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Status and Management of Grape Stem Borer, *Celosterna scrabrator* with Soil Application of Chlorantraniliprole 0.4 gr

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***Abstract*—**Grape stem borer, *Celosterna scrabrator* is an important production constraint in grapes in India. Hitherto this pest was a severe menace only on the aged and unmanaged fields but during the recent past it has also started damaging the newly established fields. In India, since Karnataka, Andra Pradesh, Tamil Nadu and Maharashtra are the major grape production states, the incidence of stem borer is also restricted and severe in these states. The grubs of the beetle bore in to the main stem and even the branches, which affect the translocation of nutrients to the areal parts of the plant. Since, the grubs bore inside the stem, the chewed material along with its excreta is discharged outside the holes and the frass is found on the ground just below the bored holes. The portion of vines above the damaged part has a sticky appearance. The leaves become pale yellow which looks like a deficiency of micronutrients. The leaves ultimately dry and drop down. The status of the incidence of the grape stem borer in different grape growing districts of Northern Karnataka was carried out during three years. In each taluka five locations were surveyed for the incidence of grape stem borer. Further, the experiment on management of stem borer was carried out in the grape gardens of Vijayapur districts under farmers field during three years. Stem borer infested plants that show live holes were selected per treatments and it was replicated three times. Live and dead holes observed during pre-treatment were closely monitored and only plants with live holes were selected and tagged. Different doses of chlorantraniliprole 0.4% GR were incorporated into the soil around the vine basins near root zone surrounded to trunk region by removing soils up to 5-10 cm with a peripheral distance of 1 to 1.5 feet from the main trunk where feeder roots are present. Irrigation was followed after application of insecticide for proper incorporation of the test chemical. The results indicated that there was sever to moderate incidence of the stem borer in all the grape growing districts of northern Karnataka. Maximum incidence was recorded in Belagavi (11 holes per vine) and minimum was in Gadag district (8.5 holes per vine). The investigations carried out to study the efficacy of chlorantraniliprole on grape stem borer for successive three years under farmers field indicated that chlorantraniliprole @ 15g/vine applied just near the active root zone of the plant followed by irrigation has successfully managed the pest. The insecticide has translocated to all the parts of the plants and thereby stopped the activity of the pest which has resulted in to better growth of the plant and higher berry yield compared to other treatments under investigation. Thus, chlorantraniliprole 0.4 GR @ 15g/vine can be effective means in managing the stem borer.

***Keywords*—**Chlorantraniliprole, grape stem borer, *Celosterna scrabrator,* management.

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I. Introduction

GRAPE stem borer, *Celosterna scrabrator* is a major production constraint in grapes in Indian situation. Hitherto, this pest was considered to be a problem only in old and neglected vineyards. However, in recent years, it has started invading even in one-year old gardens. In India, since Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra are the major grape production states in India. The incidence of stem borer is also very high in these four states. The grubs bore in to the main stem and branches and affect the translocation of nutrients and ultimately affects the growth of the plant. Since, the grubs bore inside the stem, the chewed material along with its excreta is discharged outside the holes and the frass is found on the ground just below the bored holes.

The adults make round hole on the vine and start emerging from the vines. Female beetle makes vertical slits on the bark of the trunk and even on the arms of the tree. The adult beetle lays eggs on the trunk, branches or the stem and the grubs, which hatch, bore into the stem directly. The adult beetles scrap the outer bark and feed on it. The leaves of damaged trees turn yellow in patches that resemble micronutrient deficiency, which ultimately dry and drop down. An adult beetle is dull yellow measuring about 4 cm long with minute spots. Eggs are capsule shaped and are laid singly in each of the slits and the slits are covered with a hard-gummy substance. Newly hatched grubs are cream colored with flat head which burrow into the trunk or arms and feed inside and make them hollow. The grubs pupate inside the tunnel made in the vine. In the beginning of the infestation, reddish sap oozes from the wound and chewed material of wood and excreta are observed just below the damaged plants. The boring of the grubs affects the translocation of sap to the plants and branches [1].

