	2nd spray 7 DAS	2nd spray 10 DAS	% ROC @ 10 days after 2nd spray
T1	Cyantraniliprole 300 g/L OD	30	100	17.16 (4.26)	14.84 (3.98)	13.59 (3.82)	13.66 (3.83)	8.18 (3.03)	6.73 (2.78)	6.61 (2.76)	69.98
T2	Cyantraniliprole 300 g/L OD	50	166.67	17.45 (4.30)	12.32 (3.65)	10.69 (3.42)	11.60 (3.55)	6.67 (2.77)	5.35 (2.52)	4.64 (2.37)	78.92
T3	Cyantraniliprole 300 g/L OD	70	233.33	17.66 (4.32)	10.16 (3.34)	8.17 (3.03)	9.82 (3.29)	5.45 (2.54)	4.33 (2.31)	3.95 (2.22)	82.06
T4	Cyantraniliprole 300 g/L OD	90	300	18.07 (4.37)	10.12 (3.33)	8.12 (3.02)	9.56 (3.25)	5.4 (2.53)	4.28 (2.30)	3.81 (2.19)	82.69
T5	Lambda cyhalothrin4.9%CS	12.5	250	17.68 (4.32)	12.47 (3.67)	10.83 (3.44)	11.75 (3.57)	6.89 (2.81)	5.50 (2.55)	4.98 (2.45)	77.38
T6	Emamectin benzoate 5%SG	11	220	17.72 (4.33)	14.92 (3.99)	13.67 (3.83)	13.82 (3.85)	8.36 (3.06)	6.89 (2.81)	6.90 (2.81)	68.66
T7	Untreatedcontrol	-	-	17.68 (4.33)	18.49 (4.41)	19.18 (4.49)	19.45 (4.52)	20.67 (4.66)	21.29 (4.72)	22.02 (4.85)	-
	S.Em (±)			-	**0.10**	**0.12**	**0.08**	**0.07**	**0.07**	**0.06**	-
	C.D. at 5%			**NS**	**0.30**	**0.37**	**0.24**	**0.21**	**0.20**	**0.18**	-

DAS: Days after Spray, NS: Non-significant, ROC: reduction over untreated control, Figures in parentheses are √x + 1 transformed values, those outside are original values

Table 2. Efficacy of Cyantraniliprole 300 g/L OD against Thrips, Scirtothrips dorsalis in grapes during second season

Tr. No.	Treatments	Dose		Population of *Scirtothrips dorsalis* / 3 leaves / plant							% ROC @ 10 days after 2nd spray
			Formulation	Before spray	1st spray			2nd spray			
		g a.i./ha	g or ml/ha		3DAS	7DAS	10DAS	3DAS	7 DAS	10 DAS	
T1	Cyantraniliprole 300 g/L OD	30	100	15.28 (4.03)	12.21 (3.63)	10.22 (3.35)	11.96 (3.60)	7.52 (2.92)	5.68 (2.58)	4.29 (2.30)	72.59
T2	Cyantraniliprole 300 g/L OD	50	166.67	15.25 (4.03)	11.32 (3.51)	9.04 (3.17)	10.97 (3.46)	6.33 (2.71)	4.50 (2.35)	3.11 (2.03)	80.13
T3	Cyantraniliprole 300 g/L OD	70	233.33	15.29 (4.04)	10.51 (3.39)	8.52 (3.09)	10.28 (3.36)	5.80 (2.61)	3.98 (2.23)	2.59 (1.89)	83.45
T4	Cyantraniliprole 300 g/L OD	90	300	14.84 (3.98)	10.42 (3.38)	8.47 (3.08)	10.22 (3.35)	5.75 (2.60)	3.93 (2.22)	2.54 (1.88)	83.77
T5	Lambda cyhalothrin 4.90 %CS	12.5	250	15.06 (4.01)	11.61 (3.55)	9.11 (3.18)	11.03 (3.47)	6.39 (2.72)	4.57 (2.36)	3.18 (2.04)	79.68
T6	Emamectin benzoate 5%SG	11	220	14.91 (3.99)	12.32 (3.65)	10.31 (3.36)	12.08 (3.62)	7.59 (2.93)	5.77 (2.60)	4.38 (2.32)	72.01
T7	Untreatedcontrol	-	-	15.15 (4.02)	15.24 (4.03)	15.34 (4.04)	15.43 (4.05)	15.57 (4.07)	15.63 (4.08)	15.65 (4.08)	-
S.Em (±)				-	**0.03**	**0.02**	**0.03**	**0.02**	**0.02**	**0.01**	
C.D. at 5%				**NS**	**0.08**	**0.06**	**0.08**	**0.07**	**0.05**	**0.03**	

DAS: Days after Spray, NS: Non-significant, ROC: reduction over untreated control, Figures in parentheses are √x + 1 transformed values, those outside are original values.

