Biological Forum – An International Journal **14(1): 936-940(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluation of Bioefficacy of Metaldehyde 2.5% Dry Pellet against Snails in Cabbage and its Phytotoxicity

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(Received 06 November 2021, Accepted 08 January, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Snails are important pest for a wide range of fruit orchards, ornamental plants, vegetables and field crops in India. They tend to feed on the softer parts of plants causing feeding damage to plant seedlings, with irregular holes in leaves, roots, tubers and fruits, decrease yield or cause loss of quality. Hence under such circumstances, a field experiment was conducted to evaluate the bio-efficacy and phytotoxicity of metaldehyde 2.5% dry pellet against snails in cabbage during *Rabi*, 2020, and *Kharif*, 2021. The treatments were: T_1- Metaldehyde 2.5% dry pellet @ 12.5g a.i./ha; T_2- Metaldehyde 2.5% dry pellet @ 37.5g a.i./ha; T_3- Metaldehyde 2.5% dry pellet @ 62.5g a.i./ha; T_4- Metaldehyde 2.5% dry pellet @ 87.5g a.i./ha; T_5- Carbofuran 3% GR @ 30g a.i./ha; T_6- Thiodicarb 75% WP @ 1-1.3g a.i./ha; T_7- Untreated control. Results revealed that among the different treatments Metaldehyde 2.5% dry pellet @ 87.5 g a.i./ha recorded significantly zero snails as compared to 6.00 in untreated check at 15 days after application and it was at par with Metaldehyde 2.5% dry pellet @ 62.5 g a.i./ha with 0.19 number of snails. The test compound was found to be relatively safe to natural enemies in the cabbage ecosystem and also did not cause any kind of phytotoxicity.

Keywords: Bio-efficacy, Phytotoxicity, Snails and cabbage.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*; family: Brassicaceae), is one of the most popular and the world's leading vegetable crops in terms of total production and worldwide consumption. It is rich in dietary fiber, minerals, vitamins, and other health-benefiting phytochemicals (*Chu et al*., 2002). In India, cole crops like cabbage, cauliflower, broccoli, turnip, kale, brussel sprouts, *etc.* are grown in hills and plains. Among them, cabbage (*Brassica oleracea* L. var. *capitata*) is being grown in an area of 0.399 million ha producing about 9.095 million tonnes per annum (Anonymous, 2018). Major cabbage growing states in the country are Uttar Pradesh, Orissa, Bihar, West Bengal, Assam, Karnataka, Maharashtra, Madhya Pradesh, and Tamil Nadu.

Terrestrial gastropod molluscs (slugs and snails) are one of the most diverse and successful animal groups in the terrestrial environment. Crop damage from molluscs has occurred throughout history, however twentieth-century agricultural practices, such as the cultivation of new crops, the intensification of farming systems, and the transportation of plant material, has led to molluscs adapting to these modified habitats, thus becoming significant crop pests of tropical and temperate regions (Bailey, 2002). Many snail species have also achieved pest status worldwide. The giant African snail, *Achatina fulica* (Ferussac) (Achatinidae), is a serious pest of gardens and crops in subtropical and tropical regions, capable of consuming 10% of its own body weight in a day (Schreurs, 1963). *Cornu aspersum* (Müller) (Helicidae) is a well-known, cosmopolitan pest that has been transported to most parts of the world (Guiller *et al*., 2012; Peltanova *et al.*, 2012).

The snail is known for its high reproductive rate and for its aggregative invasive behavior, with one report of approximately 3,000 snails surrounding a single citrus tree (Mead, 1971). Snails from the Achatinidae family are not only considered crop pests, but they also pose a human health risk for the transmission of *Angiostrongylus cantonensis* (Chen) and *Angiostrongylus costaricensis* (Morera & Céspedes) (Rhabditida: Angiostrongylidae) (Carvalho *et al*., 2003; Hollingsworth *et al*., 2007; Ross, 2019).

Land snails and slugs (Mollusca: Gastropoda) are important pests for a wide range of fruit orchards, ornamental plants, vegetables, and field crops all over the world. They tend to feed on the softer parts of plants causing damage to plant seedlings, with irregular holes in leaves, roots, tubers, and fruits, decrease yield or cause loss of quality due to the presence of snails or slugs or their feces in the harvested product (Godan, 1983). Snail management with pesticides is difficult because of the snail's biology and the lack of materials that are effective. Because of the snails' ability to "slime", most toxins that are contact poisons are sloughed off. The only true molluscicide in the United States is metaldehyde, which is commonly marketed as Deadline Bullets. The activity comes from its ability to cause the mucus producing cells found in snails to burst, causing the death of the snail.

