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Sunitha ND
Professor, Department of Agricultural Entomology, College of Agriculture, Vijayapura, Karnataka, India

Corresponding Author:
Sunitha ND
Professor, Department of Agricultural Entomology, College of Agriculture, Vijayapura, Karnataka, India

Studies on management of grape stem borer *Celosterna scabrator* Fab. (Cerambycidae: Coleoptera)

Sunitha ND

Abstract
Experiment was carried out to study the effect of different insecticides applied through stem injection (DDVP 76% EC@8.00% and *Metarhizium anisopliae* 1x109 CFU's/ml2 100.00ml/l), soil incorporation (Chlorantraniliprole 0.4%G @20.00 and 15.00gm/vine and Fipronil 85% WG@ 20.00 and 15.00gm/vine), stem smearing (microbial consortium@1.00ml/l) and foliar spray(microbial consortium@ 1.00ml/l) for the management of Cerambycidae stem borer *C. scabrator* of grape between 2016-18 in the grape orchards of Vijayapura (Karnataka: India). The results revealed that stem injection with DDVP 76%EC @ 8.00% was highly effective by recording 100.00 reduction in live tunnels. Soil application of Chlorantraniliprole 0.4%G @ 20.00gm per vine was found next effective treatment. Highest cost benefit ratio was obtained in treatment with soil application of Chlorantraniliprole 0.4% G @ 20.00 g/vine (1:2.83).

Keywords: Stem borer, grape, management, C:B ratio

Introduction
Grape is one of the important commercial fruit crops. In Karnataka, Vijayapura ranked first with an area and production of 10,652 ha and 211.64 MT respectively (Anon, 2018) [1].
More than 100 pests are known to attack grape in India. Stem borers pose serious problems to grapevine cultivation in many countries (Mani *et al*., 2014a) [2] among the different species of insect pests attacking grape vine, the wood borer *Celosterna scabrator* Fab. is becoming a major pest in the recent past. Studies revealed mean yield loss 3475.75 kg per acre from borer-affected vines. **(**Sunitha *et al*., 2017) [3].
Females make ovipositional injury and both females and males scrape the green matter from tender twigs and shoots and gnaw the shoots resulting in wilting beyond that point. While emerging out they cut circular holes on trunks and branches of tree. The grubs after hatching make their way into the tree by making a small entry whole and make extensive tunneling in both the directions from the entry holes, affecting the translocation of the nutrients. The leaves turn yellow, later turn brown and drop. The borer affected vines become weak and give very low berry yield (Sunitha, 2018) [4].
The global demand for horticulture crop production is on the rise, largely in response to public awareness of the associated health benefits of fruits and vegetables, as well as for their preventative attributes to various forms of cancer and heart disease (Wu *et al*., 2004) [5]. Profitability in global food markets requires meeting high food quality standards, often through the judicious use of crop protection materials, including pesticides (Perry *et al*., 1998) [6]. Effective use of pesticides in an Integrated Pest Management (IPM) program requires precise delivery of selected materials to the crop canopy (MccArtney and Obermiller, 2008) [7].
The present study aimed at evaluating different insecticides applied through different methods for the management of grape stem borer *C. scabrator*.

Material and Methods
Experiment on evaluation of different methods of management of cerambycid stem borer in grape ecosystem was carried out between 2015-16 and 2017-18 in the grape orchards of Vijayapura (Karnataka: India). All the experiments were carried out in orchards with Thompson seedless variety planted with a spacing of with spacing of 8 feet between rows and six feet between the plants.

The experiment was laid out in Randomized Complete Block Design (RCBD) with 9 treatments (Table 1) replicated thrice with 25 grapevines with live tunnels (Fig 1) for each treatment. The two insecticides *viz.* Chlorantraniliprole 0.4%G and Fipronil 80%WG were applied into the soil near active root zone around the trunk to the depth of 5-10 cms which was followed by irrigation. DDVP 76% EC and *M. anisopliae* were applied through stem injection with the aid of syringe into the live tunnel. (Fig 2). Before releasing the chemicals into the live holes, the tunnels were cleared with the help of a metal wire to make way for the insecticides. Later the insecticides were squeezed into the tunnel till the insecticides flow out of the tunnel and immediately the entry holes were plugged with wet mud. The microbial agent Borer guard TM was applied through spraying as well as stem smearing with cotton pad. Observations were recorded on number of live tunnels at 7, 15, 30, 45 and 60 days after the application of treatments and finally percent reduction in live tunnels is worked out. The data was converted to arc sin values before statistical analysis and subjected to statistical analysis under a randomized complete block design. Yield data was recorded from 50 healthy vines and 50 stem borer affected vines which was then converted to yield per acre and later C:B ratio was worked out.