Table 3. Assessment of Per cent damage of thrips, Scirtothrips dorsalis in grapes

Tr. No.	Treatments	Dose		Berry Damage % (First season)		Berry Damage % (Second season)	
			Formulation				
		g a.i./ha	g or ml/ha	Full Berry Stage(%)	Harvest(%)	Full Berry Stage(%)	Harvest(%)
T1	Cyantraniliprole 300 g/L OD	30	100	32.75 (34.91)	25.71 (30.47)	32.98 (35.05)	25.94 (30.62)
T2	Cyantraniliprole 300 g/L OD	50	166.67	28.20 (32.08)	21.16 (27.39)	28.43 (32.22)	21.39 (27.55)
T3	Cyantraniliprole 300 g/L OD	70	233.33	22.76 (28.49)	15.72 (23.36)	22.99 (28.65)	15.95 (23.54)
T4	Cyantraniliprole 300 g/L OD	90	300	22.60 (28.39)	15.56 (23.23)	22.83 (28.54)	15.79 (23.41)
T5	Lambda cyhalothrin4.90% CS	12.5	250	28.62 (32.34)	21.58 (27.68)	28.85 (32.49)	21.81 (27.84)
T6	Emamectin benzoate 5% SG	11	220	33.10 (35.12)	26.06 (30.70)	33.33 (35.26)	26.29 (30.85)
T7	Untreated control	-	-	45.96 (42.68)	45.76 (42.57)	46.20 (42.82)	46.08 (42.75)
S.EM. ±				0.40	0.36	**0.36**	**0.29**
C.D. at 5%				**1.25**	**1.12**	**1.12**	**0.91**

Figures in parenthesis are arcsine transformed values, those outside are original values.

Table 4. Efficacy of Cyantraniliprole 300 g/L OD against flea beetle, Scelodonta strigicollis in grapes during first season

Tr. No.	Treatments	Dose g a.i./ha	Dose Formulation g or ml/ha	Before spray	1st spray 3DAS	1st spray 7DAS	1st spray 10DAS	2nd spray 3DAS	2nd spray 7 DAS	2nd spray 10 DAS	% ROC @ 10 days after 2nd spray
T1	Cyantraniliprole 300 g/L OD	30	100	4.86 (2.42)	4.16 (2.27)	3.73 (2.17)	5.01 (2.45)	2.83 (1.96)	2.46 (1.86)	1.85 (1.69)	70.01
T2	Cyantraniliprole 300 g/L OD	50	166.67	4.89 (2.43)	3.84 (2.20)	3.41 (2.10)	3.98 (2.23)	2.51 (1.87)	2.14 (1.77)	1.34 (1.53)	78.28
T3	Cyantraniliprole 300 g/L OD	70	233.33	4.91 (2.43)	2.84 (1.96)	2.41 (1.85)	3.15 (2.04)	1.51 (1.58)	1.14 (1.46)	0.92 (1.39)	85.09
T4	Cyantraniliprole 300 g/L OD	90	300	4.86 (2.42)	2.78 (1.94)	2.35 (1.83)	3.09 (2.02)	1.45 (1.57)	1.08 (1.44)	0.89 (1.37)	85.57
T5	Lambda cyhalothrin 4.90%CS	12.5	250	4.85 (2.42)	3.89 (2.21)	3.46 (2.11)	4.06 (2.25)	2.56 (1.89)	2.19 (1.79)	1.37 (1.54)	77.79
T6	Emamectin benzoate 5%SG	11	220	4.84 (2.42)	4.28 (2.30)	3.85 (2.20)	5.10 (2.47)	2.95 (1.99)	2.58 (1.89)	1.82 (1.68)	70.50
T7	Untreatedcontrol	-	-	4.89 (2.43)	4.97 (2.44)	5.04 (2.46)	5.91 (2.63)	5.97 (2.64)	6.03 (2.65)	6.17 (2.66)	-
S.Em (±)				-	**0.04**	**0.06**	**0.06**	**0.05**	**0.03**	**0.04**	-
C.D. at 5%				**NS**	**0.12**	**0.18**	**0.17**	**0.14**	**0.10**	**0.12**	-

DAS: Days after Spray, NS: Non-significant, ROC: Reduction over untreated control, Figures in parentheses are √x + 1 transformed values, those outside are original values.