If metaldehyde bait were applied to cabbage once the slugs had already entered into the heads, it is questionable whether they would still be attracted to the bait and come out of the heads. So this study will be undertaken to evaluate the efficacy of metaldehyde in managing the snails on cabbage.

MATERIALS AND METHODS

The field experiment was carried out during *Rabi*-2020 and *Kharif*-2021 at Agricultural Research Station, Gangavathi, Karnataka, India. The experiment was laid out in randomized block design with seven treatments and three replications. The cabbage seedlings of variety Green Valley for Kharif and Rabi were transplanted in the field with 45cm × 45cm spacing with a plot size of 5m × 5m for each treatment. The standard agronomic practices as per the recommendation of UAS Raichur (Anonymous, 2017) were followed except plant protection measures.

Treatment details for bio efficacy studies.

Tr. No.	Treatment	Dosage (g a.i. /ha)	Formulation (g/ha)	Method of application
1.	Metaldehyde 2.5% dry pellet	12.5	312.5	Broadcast in field
2.	Metaldehyde 2.5% dry pellet	37.5	937.5	Broadcast in field
3.	Metaldehyde 2.5% dry pellet	62.5	1562.5	Broadcast in field
4.	Metaldehyde 2.5% dry pellet	87.5	2187.5	Broadcast in field
5.	Carbofuran 3% GR	30	1000	Broadcast in field
6.	Thiodicarb 75% WP	1-1.3	750-1000	Foliar spray
7.	Untreated control	--	--	

Treatment details for phytotoxicity studies.

Tr. No.	Treatment	Dosage (g a.i. /ha)	Formulation (g/ha)	Method of application
1.	Metaldehyde 2.5% dry pellet	12.5	312.5	Broadcast in field
2.	Metaldehyde 2.5% dry pellet	37.5	937.5	Broadcast in field
3.	Metaldehyde 2.5% dry pellet	62.5	1562.5	Broadcast in field
4.	Metaldehyde 2.5% dry pellet	87.5	2187.5	Broadcast in field
5.	Untreated control	--	--	

Observations:

(i) Snails in cabbage field. Observations were made on the number of snails in 10 randomly selected plants in the plot before application and at 1, 5, 10, and 15 days after 1^{st} application and 2^{nd} application. The collected data were subjected to statistical analysis and per cent reduction over control was calculated after each spray. Further, these data were subjected to statistical analysis after transforming them to square root transformation ($\sqrt{x+1}$).

(ii) Impact on natural enemies. Recorded the pre and post-application effect of a test chemical on the number of natural enemies' population *viz*., toads per plot present in the cabbage ecosystem during the study at 5, 10, and 15 days after application.

Head yield: Head yield was recorded at the time of final harvest plot wise (in kilograms), later it was converted to quintals per hectare (q/ha).

Phytotoxicity studies: The observation on phyto-toxicity symptoms *viz*., leaf tip burning, necrosis, wilting, stunting, yellowing, vein clearing, hyponasty and epinasty were recorded at 3, 5, 7 and 10 days after application by using following scale.

Phytotoxicity rating Scale (PRS):

% injury	Scale	% injury	Scale
0-10%	1	51-60%	6
11-20%	2	61-70%	7
21-30%	3	71-80%	8
31-40%	4	81-90%	9
41-50%	5	91-100%	10

RESULTS AND DISCUSSION

A. Snails in cabbage

During the first application before the imposition of insecticides, the number of snails was uniform ranging from 4.85 to 5.33 snails per plot (Table 1). However, variation was observed only after the imposition of the treatments. Among the different treatments Metaldehyde 2.5% dry pellet @ 87.5 g a.i./ha recorded significantly zero snails as compared to 6.00 in untreated check with 100.00% reduction over control at 15 days after application and it was at par with Metaldehyde 2.5% dry pellet @ 62.5 g a.i./ha with 0.19 number of snails with 96.92% reduction over control. Metaldehyde 2.5% dry pellet @ 37.5 g a.i./ha was the next best treatment (1.39 number of snails) followed by Thiodicarb 75% WP @ 1-1.3 g a.i./ha (1.48 number of snails), Carbofuran 3% GR @ 30 g a.i./ha (1.66 number of snails) and Metaldehyde 2.5% dry pellet @ 12.5 g a.i./ha (1.87 number of snails) (Table 1).