Owing to the serious magnitude of damage and limited work carried out on this insect in grape ecosystem, an experiment was laid out to evaluate the new formulation of chlorantraniliprole so the effective management strategies can be worked out. Further, there are no effective means for the management of this insect under field condition and no insecticides have label claim against grape stem borer. However, there is a current practice of using Dichlorovos 76 EC as stem injection by the farmer. Hence, chlorantraniliprole 0.4 GR, a new formulation as a soil applicant has been investigated for its effectiveness in the management of grape stem borer under field condition

II. Material and Methods

The experiment was conducted in Grape garden of Hittinahalli village near The Regional Agricultural Research Station, UAS Campus, Vijayapur (University of Agricultural Sciences, Dharwad-Karnataka-India) against the stem borer species, *Celosterna scrabrator* during 2014-15, 2015-16 and 2016-17

A. Survey for Incidence of Grape Stem Borer in Grape Growing Districts of Northern Karnataka

Survey was conducted in four different districts of northern Karnataka where grape is being grown during the December month of 2014-15 to 2015-2016. Four districts mainly Vijayapur, Bagalkote, Gadag and Belagavi were surveyed. In each district, the major grape growing taluks were observed and in each taluk five grape gardens were visited to observe the incidence of grape stem borer.

In Vijayapur district, five taluks (Vijayapur, Sindagi, Indi, Basavanabagewadi and Muddebihal), in Bagalakote district five taluks (Bagalakote, Badami, Hunagunda, Bilagi and Jamakhandi), five taluks in Belagavi district (Belagavi, Gokak, Athani, Ramadurga and Chikkodi) and two taluks in Gadag district (Gadag and Rona) were surveyed for the natural occurrence of grape stem borer. In each grape garden, nearly 20 vines were examined for the presence of live and dead holes made by the stem borer.

The pooled mean of total number of dead and live holes from 20 vines was averaged and holes per vine was computed and presented in Table I. Further, the average of all the taluks is calculated and presented as district average. Furthermore, the average of all the four districts is calculated and presented as total average.

B. Studies on the Management of Grape Stem Borer under Field Condition

For conducting this experiment, one stem borer infested plant that shows live holes was selected per treatments and it was replicated three times. Live holes were identified based on initial reddish sap/gum oozes from the wound and chewed material of wood and excreta seen below the damaged plant. During pre-treatment live and dead holes were closely monitored and only plants with live holes were selected and tagged. Cleaning of 1-2 meter area around the trunk of the plant was done before application of the insecticide.

C. Method of Application of Chlorantraniliprole 0.4% GR

Soil application of chlorantraniliprole was done near the plant root zone immediately after stem borer infestation was noticed i.e., initial symptoms like hole on the trunk, wooden frass coming out or fallen wooden frass on the ground below the infested plant. Different doses of chlorantraniliprole 0.4% GR were incorporated into the soil around the vine basins near active root zone surrounded to trunk region by removing soils up to 5-10 cm with a peripheral distance of 1 to 1.5 feet from the main trunk where feeder roots are present. Drip irrigation was given for proper incorporation of the granules of the insecticides. Only one application was done per season.

D. Method of Application of Dichlorvos 76 EC through Stem Injection

In India no insecticides have label claim against grape stem borer. However, there is a current practice of using Dichlorvos 76 EC as stem injection by the farmer. Hence this treatment was used as a standard treatment. For administering the insecticide solution into the live holes squeezed bottle of 250 ml capacity was used. Based on the length of the live hole, proportionate quantity of insecticidal solution was used. Insecticide quantity used was in proportion with the tunnel length. Stock solution of dichlorvos 76EC @ 80ml/liter was prepared and with the help of 250 ml capacity squeezed bottle, the insecticidal solution was administered in to the live hole till the tunnel gets filled up [2]. Observations were recorded on reduction in the live holes at 15, 20, 25, 30, 35, 40, 45, 50, 55 & 60 days after the treatment. The per cent reduction in the live hole was worked out and the data was subjected to arc sine transformation before analysis

III. Results and Discussion

A. Survey for Incidence of Grape Stem Borer in Grape Growing Districts of Northern Karnataka (Mean of Three Years)

The survey on the incidence of the stem borer was carried out in four grape growing districts of northern Karnataka for three years (2014-15 to 2016-17) and the mean values are presented in Table I.