Table 5. Efficacy of Cyantraniliprole 300 g/L OD against flea beetle, Scelodonta strigicollis in grapes during second season

Tr. No.	Treatments	Dose g a.i./ha	Dose Formulation g or ml/ha	Before spray	1st spray 3DAS	1st spray 7DAS	1st spray 10DAS	2nd spray 3DAS	2nd spray 7 DAS	2nd spray 10 DAS	% ROC @ 10 days after 2nd spray
T1	Cyantraniliprole 300 g/L OD	30	100	5.04 (2.46)	4.34 (2.31)	3.91 (2.22)	4.65 (2.38)	3.01 (2.00)	2.64 (1.91)	1.77 (1.66)	71.68
T2	Cyantraniliprole 300 g/L OD	50	166.67	5.07 (2.46)	4.02 (2.24)	3.59 (2.14)	4.33 (2.31)	2.69 (1.92)	2.32 (1.82)	1.48 (1.57)	76.32
T3	Cyantraniliprole 300 g/L OD	70	233.33	5.09 (2.47)	3.02 (2.00)	2.59 (1.89)	3.33 (2.08)	1.69 (1.64)	1.32 (1.52)	1.10 (1.45)	82.40
T4	Cyantraniliprole 300 g/L OD	90	300	5.04 (2.46)	2.96 (1.99)	2.53 (1.88)	3.27 (2.07)	1.63 (1.62)	1.26 (1.50)	1.07 (1.44)	82.88
T5	Lambda cyhalothrin 4.90%CS	12.5	250	5.03 (2.46)	4.07 (2.25)	3.64 (2.15)	4.38 (2.32)	2.74 (1.93)	2.37 (1.84)	1.49 (1.58)	76.16
T6	Emamectin benzoate 5% SG	11	220	5.02 (2.45)	4.46 (2.34)	4.03 (2.24)	4.77 (2.40)	3.13 (2.03)	2.69 (1.92)	1.81 (1.68)	71.04
T7	Untreatedcontrol	-	-	5.07 (2.46)	5.15 (2.48)	5.22 (2.49)	5.49 (2.55)	6.05 (2.66)	6.12 (2.67)	6.25 (2.69)	-
S.Em (±)				-	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	
C.D. at 5%				**NS**	**0.03**	**0.04**	**0.05**	**0.03**	**0.03**	**0.03**	

DAS: Days after Spray, NS: Non-significant, ROC: Reduction over untreated control, Figures in parentheses are √x + 1 transformed values, those outside are original values.

Table 6. Effect of Cyantraniliprole 300 g/L OD against Coccinellid population in grapes during first and second seasons

Tr. No.	Treatments	Dose		Number of coccinellids / 5 plants						
		g a.i./ha	Formulation g or ml/ha	Before spray	1st spray			2nd spray		
					3DAS	7DAS	10DAS	3DAS	7 DAS	10 DAS
T1	Cyantraniliprole 300 g/L OD	30	100	5.32 (2.51)	4.32 (2.31)	4.66 (2.38)	4.99 (2.45)	4.99 (2.45)	4.66 (2.38)	4.32 (2.31)
T2	Cyantraniliprole 300 g/L OD	50	166.67	4.99 (2.45)	4.32 (2.31)	4.32 (2.31)	4.32 (2.31)	4.66 (2.38)	3.99 (2.23)	3.99 (2.23)
T3	Cyantraniliprole 300 g/L OD	70	233.33	4.66 (2.38)	3.99 (2.23)	4.32 (2.31)	4.66 (2.38)	4.32 (2.31)	4.66 (2.38)	4.66 (2.38)
T4	Cyantraniliprole 300 g/L OD	90	300	5.32 (2.51)	4.32 (2.31)	4.66 (2.38)	4.99 (2.45)	4.99 (2.45)	4.99 (2.45)	3.99 (2.23)
T5	Lambda cyhalothrin 4.90%CS	12.5	250	5.66 (2.58)	4.66 (2.38)	4.32 (2.31)	4.32 (2.31)	4.66 (2.38)	5.66 (2.58)	4.66 (2.38)
T6	Emamectin benzoate 5% SG	11	220	4.99 (2.38)	4.66 (2.45)	4.66 (2.38)	4.66 (2.38)	4.99 (2.45)	5.32 (2.51)	5.32 (2.51)
T7	Untreated control	-	-	5.99 (2.64)	4.32 (2.31)	4.99 (2.45)	5.32 (2.51)	5.66 (2.58)	5.32 (2.51)	4.99 (2.45)
	S.Em (±)			-	-	-	-	-	-	-
	C.D. at 5%			NS	NS	NS	NS	NS	NS	NS

DAS: Days after Spray, NS: Non-significant, Figures in parentheses are $\sqrt{x} + 1$ transformed values, those outside are original values.