Table 1: Bioefficacy of Metaldehyde 2.5% dry pellet against snails in cabbage during first application in *Rabi*-2020 and *Kharif*- 2021 (Pooled data).

Tr. No	Treatment details	Dose (g a.i./ha)	Number of snails					% ROC
			DBS	1 DAS	5 DAS	10 DAS	15 DAS	
T_1	Metaldehyde 2.5% dry pellet	12.5	5.02 (2.45)	4.60 (2.36)	3.59 (2.14)	2.78 (1.94)	1.87 (1.69)	68.88
T_2	Metaldehyde 2.5% dry pellet	37.5	4.85 (2.41)	4.24 (2.28)	3.40 (2.09)	2.39 (1.84)	1.39 (1.54)	77.01
T_3	Metaldehyde 2.5% dry pellet	62.5	5.30 (2.50)	4.48 (2.33)	2.72 (1.92)	1.07 (1.44)	0.19 (1.08)	96.92
T_4	Metaldehyde 2.5% dry pellet	87.5	4.97 (2.44)	3.88 (2.20)	1.92 (1.69)	0.45 (1.19)	0.00 (1.00)	100.00
T_5	Carbofuran 3% GR	30	5.33 (2.50)	4.70 (2.38)	3.35 (2.07)	2.65 (1.90)	1.66 (1.62)	72.31
T_6	Thiodicarb 75% WP	1 - 1.3	4.94 (2.43)	4.30 (2.29)	3.35 (2.08)	2.29 (1.81)	1.48 (1.57)	75.39
T_7	Untreated control	-	5.15 (2.48)	5.22 (2.49)	5.48 (2.54)	5.74 (2.59)	6.00 (2.64)	-
S.Em.±			0.39	0.37	0.32	0.25	0.17	-
C.D. (p=0.05)			NS	NS	0.98	0.77	0.53	-
C.V. (%)			10.40	10.69	11.02	12.60	11.79	-

Note: DBS=Day before Spray; DAS=Day after Spray; NS-Non Significant; ROC-Reduction over control; Figures in the parentheses are $\sqrt{x+0.5}$ transformations

A similar trend was noticed during the second application also where in the treatments Metaldehyde 2.5% dry pellet @ 87.5 g a.i./ha and Metaldehyde 2.5% dry pellet @ 62.5 g a.i./ha recorded zero snails with 100.00% reduction over control followed by Metaldehyde 2.5% dry pellet @ 37.5 g a.i./ha and Thiodicarb 75% WP @ 1-1.3 g a.i./ha with 0.80 and 0.84 snails respectively (Table 2).

The literature pertaining to the bioefficacy of Metaldehyde 2.5% dry pellet against snails in cabbage is very scanty.

Table 2: Bioefficacy of Metaldehyde 2.5% dry pellet against snails in cabbage during second application in *Rabi*-2020 and *Kharif*- 2021 (Pooled data)

Tr. No	Treatment details	Dose (g a.i./ha)	Number of snails					% ROC
			DBS	1 DAS	5 DAS	10 DAS	15 DAS	
T_1	Metaldehyde 2.5% dry pellet	12.5	3.97 (2.23)	3.38 (2.08)	2.79 (1.93)	1.97 (1.71)	1.10 (1.44)	82.92
T_2	Metaldehyde 2.5% dry pellet	37.5	3.92 (2.21)	3.25 (2.05)	2.58 (1.88)	1.87 (1.68)	0.80 (1.34)	87.57
T_3	Metaldehyde 2.5% dry pellet	62.5	3.79 (2.19)	2.92 (1.97)	1.67 (1.63)	0.49 (1.22)	0.00 (1.00)	100.00
T_4	Metaldehyde 2.5% dry pellet	87.5	3.62 (2.14)	2.72 (1.92)	1.39 (1.54)	0.05 (1.02)	0.00 (1.00)	100.00
T_5	Carbofuran 3% GR	30	3.88 (2.20)	3.40 (2.08)	2.57 (1.87)	1.70 (1.63)	0.87 (1.36)	86.48
T_6	Thiodicarb 75% WP	1 - 1.3	4.04 (2.24)	3.40 (2.09)	2.55 (1.87)	1.65 (1.62)	0.84 (1.35)	86.95
T_7	Untreated control	-	5.80 (2.61)	5.99 (2.64)	6.17 (2.67)	6.32 (2.70)	6.45 (2.73)	-
S.Em.±			0.24	0.35	0.45	0.64	0.62	-
C.D. (p=0.05)			0.72	1.02	1.33	1.89	1.82	-
C.V. (%)			10.46	11.71	12.81	10.06	12.47	-