Table 1: Treatment details for the management of *Celosterna scabrator* Fab.

Sl. No	Treatments	Dose	Method of application of insecticides
1	DDVP 76%EC	8.0%	Stem injection
2	Chlorantraniliprole 0.4%G	20gm/ vine	Soil application
3.	Fipronil 80%WG	20gm/vine	Soil application
4	Chlorantraniliprole 0.4% G	15 gm/ vine	Soil application
5.	Fipronil 80%WG	15 gm/vine	Soil application
6.	*Metarhizium anisopliae* (1x109 CFU's/ml)	100 ml /lit of water	Stem injection
7.	Microbial consortium	1ml/lit of water	Stem smearing
8.	Microbial consortium	1ml/lit of water	Foliar Spray
9.	UTC	-	-

Microbial consortium = *Beauveria bassiana(*1x109 CFU's/ml) + *Metarhizium anisopliae (*1x109 CFU's/ml) + *Verticillium lecanii,* (1x109 CFU's/ml) + *Bacillus thuringiensis*-K, (1x109 spores/ml) + *Cellulomonas uda (*1x109 spores/ml) + *Cellulomonas gelida* (1x109 spores /ml) @1ml /l of water

Fig 1: Grape vine with active grub inside (Live tunnel)

Fig 2: Stem injection of DDVP 76%EC

Results and discussion

Percent reduction in live tunnels of *Celosterna scabrator* Fab grubs (2016-17)

At 7 days after treatment, non-significant difference was found between the different treatments. At 15 DAT, there was a significant difference among various treatments (CD=9.82). Stem injection of DDVP 76%EC @ 8.00% resulted in 100.00% reduction in live tunnels and it was found significantly superior to all other treatments. Soil application of Chlorantraniliprole 0.4%G@ 20gm/vine was found next best treatment (56.66%) followed by soil application of Fipronil 80%WG @ 20.00gm/vine (23.33%). Rest of the treatments recorded no reduction in live tunnels and were on par with UTC. At 30 DAT, stem injection of DDVP 76%EC @ 8.00% recorded 100.00% reduction in live tunnels and was found significantly superior to other treatments and was followed by soil application of Chlorantraniliprole 0.4% G @ 20.00gm/vine (71.66%), soil application of Fipronil 80%WG @20.00gm/vine (51.66%), soil application of Chlorantraniliprole 0.4% G @ 15.00gm/vine (51.66%), soil application of Fipronil 85% WG @ 15.00gm/vine (40.00%). Higher doses of chlorantraniliprole 0.4% G and Fipronil 85% WG were found on par with each other. Stem injection of *M. anisopliae*, spray and stem smearing of microbial consortium recorded 0.00% reduction in live tunnels and were at par with UTC with respect to reduction in live tunnels. At 45 DAT, all the treatments differed significantly from each other (CD=0.95). The order of superiority of treatments was stem injection of DDVP 76%EC @ 8.00% (100.00) followed by soil application of Chlorantraniliprole 0.4%G @ 20.00gm/vine (85.00%), soil application of Fipronil 85%WG @ 20.00gm/vine (63.33%), soil application of Chlorantraniliprole 0.4%G@ 15.00gm/vine smearing of microbial consortium (33.33%) and spray of microbial consortium (31.66%). UTC recorded 0.00% reduction in live tunnels. At 60 DAT also similar trend was observed and significant difference was observed between each treatment (CD=3.57) except soil application of lower doses of Chlorantraniliprole 0.4% G and Fipronil 80% WG which

were found on par with each other. Stem injection of DDVP 76% EC @ 8.00% recorded 100.00% reduction in live tunnels and was found significantly superior to all other treatments. This was followed by soil application of chlorantraniprole 0.4%G@ 20.00gm/vine (86.66%), soil application of Fipronil 80% WG @ 20.00 g /vine (73.33%) soil application of Chlorantraniliprole 0.4% G @ 15.00gm/vine (66.66%), soil application of Fipronil 80% WG @ 15.00 g (66.66%), stem injection of *M. anisopliae* (61.66%), Stem smearing of microbial consortium (55.00%) and spray of microbial consortium (43.66%). (Table 2)