Vijayapur district: In Vijayapur, the total number of holes ranged from 9.50 to 13.00 holes per vine. The number of live holes ranged between 4 to 8.5 holes per vine while, the dead holes ranged from 3.50 to 6.00 holes per vine. Highest number of live holes was found in Vijayapur taluk (8.50 holes/vine), whereas, lowest number was noticed in BasavanaBagewadi taluk (4 holes/vine)

Bagalkote district: In Bagalkote district totally five taluks were surveyed for the incidence of grape stem borer. Among the different taluks surveyed the number of holes ranged from 6.00 to 9.50 per vine. Among the different taluks, highest number of holes were found in Jamakhandi taluk (9.50) and minimum number of holes were noticed in Hunagund taluk (6.00). As per the live holes are concerned, maximum holes were registered in Bilagi taluk (6.50) and minimum holes in Bagalkote taluk (3.50). In Bagalkote district, the average number of total holes was 7.70 per vine of which 5.20 live holes and 2.5 dead holes

Belagavi district: In Belagavi district, the average total number of holes per vine was 11.00 of which 7.80 are live holes and 3.20 are dead holes. Among the different taluks surveyed, Ramadurg taluk recorded maximum number of live holes (9.50) whereas, Chikkodi taluk has recorded lowest live holes per vine (6.50)

Gadag district: In Gadag district, only two taluks were surveyed of which Gadag taluk has recorded more number of live holes (5.00) followed by Ron taluk (4.50).

In general, irrespective of the district, the average number of holes made by the stem borer was 9.52 per vine of which

6.01 holes were live holes and 3.51 holes were dead holes

TABLE I
SURVEY FOR THE INCIDENCE OF THE GRAPE STEM BORER IN NORTHERN KARNATAKA (MEAN OF THREE YEARS)

Districts	Taluk	Total no of holes/Vine	No. of live holes/Vine	No. of dead holes/Vine
Vijaya pura	Vijayapur	13.00	8.50	4.50
	Indi	9.50	5.50	4.00
	Sindagi	12.50	7.50	5.00
	BasavanBagevadi	10.00	4.00	6.00
	Muddebihal	9.50	6.00	3.50
District average		10.90	6.30	4.60
Bagal-kote	Bagalkote	6.50	3.50	3.00
	Badami	8.50	5.50	3.00
	Hunagund	6.00	4.50	1.50
	Bilagi	8.00	6.50	1.50
	Jamakhandi	9.50	6.00	3.50
District average		7.70	5.20	2.50
Belagavi	Belagavi	10.00	7.50	3.50
	Athani	11.50	8.00	3.50
	Ramadurga	12.50	9.50	2.00
	Gokak	10.50	7.50	3.00
	Chikkodi	10.50	6.50	4.00
District average		11.00	7.80	3.20
Gadag	Gadag	9.00	5.00	4.00
	Ron	8.00	4.50	3.50
District average		8.50	4.75	3.75
Total average		9.52	6.01	3.51

B. Management of Grape Stem Borer with Soil Application of Chlorantraniliprole

Reduction in the live holes: The observations on the number of live hole reduction (Pooled mean of three years) on the grape vine as influenced by different doses of Chlorantraniliprole 0.4GR is presented in Table II. The hole which discharges wet frass everyday was considered as live hole. The number of live holes was recorded before the imposition of treatments which ranged between 10 to 12 holes per vine and there was no statistical difference among the different treatment a day before treatment.

Since there was no statistical difference observed among the treatments up to 15 days after treatment, the data on live hole reduction is presented only after 15 days of the imposition of the treatments (DAT). At 15 DAT, there was a statistical difference among the treatments and the per cent live hole reduction varied from 1.25 to 98.50. Maximum reduction in the live holes was recorded in the treatment with standard check (Dichlorvos 70 EC @ 80 ml/l). Among different doses, chlorantraniliprole 0.4GR @ 15, 20 and 30 g/vine have recorded more reduction in the live holes. There was a gradual increase in the amount of live holes reduced towards 35 days after treatment in all the doses of chlorantraniliprole 0.4 GR. The treatment with chlorantraniliprole 0.4GR @ 15, 20 and 30 g/vine have recorded cent per cent reduction in the live holes at 35 DAT. These three doses were found statistically superior over other treatments and proved effective even up to 45 DAT.