Note: DBS=Day before Spray; DAS=Day after Spray; NS-Non Significant; ROC-Reduction over control; Figures in the parentheses are $\sqrt{x+0.5}$ transformations

So, some of the similar studies conducted to evaluate the bioefficacy of Metaldehyde were discussed here to support the present study. The present findings are in agreement with the results of Pieterse *et al*. (2020) who reported that metaldehyde at a concentration of 40 g/kg caused significantly higher snail mortality compared with 15 g/kg treatments on most days during the trial. Bourne *et al.* (1988) reported that metaldehyde has a greater feeding deterrence, and maybe inherently more toxic than methiocarb. The symptoms of poisoning between the two were different because methiocarb poisoned snails gained weight and appeared bloated, whereas metaldehyde poisoned slugs lost weight and adopted a darker, shrunken appearance.

B. Impact on natural enemies

Recorded the pre and post-application effect of a test chemical on the number of natural enemies' population *viz*., toads present in the cabbage ecosystem during the study at intervals of before and 5, 10 and 15 days after application. Further, these data were subjected to statistical analysis after transforming them to square root transformations (Table 3).

Impact on head yield: Head yield in all the dosages of Metaldehyde 2.5% dry pellet was significantly higher when compared to untreated check (188.61 q/ha). Significantly higher head yield of 289.24 q/ha was recorded in Metaldehyde 2.5% dry pellet @ 87.5 g a.i./ha and it was followed by Metaldehyde 2.5% dry pellet @ 62.5 g a.i./ha (285.63 q/ha), Metaldehyde 2.5% dry pellet @ 37.5 g a.i./ha (264.64 q/ha), carbofuran 3% GR @ 30 g a.i./ha (261.23 q/ha), Thiodicarb 75% WP @ 1.3 g a.i./ha (258.29 q/ha) and Metaldehyde 2.5% dry pellet @ 12.5 g a.i./ha (226.53 q/ha) (Table 4).

Table 3: Impact of Metaldehyde 2.5% dry pellet on natural enemies in cabbage ecosystem during *Rabi*-2020 and *Kharif*- 2021 (Pooled data).

Tr. No	Treatment details	Dose (g a.i./ha)	Number of toads			
			DBS	5 DAS	10 DAS	15 DAS
T_1	Metaldehyde 2.5% dry pellet	12.5	2.15 (1.77)	1.82 (1.68)	1.70 (1.64)	1.84 (1.68)
T_2	Metaldehyde 2.5% dry pellet	37.5	2.15 (1.77)	1.79 (1.66)	1.64 (1.61)	1.74 (1.65)
T_3	Metaldehyde 2.5% dry pellet	62.5	2.29 (1.81)	1.77 (1.66)	1.59 (1.60)	1.69 (1.64)
T_4	Metaldehyde 2.5% dry pellet	87.5	2.17 (1.77)	1.72 (1.65)	1.52 (1.58)	1.62 (1.62)
T_5	Carbofuran 3% GR	30	2.11 (1.75)	1.80 (1.67)	1.70 (1.64)	1.78 (1.66)
T_6	Thiodicarb 75% WP	1 - 1.3	2.12 (1.76)	1.82 (1.67)	1.69 (1.63)	1.78 (1.66)
T_7	Untreated control	-	2.34 (1.82)	2.65 (1.87)	2.62 (1.90)	2.73 (1.93)
S.Em.±			0.16	0.16	0.19	0.17
C.D. (p=0.05)			NS	NS	NS	0.50
C.V. (%)			11.12	13.15	10.45	12.09

Note: DBS=Day before Spray; DAS=Day after Spray; NS-Non Significant; ROC-Reduction over control; Figures in the parentheses are $\sqrt{x+0.5}$ transformations

Table 4: Impact of Metaldehyde 2.5% dry pellet on head yield in cabbage (Pooled data of two seasons).