Percent reduction in live tunnels of *Celosterna scabrator* Fab grubs (2017-18)

The perusal of data from table 3 revealed similar trend as that of first season of experiment with none of the treatments giving any reduction in live tunnels at 7 DAT and all treatments were at par. AT 15 DAT significant difference was observed between the treatments (CD=5.66). Stem injection of DDVP 76% EC @ 8.00% was found significantly superior to other treatments and recorded 68.33% reduction in live tunnels. Soil application of Chlorantaniliprole 0.4% G @ 20.00gm/vine was found be next best treatment by recording 56.66% reduction in live tunnels and it was followed by higher dose of Fipronil 85% WG (23.33%). Soil application of lower doses of chlorantraniliprole 0.4% G and Fipronil 80% WG, stem injection of *M. anisopliae*, spray and stem smearing of microbial consortium failed to give any control and recorded 0.00% reduction in live tunnels and were found at par along with UTC. AT 30 DAT, stem injection of DDVP 76% EC @8.00% was found significantly superior and recorded 90.00% reduction in live tunnels (CD=8.22). Soil application of Chlorantraniliprole 0.4% G @ 20.00gm/vine was found next best treatment (76.66%) and differed significantly from soil application of Fipronil 85% WG @20.00gm/vine (51.66%), soil application of Chlorantraniliprole 0.4% G @ 15.00gm/vine (51.66%), soil application (61.66%), soil application of Fipronil 85%WG @) 15.00gm/vine (55.00%), stem injection of *M. anisopliae* (46.66%), stem of Fipronil 85% WG @ 15.00gm/vine (33.33%) and rest of the treatments. Bio control agents failed to record any control and recorded 0.00% reduction in live tunnels. At 45 DAT also, similar trend observed except that the biocontrol agents *viz*., *M. anisopliae* and microbial consortium began to show reduction of live tunnels. *M. anisopliae* recorded 31.66% reduction in live tunnels and was at par with stem smearing of Borerguard (33.33%). Spray of microbial consortium recorded 20.00% reduction in live tunnels and found significantly inferior to *M. anisopliae* and stem smearing of microbial consortium DDVP 76% EC@ 8.00% resulted in 100.00% reductions in live tunnels and was significantly superior to all other treatments. At 60 DAT all the treatments differed significantly from each other (CD=0.75) with stem injection of DDVP 76% EC @8.00% recording 100.00% reduction in live tunnels followed by soil application of higher dose of chlorantraniliprole 0.4% G (88.33%), soil application of higher dose of Fipronil 85% WG (75.00%), soil application of lower dose of chlorantraniliprole 0.4% G (68.33%), soil application of lower dose of Fipronil 85% WG (66.66%), stem injection of *M. anisopliae* (60.50%), stem smearing of microbial consortium (55.00%), spray of microbial consortium (30.00%).

Percent reduction in live tunnels of *Celosterna scabrator* Fab grubs. (2016-17 and 17-18)