Though at 50 DAT, there was a gradual decrease in the number of live holes reduced, the three doses (15, 20 and 30 g/vine) were very effective and in these treatments the live holes reduction at 60 DAT was more than 90 per cent. Chlorantraniliprole is belonging to a new class of selective insecticides (anthranilic diamides) which features a novel mode of action. The insecticide will activate the insect ryanodine receptors (RyRs) which ultimately release the intracellular calcium from the insect muscle cells. As a result of deplietion of calcium, the insect gets paralysed [3]. Chlorantraniliprole has a low mammalian toxicity and high intrinsic efficacy against the target insect pests with a strong ovi-larvicidal and larvicidal properties and no cross-resistance to any existing insecticide.

Reduction in frass: The frass collected per vine at different intervals is presented in Table III. It is evident from the results that there was no statistical difference among the different treatments at 1 and 3 DAT. At 5 DAT, there was a significant difference among the treatments where the amount of frass collected varied from 0.00 to 3.50 g/vine. Absolutely no frass was collected in the standard check (stem injection with dichlorvos 80 ml/l). Among the different doses, chlorantraniliprole 0.4 GR at 30 g /vine recorded less frass (0.70 g/vine) compared to other doses and was statistically on par with chlorantraniliprole 0.4GR @ 20 and 15 g/vine (0.80 and 1.00 g/vine, respectively). Similar trend was noticed in the efficacy of the treatments at 7 and 10 days after treatment wherein there was no frass collected in the standard check and among the different doses, chlorantraniliprole 0.4GR @ 15, 20 and 30 g /vine have recorded least amount of frass and were statistically on par with each other.

The standard check proved effective only up to 10 DAT, where there was no activity of insect noticed as indicated by zero amounts of frass in this treatment. But, after 15 DAT, there was a gradual increase in the amount of frass collected which clearly indicated the activity of the insect which has started damaging the stem. On the contrary to the standard check, the different doses of chlorantraniliprole 0.4GR have consistently prevented the activity of insect as indicated by the least amount of frass collected from 15 days to 30 days after treatment. Further, at 35 days after treatment, the activity of the insect was totally ceased and there was no frass collected in the treatments with chlorantraniliprole 0.4GR @ 15, 20 and 30 g/vine. These treatments proved very effective even up to 45 days after treatment indicating their superiority over other treatments. However, after 50 DAT there was a gradual increase in the frass collected which indicated that the test insecticide is most effective even up to 50 days of the treatment. In the lower dosages of chlorantraniliprole 0.4GR, there was no consistency in the result as indicated by the varied amount of frass collected over intervals.

The average frass collected and the total frass collected up to 60 DAT is presented in Table IV. Irrespective of the interval of the observation, the average from collected (15 days interval) was 0.64 to 4.10 g/vine. Lowest amount of average frass was collected in the treatments with chlorantraniliprole 0.4GR @ 15, 20 and 30g/vine with average frass amounting to 0.73, 0.81 and 0.64 g/vine, respectively.

TABLE II
INFLUENCE OF DIFFERENT DOSES OF CHLORANTRANILIPROLE 0.4GR (FERTERRA) ON THE LIVE HOLES OF GRAPE STEM BORER UNDER FIELD CONDITION (MEAN OF THREE YEARS)

Sl. No	Treatments	No. of live holes/vine before treatment	Live hole reduction (%) at different DAT									
			15	20	25	30	35	40	45	50	55	60
1	Chlorantraniliprole 0.4 GR (5g/Vine)	12.00	10.25	12.50	20.50	20.90	30.50	25.25	20.15	15.15	5.75	0.75
2	Chlorantraniliprole 0.4 GR (10g/Vine)	11.00	10.50	15.10	31.50	35.25	43.80	50.75	53.75	35.15	17.50	10.25
3	Chlorantraniliprole 0.4 GR (15g/Vine)	11.00	15.25	18.50	36.15	50.15	100.00	100.00	100.00	93.45	90.50	90.00
4	Chlorantraniliprole 0.4 GR (20g/Vine)	10.00	16.50	20.30	40.15	65.30	100.00	100.00	100.00	95.25	92.50	91.00
5	Chlorantraniliprole 0.4 GR (30g/Vine)	12.00	20.10	25.10	42.15	55.60	100.00	100.00	100.00	100.00	98.50	95.25
6	Dichlorvos stem injection (80ml/lt.) (Std. Check)	11.00	98.50	94.50	75.25	65.15	48.75	30.15	20.15	0.50	1.50	0.55
7	Untreated check	11.00	1.25	1.15	2.00	0.50	0.77	0.75	0.50	1.25	1.00	0.75
	SEm±	-	3.22	1.86	2.44	1.93	3.12	3.28	3.04	3.09	2.14	1.95
	CD (5%)	NS	9.93	5.66	7.43	5.93	9.65	10.11	9.28	9.52	6.60	6.04
	CV (%)	-	19.12	10.51	11.87	8.90	9.68	10.45	10.15	11.95	9.32	9.56