Table 7. Effect of Cyantraniliprole 300 g/L OD to Spiders population in grapes during first and second seasons

Tr. No.	Treatments	Dose		Number of Spiders / 5 plants						
		g a.i./ha	Formulation g or ml/ha	Before Spray	1st spray			2nd spray		
					3DAS	7DAS	10DAS	3DAS	7 DAS	10 DAS
T1	Cyantraniliprole 300 g/L OD	30	100	4.66 (2.38)	2.74 (1.93)	3.07 (2.02)	3.40 (2.10)	3.74 (2.18)	4.07 (2.25)	4.40 (2.32)
T2	Cyantraniliprole 300 g/L OD	50	166.67	3.99 (2.23)	3.40 (2.10)	3.40 (2.10)	3.07 (2.02)	3.40 (2.10)	3.74 (2.18)	3.74 (2.18)
T3	Cyantraniliprole 300 g/L OD	70	233.33	4.32 (2.31)	3.07 (2.02)	2.74 (1.93)	3.07 (2.02)	3.07 (2.02)	3.40 (2.10)	3.74 (2.18)
T4	Cyantraniliprole 300 g/L OD	90	300	4.66 (2.38)	3.40 (2.10)	3.07 (2.02)	3.40 (2.10)	3.74 (2.18)	3.74 (2.18)	4.07 (2.25)
T5	Lambda cyhalothrin4.90% CS	12.5	250	4.99 (2.45)	3.07 (2.02)	2.40 (1.84)	2.74 (1.93)	3.07 (2.02)	3.40 (2.10)	3.74 (2.18)
T6	Emamectin benzoate 5% SG	11	220	4.07 (2.25)	3.40 (2.10)	3.40 (2.10)	3.74 (2.18)	3.40 (2.10)	3.74 (2.18)	3.40 (2.10)
T7	Untreated control	-	-	4.66 (2.38)	3.92 (2.22)	3.40 (2.10)	3.40 (2.10)	3.74 (2.18)	4.07 (2.25)	4.40 (2.32)
	S.Em (±)			-	-	-	-	-	-	-
	C.D. at 5%			NS	NS	NS	NS	NS	NS	NS

DAS: Days after Spray, NS: Non-significant, Figures in parentheses are $\sqrt{x} + 1$ transformed values, those outside are original values.

Table 8. Phytotoxic effect of Cyantraniliprole 300 g/L OD in grapes after first application during first and second seasons

Tr. No.	Treatments	Dose (g a.i./ha)	Phytotoxicity rating*				
			Chlorosis**	Stunting**	Necrosis**	Epinasty**	Hyponasty**
T1	Cyantraniliprole 300 g/L OD	70	0	0	0	0	0
T2	Cyantraniliprole 300 g/L OD	140	0	0	0	0	0
T3	Untreated check	-	0	0	0	0	0

*Observed on 3, 7 & 10 days after treatment; **Mean of three replications

Table 9. Phytotoxic effect of Cyantraniliprole 300 g/L OD in grapes after second application during first and second seasons

Tr. No.	Treatments	Dose (g a.i./ha)	Phytotoxicity rating*				
			Chlorosis**	Stunting**	Necrosis**	Epinasty**	Hyponasty**
T1	Cyantraniliprole 300 g/L OD	70	0	0	0	0	0
T2	Cyantraniliprole 300 g/L OD	140	0	0	0	0	0
T3	Untreated check	-	0	0	0	0	0

*Observed on 3, 7 & 10 days after treatment; **Mean of three replications

Table 10. Effect of Cyantraniliprole 300 g/L OD in grapes yield during first and second seasons.

Tr. No.	Treatments	Dose		Grapes Yield(t/ha) for First season	Grapes Yield(t/ha) for Second season
		g a.i./ha	Formulation(g or ml/ha)		
T1	Cyantraniliprole 300 g/L OD	30	100	15.36	15.52
T2	Cyantraniliprole 300 g/L OD	50	166.67	17.27	17.43
T3	Cyantraniliprole 300 g/L OD	70	233.33	19.36	19.52
T4	Cyantraniliprole 300 g/L OD	90	300	19.45	19.61
T5	Lambda cyhalothrin 4.90% CS	12.5	250	17.12	17.28
T6	Emamectin benzoate 5% SG	11	220	15.26	15.42
T7	Untreated control	-	-	13.58	13.74
S.Em (±)				**0.20**	**0.36**
C. D. (P=0.05)				**0.61**	**1.12**

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