The data pertaining to this is presented in table 4. At 7 DAT all the treatments were found at par. At 15DAT stem injection of DDVP 76% EC @8.00% recoded 84.16% reduction in live tunnels. Soil application of chlorantraniliprole 0.4% G @20.00gm/vine was found next best treatment (56.66%) followed by soil application of Fipronil 85% WG @ 20.00gm/vine (23.33%). Rest of the treatments and UTC were found at par and recorded 0.00% reduction. (CD=7.01). At 30 DAT stem injection of DDVP 76% EC@8.00% recorded 95.00% reduction in live tunnels and was found significantly superior to rest of the treatments. (CD=9.15) Soil application of Chlorantraniliprole 0.4%G @ 20.00gm/vine was found next best treatment (74.16%) and differed significantly from soil application of chlorantraniliprole 0.4% G @ 15.00gm/vine (51.66%), soil application of Fipronil 85% WG @20.00gm/vine 51.66%), soil application of Fipronil 85% WG @ 15.00gm/vine (36.66%) and rest of the treatments which recorded 0.00% reduction. At 45DAT, similar trend was observed. DDVP 76% EC@8.00% recorded 100.00% reduction in live tunnels. Microbial insecticides became effective and were found at par. Stem smearing and spraying of microbial consortium recorded 33.33% reduction in live tunnels and stem injection of *M. anisolpliae* recorded 31.66% reduction in live tunnels. (CD=5.84) At 60 DAT the percent reduction in live tunnels showed increasing trend like at other intervals of observation. Trend was similar to that of 45 DAT. But stem injection of *M. anisopliae* was found on par with soil application of Fipronil 85% WG @15.00gm and significantly superior to microbial consortium by recording 60.83% reduction in live tunnels. Stem smearing of microbial consortium (55.00%) was found significantly superior to foliar application (36.83%) (CD = 6.55) The experiment conducted on evaluation of different methods of *C. scabrator* grub management revealed that stem injection with DDVP 76%EC@ 8.00% was very effective in grub management by recording 100.00 reduction in live tunnels at 45 DAT. This may be due to the fumigant action of the insecticide. Soil application of Chlorantraniliprole 0.4%G and Fipronil 85% WG were found effective treatments next to DDVP 76% EC followed by bio control agents *M. anisopliae* and microbial consortium.

Table 2: Percent reduction in live tunnels of *Celosterna scabrator* Fab grubs at different intervals of treatment (2016-17)

Treatments	Percent reduction in live tunnels				
	7 DAT	15 DAT	30 DAT	45 DAT	60 DAT
DDVP 76%EC@8.0%	0.00a(0.00)	100.00a(90.0b)	100.00a(90.00)	100.00a(90.00)	100.00a(90.00)
Chlorantraniliprole 0.4% G @ 20 gm/ vine	0.00a(0.00)	56.66b(48.83)	71.66b(57.84)	85.00b(67.21)	86.66b(68.58)
Fipronil 80% WG @ 20 gm/vine	0.00a(0.00)	23.33c(28.88)	51.66c(45.95)	63.33c(52.73)	73.33c(58.91)
Chlorantraniliprole 0.4%G@ 15 gm/ vine	0.00a(1.81)	0.00d(0.00)	51.66c(45.95)	61.66d(51.74)	66.66d(54.73)
Fipronil 80%WG @ 15gm/vine	0.00a(0.00)	0.00d(0.00)	40.00d(39.23)	55.00e(47.87)	66.66d(54.73)
Metarhizium anisopliae (1x109 CFU's/ml) @100ml/lit ofwater	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	46.66f(43.08)	61.66e (51.74)
Microbial consortium @ 1ml /l of water (Stem smearing)	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	33.33g(35.26)	55.00f(47.87)
Microbial consortium @ 1ml /l of water (Foliar Spray)	0.00a(1.81)	0.00d(0.00)	0.00e(0.00)	31.66h(34.24)	43.66g(41.36)
UTC	0.00a(1.81)	0.00d(0.00)	0.00e(0.00)	0.00i(0.00)	0.00h(0.00)
S. Em ±	-	3.26	2.55	0.31	1.19
CD @ 5%	NS	9.82	7.63	0.95	3.57
CV	-	10.58	11.72	9.46	10.05

Mean value with different superscripts vary significantly by DMRT. Figures in the parentheses are arc sine transformed values. DAT=days after treatment, n=25.