Note: DAT-Days After Treatment: Original values were transformed to arc sine transformation before analysis.

TABLE III
INFLUENCE OF DIFFERENT DOSES OF CHLORANTRANILIPROLE 0.4GR (FERTERRA) ON THE FRASS OF GRAPE STEM BORER UNDER FIELD CONDITION (MEAN OF THREE YEARS)

SI.No	Treatments	Frass collected per vine (gm) at different DAT														
		1	3	5	7	10	15	20	25	30	35	40	45	50	55	60
1	Chlorantraniliprole 0.4 GR (5g/Vine)	3.50	3.20	3.00	3.00	2.50	2.20	1.80	2.50	2.57	2.90	3.40	3.50	3.80	4.20	4.50
2	Chlorantraniliprole 0.4 GR(10g/Vine)	3.20	3.00	2.50	2.00	1.50	1.00	0.85	2.16	2.20	2.80	3.00	3.00	2.97	4.30	4.60
3	Chlorantraniliprole 0.4 GR(15g/Vine)	3.00	3.00	1.00	0.80	0.50	0.50	0.40	0.30	0.20	0.00	0.00	0.00	0.45	0.54	0.20
4	Chlorantraniliprole 0.4 GR(20g/Vine)	4.20	4.00	0.80	0.50	0.50	0.40	0.35	0.30	0.10	0.00	0.00	0.00	0.32	0.45	0.18
5	Chlorantraniliprole 0.4 GR(30g/Vine)	3.20	3.40	0.70	0.50	0.40	0.20	0.20	0.30	0.10	0.00	0.00	0.00	0.00	0.25	0.30
6	Dichlorvos stem injection (80ml/lt.) (Std. check)	4.10	2.10	0.00	0.00	0.00	0.85	1.20	2.10	2.50	2.90	3.10	3.45	3.80	4.00	4.10
7	Untreated check	3.20	2.80	3.50	4.30	4.00	4.23	4.85	4.25	4.38	5.13	4.10	4.30	3.80	4.10	4.50
	SEm±	-	-	0.09	0.11	0.07	0.08	0.08	0.07	0.08	0.11	0.07	0.06	0.08	0.10	0.09
	CD (5%)	NS	NS	0.30	0.35	0.23	0.25	0.24	0.21	0.26	0.34	0.22	0.21	0.27	0.30	0.30
	CV (%)	-	-	12.21	14.86	10.30	11.22	10.76	8.73	10.92	13.50	9.00	8.28	10.34	10.58	10.50

Note: DAT-Days After Treatment the original values were subjected to $\sqrt{X+0.5}$ transformation before analysis.

Further, the total frass collected (up to 60 days) in three doses was also less which was amounting to 9.55, 12.10 and 10.89 g/vine in the treatments with chlorantraniliprole 0.4GR @ 30, 20 and 15g/vine, respectively.

Therefore, it can be clearly inferred that among the different doses of chlorantraniliprole 0.4GR, though three doses *viz.* 15, 20 and 30 g/vine have recorded lowest frass per vine, the lower doses of 15g/vine can be a effective and economical dose for the management of stem borer. Further, the standard check (Dichlorvos) has proved very effective up to 10 DAT, thereafter, the efficacy declined and at 45 days after treatment it remained on par with the untreated check.