Treatment details	Head yield (q/ha)		
	Kharif	Rabi	Pooled
Metaldehyde 2.5% dry pellet	220.44	232.62	226.53
Metaldehyde 2.5% dry pellet	262.06	267.23	264.64
Metaldehyde 2.5% dry pellet	284.71	286.55	285.63
Metaldehyde 2.5% dry pellet	288.14	290.34	289.24
Carbofuran 3% GR	260.53	261.93	261.23
Thiodicarb 75% WP	257.91	258.67	258.29
Untreated control	186.35	190.88	188.61
S.Em.±	0.53	0.55	0.62
C.D. (p=0.05)	1.66	1.71	1.94
C.V. (%)	5.54	5.97	6.80

Phytotoxicity: The data on phytotoxicity symptoms revealed that Metaldehyde 2.5% dry pellet did not cause phytotoxicity in any form (epinasty, hyponasty, necrosis, leaf tip burning, wilting and stunting) (Table 5).

Table 5. Evaluation of Metaldehyde 2.5% dry pellet for phytotoxicity on cabbage plants.

Tr. No	Treatments	Dose (g a.i./ha)	Phytotoxicity symptoms						
			Necrosis	Wilting	Vein clearing	Stunting	Yellowing	Epinasty	Hyponasty
a. 3 Days after spray									
T_1	Metaldehyde 2.5% pellet	12.5	0	0	0	0	0	0	0
T_2	Metaldehyde 2.5% pellet	37.5	0	0	0	0	0	0	0
T_3	Metaldehyde 2.5% pellet	62.5	0	0	0	0	0	0	0
T_4	Metaldehyde 2.5% pellet	87.5	0	0	0	0	0	0	0
T_5	Untreated Check	-	0	0	0	0	0	0	0
b. 5 days after spray									
T_1	Metaldehyde 2.5% pellet	12.5	0	0	0	0	0	0	0
T_2	Metaldehyde 2.5% pellet	37.5	0	0	0	0	0	0	0
T_3	Metaldehyde 2.5% pellet	62.5	0	0	0	0	0	0	0
T_4	Metaldehyde 2.5% pellet	87.5	0	0	0	0	0	0	0
T_5	Untreated Check	-	0	0	0	0	0	0	0
c. 7 days after spray									
T_1	Metaldehyde 2.5% pellet	12.5	0	0	0	0	0	0	0
T_2	Metaldehyde 2.5% pellet	37.5	0	0	0	0	0	0	0
T_3	Metaldehyde 2.5% pellet	62.5	0	0	0	0	0	0	0
T_4	Metaldehyde 2.5% pellet	87.5	0	0	0	0	0	0	0
T_5	Untreated Check	-	0	0	0	0	0	0	0
d. 10 days after spray									
T_1	Metaldehyde 2.5% pellet	12.5	0	0	0	0	0	0	0
T_2	Metaldehyde 2.5% pellet	37.5	0	0	0	0	0	0	0
T_3	Metaldehyde 2.5% pellet	62.5	0	0	0	0	0	0	0
T_4	Metaldehyde 2.5% pellet	87.5	0	0	0	0	0	0	0
T_5	Untreated Check	-	0	0	0	0	0	0	0

CONCLUSION

Based on the evaluations it can be concluded that the insecticide Metaldehyde 2.5% dry pellet @ 87.5 g a.i./ha was found effective in reducing the snail populations and obtaining a higher head yield. Further, it had less impact on natural enemies and did not cause phytotoxicity to the cabbage crop. So Metaldehyde 2.5% dry pellet @ 87.5 g a.i./ha can be used for the effective management of snail pests in the field.

Acknowledgement. The authors are very much grateful to the college of Agriculture, Gangavathi for providing the field facilities for conducting the experiment. Further, all sort of financial assistance rendered by M/s. PI Industries Limited for the above study is gratefully acknowledged.

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How to cite this article: Badari Prasad P.R., Raghavendra Yaligar, Sujay Hurali, Mansoor, Suhasini and Hanumanthappa Shrihari (2022). Evaluation of Bioefficacy of Metaldehyde 2.5% Dry Pellet Against Snails in Cabbage and its Phytotoxicity. *Biological Forum – An International Journal, 14*(1): 936-940.