Table 3: Percent reduction in live tunnels *Celosterna scabrator* Fab grubs at different intervals of treatment (2017-18)

Treatments	Percent reduction in live tunnels				
	7 DAT	15 DAT	30 DAT	45 DAT	60 DAT
DDVP 76% EC @ 8.0%	0.00a(0.00)	68.33a(55.75)	90.00a(71.51)	100.00a(90.00)	100.00a(90.00)
Chlorantraniliprole 0.4% G @ 20gm/ vine	0.00a(0.00)	56.66b(48.83)	76.66d(61.11)	86.66b(68.58)	88.33b(70.02)
Fipronil 80% WG @ 20g/vine	0.00a(0.00)	23.33c(28.88)	51.66c(45.95)	63.33c(52.73)	75.00c(60.00)
Chlorantraniliprole 0.4% G @ 15gm/ vine	0.00a(0.00)	0.00d(0.00)	51.66c(45.95)	65.00c(53.73)	68.33d(55.75)
Fipronil 80%WG @ 15gm/vine	0.00a(0.00)	0.00d(0.00)	33.33d(35.26)	48.33d(44.04)	66.66e(54.73)
Metarhizium anisopliae (1x109 CFU's/ml) @100ml/lit of water	0.00a(0.00)	0.00d(0.00)	0.00e(1.81)	31.66e(34.24)	60.00f(50.77)
Microbial consortium @ 1ml /l of water (Stem smearing)	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	33.33e(35.26)	55.00g(47.87)
Microbial consortium @ 1ml /l of water (Foliar spray)	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	20.00f(26.57)	30.00h(33.21)
UTC	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	0.00g(0.00)	0.00i(0.00)
S. Em ±	-	1.83	2.74	1.55	0.26
CD @ 5%	NS	5.66	8.22	4.66	0.75
CV	-	12.44	11.65	10.31	13.23

Mean value with different superscripts vary significantly by DMRT. Figures in the parentheses are arc sine transformed values. DAT=days after treatment, n=25

Table 4: Percent reduction in live tunnels of *Celosterna scabrator* Fab grubs at different intervals of treatment (Mean of 2016-17 and 2017-18)

Treatments	Percent reduction in live tunnels				
	7 DAT	15 DAT	30 DAT	45 DAT	60 DAT
DDVP 76%EC@8.0%	0.00a(0.00)	84.16a(66.55)	95.00a(77.08)	100.00a(90.00)	100.00a(90.00)
Chlorantraniliprole 0.4%G@ 20gm/vine	0.00a(0.00)	56.66b(48.83)	74.16b(59.45)	85.83b(67.89)	87.49b(69.29)
Fipronil 80%WG@ 20gm/vine	0.00a(0.00)	23.33c(28.88)	51.66c(45.95)	63.33c(52.73)	70.83c(57.31)
Chlorantraniliprole 0.4% G@ 15gm/vine	0.00a(0.00)	0.10d(1.81)	51.66c(45.95)	63.33c(52.73)	70.83c(57.31)
Fipronil 80%WG @ 15gm/vine	0.00a(0.00)	0.00d(0.00)	36.66d(37.26)	51.66d(45.95)	66.66d(54.73)
Metarhizium anisopliae (1x109 CFU's/ml) @100ml/lit of water	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	31.66e(34.24)	60.83d(51.25)
Microbial consortium @1ml/l of water (Stem smearing)	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	33.33e(35.26)	55.00e(47.87)
Microbial consortium @ 1ml /l of water (Foliar Spray)	0.00a(0.00)	0.00d(0.00)	0.00e(0.00)	33.33e(35.26)	36.83f(37.36)
UTC	0.00a(0.00)	0.00d(1.81)	0.00e(0.00)	0.00f(0.00)	0.00g(0.00)
S. Em ±	-	2.33	3.04	1.96	2.19
CD @ 5%	NS	7.01	9.15	5.84	6.55
CV	-	14.21	11.68	12.57	10.88

Mean value with different superscripts vary significantly by DMRT. Figures in the parentheses are arc sine transformed values. DAT=days after treatment, n=25

Yield and C:B ratio under different methods of management of grubs of *Celosterna scabrator* Fab.

Yield: 2016-17

Significant difference was recorded among various treatments (CD=4.81). Each treatment differed significantly from each other except two methods of application of microbial consortium which were on par with each other. Soil application of Fipronil 85%WG @20.00gm/vine recorded highest yield of 187.00 kg/20 vines followed by soil application of Chlorantraniliprole 0.4%G @ 20.00 GM/vine (171.90 kg), stem injection of DDVP 76% EC @ 0.05% (162.30 kg), soil application of Fipronil 85% WG @ 15.00gm/vine (156.50 kg), soil application of Chlorantraniliprole 0.4%G @15.00 gm/vine(150.30 kg), stem injection of *M. anisopliae* (133.40 kg), stem smearing of microbial consortium (126.00 kg), spray of microbial consortium (125.10 kg). UTC recorded significantly lowest yield of 41.80 kg.