The present results clearly indicated the superiority of newer insecticide i.e. chlorantraniliprole 0.4GR in controlling grape stem borer. Further, as a soil applicant, chlorantraniliprole is taken up through plant roots and translocated throughout the different growing parts of the plant by providing protection against the insect pests [4]. There is no published literature to compare present findings as the present investigation is first of its kind to evaluate newer insecticide in the form of granules through soil application in grape ecosystem. However, the efficacy of chlorantraniliprole against many lepidopteran insect pests is well documented in various crops. The present results are in accordance with Mohan Kumar [5] who reported that chlorantraniliprole 18.5 SC recorded highest per cent reduction in the larvae of safflower leaf eating caterpillar, *Perigia capensis* in safflower ecosystem. Chlorantraniliprole 18.5 SC @ 0.20 ml/l has also exhibited superiority in controlling the larval population of citrus butterfly [6]. These findings are strongly supports to the results of the present study. The standard check, though was very effective in the beginning, there was steady decrease in

the reduction of live holes was observed, where it was almost on par with the untreated check at 60 DAT (Table IV). The efficacy of dichlorvos as a stem injection for the management of grape stem borer has been well documented by several workers [1], [2], [7], [8]. They reported 100 per cent reduction in the live holes at 7 days after stem injection of dichlorvos 76 EC @ 80ml/l of water, which is in agreement with the present findings.

TABLE IV
AVERAGE AND TOTAL FRASS COLLECTED IN DIFFERENT DOSES OF CHLORANTRANILIPROLE IN GRAPE (MEAN OF THREE YEARS)

Sl. No	Treatments	Average frass collected in g/vine (Average of 15 intervals)	Total frass collected in g/vine (Total of 15 intervals)
1	Chlorantraniliprole 0.4 GR (5g/Vine)	3.10	46.57
2	Chlorantraniliprole 0.4 GR (10g/Vine)	2.61	39.10
3	Chlorantraniliprole 0.4 GR (15g/Vine)	0.73	10.89
4	Chlorantraniliprole 0.4 GR (20g/Vine)	0.81	12.10
5	Chlorantraniliprole 0.4 GR (30g/Vine)	0.64	9.55
6	Dichlorvos stem injection (80ml/lt.) (Std. Check)	2.28	34.20
7	Untreated check	4.10	61.44

TABLE V
YIELD OF GRAPE AS INFLUENCED BY DIFFERENT DOSES OF CHLORANTRANILIPROLE (MEAN OF THREE SEASONS)

Sl. No	Treatments	Yield (kg/vine)
1	Chlorantraniliprole 0.4 GR (5g/Vine)	29.00
2	Chlorantraniliprole 0.4 GR (10g/Vine)	31.00
3	Chlorantraniliprole 0.4 GR (15g/Vine)	36.33
4	Chlorantraniliprole 0.4 GR (20g/Vine)	37.00
5	Chlorantraniliprole 0.4 GR (30g/Vine)	39.33
6	Dichlorvos stem injection (80ml/lt.) (Std. Check)	30.67
7	Untreated check	16.67
	SEm±	1.76
	CD (5%)	3.37
	CV (%)	6.40

IV CONCLUSION

Based on the observations recorded for three years, it can be clearly inferred that among the different doses, chlorantraniliprole 0.4GR @ 15g/vine was found to be effective against the stem borer which can be recommended for the control of grape stem borer as it provides long term protection to the plants against the borer with higher yields

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Published 75 research papers in peer reviewed national and international journals. Authored three books on IPM and Microbial pesticides and published 200 popular articles. Involved in the development of 10 crop protection technologies for the benefit of farming community. Attended several national seminars and conferences and presented more than 50 research papers. Participated in Scientific international conferences in Germany, France, Thailand, Israel and Netherlands and presented research papers. Operated several projects on microbial bio-pesticides and integrated pest management. Presently working on new paradigms in exploration of microbial endophytes in pest management.

Guiding M. Sc and Ph. D. students in Agricultural Entomology, Handling courses for UG and PG students. Active member of several prestigious national and international scientific bodies including the World Academy of Young Scientists, World Academy Science, Engineering and Technology, Indian Science Congress Association, Entomological Society of India etc. Presently working as Assistant Professor of Agricultural Entomology with the University of Agricultural Sciences, Dharwad (Karnataka-India)