Yield: 2017-18

Fruit yield obtained from each treatment revealed significant difference (CD =6.12). Stem injection of DDVP 76% EC @

8.00% recorded significantly highest yield (189.00kg) followed by soil application of Chlorantraniliprole 0.4% G @ 20.00 gm /vine(172.50), soil application of Fipronil 0.4% G @2 0.00gm/vine (167.40 1kg), soil application of Chlorantraniliprole 0.4% G @ 15.00 gm/vine (157.13 kg), soil application of Fipronil 0.4%G @15.00gm/vine (149.66 kg),stem injection of *M. anisopliae* (136.33 kg),stem smearing of microbial consortium (130.66 kg), spray of microbial consortium (125.66kg). Treatments *M. anisopliae* and stem smearing of microbial consortium were found at par. Highest dose of chlorantraniliprole 0.4%G and Fipronil 85%WG were found at par. UTC recorded 46.33 kg fruit yield.

Mean

Pooled analysis of two seasons data on fruit yield revealed significant differences between various treatments (CD=5.26). Stem injection of DDVP 76%EC@0.08% and soil application of high doses of chlorantraniliprole 0.4%G and Fipronil 85%WG were found at par and significantly superior over other treatments and recorded 175.65, 172.23 and 177.70 kg of fruit yield respectively. Soil application of lower doses of Chlorantraniliprole0.4%G and Fipronil 85%WG were found on par with each other and recordd 153.71 and153.08 kg respectively. *M. anisopliae* was found next best treatment (134.86 kg) and differed significantly from stem smearing of microbial consortium (128.33kg) and spray of microbial consortium (125.38kg). UTC recorded significantly lowest fruit yield of 44.06.kg

Table 5: Yield of grape fruits under different treatments and C:B ratio

Treatments	Yield / 20 vines (Kg)				
	2016-7	2017-8	Mean	Cost of Pest management/ acre (Rs)	C:B ratio
DDVP 76% EC @ 8.0%	162.30c	189.00a	175.65a	5440.00	2.77
Chlorantraniliprole 0.4%G @ 20 gm/ vine	171.90b	172.56b	172.23a	2210.00	2.83
Fipronil 80%WG @ 20 gm/vine	187.00a	167.40b	177.70a	2856.00	2.74
Chlorantraniliprole 0.4% G @ 15 gm/ vine	150.30e	157.13c	153.71b	1657.00	2.55
Fipronil 80% WG @ 15 gm/vine	156.50d	149.66d	153.08b	2142.00	2.67
Metarhizium anisopliae (1x109 CFU's/ml) @ 100 ml/lit of water	133.40f	136.33e	134.86c	800.00	2.26
Microbial consortium @ 1ml /l of water (Stem Smearing)	126.00g	130.66e	128.33d	265.00	2.17
Microbial consortium @ 1ml /l of water (Foliar spray)	125.10g	125.66f	125.38d	156.00	2.12
UTC	41.80h	46.33g	44.06e	0.00	-0.74
S. Em ±	1.59	2.03	1.76		
CD @ 5%	4.81	6.12	5.26		
CV	9.79	11.25	10.92		

Market price of grape fruits: Rs 35.00/Kg. Orchard management cost excluding pest management = Rs 70,000/acre

C:B Ratio

The cost benefit ratio of pest management practices indicated highest cost benefit ratio in soil application of Chlorantraniliprole 0.4% G @ 20.00 g (1:2.83), followed by stem injection of DDVP 76% EC (1: 2.77), Fipronil 80% WG @ 20.00 g (1: 2.74), Fipronil80% WG @15.00 g (1:2.67) and Chlorantraniliprole 0.4% @ 15.00 g (1:2.55). The C: Bratio was low in microbial insecticides compared to other insecticides. *M. anisopliae* recorded C:B ratio of 1:2.26 followed by stem smearing of microbial consortium (1:2.17).Lowest cost benefit ratio was observed in spray of microbial consortium (1:2.12).However, these microbial insecticides were superior to UTC. Highest cost benefit ratio in soil application of Chlorantraniliprole 0.4% G @ 20.00g/vine may be due to lesser cost of pest management compared to stem injection of DDVP76% EC@8.00% and soil application of Fipronil 80% WG@ 20.00gm/Vine. Other treatments recorded significantly lowest yield compared to Chlorantraniliprole 0.4% G @ 20.00 g/vine, Fipronil 80% WG@ 20.00gm/Vine and stem injection of DDVP 76% EC@8.00%.(Table 5)

The findings on effect of DDVP on *C. scabrator* are in agreement with Jagginavar *et al.* (2006) [8] who reported that the method of applying dichlorvos is to inject the chemical(8%)into the stem of the affected plant using a squeeze bottle until the hole is filled to killthe stem borer larvae. Similarly the present findings are in fully agreement with Jagginavar *et al.*, (2008) [9] who showed superiority of stem injection of 8.00% Dichlorvos 76% EC which recorded hundred per cent reduction of live tunnels of *C. scabrator* and Sawant *et al.*, (2008) [10] who reported that injecting vines with 2 ml of Dichlorvos 76% EC at 60-75days after pruning with syringe to kill the larval stage of stem borer is a good practice for managing *C. scabrator*. The present findings are also in line with Mani *et al.*, (2014) [11] whoreported that dichlorvos at 5 ml/hole is effective in killing the larvae of stem borer, Anitha Kumari and Vijaya (2015) [12] who found that stem injection of dichlorvos 76% EC @ 80ml/ live hole has recorded hundred per cent reduction in live tunnels and Kambrekar *et al.*,(2017b) [13] who reported that stem injection of Dichlorvos 70EC@80ml/l resulted in 100.00% reduction in live tunnels at 35 days after treatment and absolutely no frass was collected from live tunnels at 5 days after treatment.

The present findings on efficacy of Fipronil are in agreement with the findings of Goodwin (2005) [14] who reported that Fipronil 200 SC @ 100 ml/100 litre of water controlled emerging adults and young of stem borer *A. vastator* (Cerambycidae: Coleoptera). But the chemical was applied as dormant spray. The results obtained on the efficacy of Chlorantraniliprole 0.4%G are supported by Kambrekar *et al*., (2017a)[15] who evaluated different doses of the chemical and found that Chlorantraniliprole (Ferterra 0.4 GR) @ 15.00g/vine can be effective means in managing the stem borer *C. scabrator* which reduces the cost on plant protection and increases the returns. The present findings on efficacy of *M. anisopliae* are supported by Arshad and Hafiz (1983)[16] who reported the effect of entomopathogen *B. bassiana* which caused 94.3o% mortality of stem borer *A. vastator* and Rodriguez-Gonzalez *et al*. (2017b) [17] who evaluated six insecticides for their ovicidal action against *X. arvicola* eggs and found that *B. bassiana* caused 84.30% mortality of eggs in Petri dishes, 33.30% mortality on branches and 50.00% mortality on trunks of grape vine and concluded that *B. bassiana* is the best insecticide with residual effect on neonate

larvae of *X. arvicola* on trunks, where the grater thickness of rhytidome and cracks favoured the development of this fungus to invade actively the larvae through their shell and proliferate inside. Microbial consortium contains composting microbe cultures and bio pesticide cultures. Composting microbes have an affinity for soft biomass like excreta coming out of hole bored by stem borer. They decompose the excreta and act as a scout. Later entomopathogenic microbes piggy back on the composting culture microbes as the scouts of the composting culture, microbes keep going inside the hole, the entomopathogenic microbes go inside and attack borers, pathogens and kill them.

Conclusion

Grapevine is encountered by more than 100 insect pests. Among them, the stem borer *Celosterna scabrator* Fab. (Cerambycidae: Coleoptera) causes severe loss to grapevine. In view of the habitat of the damaging stage of the pest, different insecticides were applied through stem injection, soil application, stem smearing and foliar spray techniques. The cost benefit ratio of pest management practices indicated highest cost benefit ratio in soil application of Chlorantraniliprole 0.4% G @ 20.00 g (1:2.83). This was also found to be a safe technique of pesticide application.

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