Original Research Article

Management of carrot root borer, *Melanagromyza* sp. in carrot *Dacus carota* L.

Abstract

A field experiment was conducted during *rabi*/*summer* 2021-22 at Nagaral village of Ron taluka in Gadag district, Karnataka to identify the appropriate causal agent for carrot root damage and to assess the field efficiency of different insecticide molecules against agromyzid fly, *Melanagromyza* sp. The experiment was laid out in randomized block design with 11 treatments replicated thrice. The crop was cultivated during 1st January 2022 as per the recommended package of practices except the insect protection measures. Observation on per cent infestation by agromyzid fly was recorded in each treatment by adopting a destructive sample technique from 40 days after sowing to 100 days after sowing. Per cent damage and yield parameters were subjected to one-way ANOVA and Duncan's Multiple Range Test. Result indicated that highest reduction of agromyzid fly damage over untreated control was recorded in treatment with soil application with chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS (71.86% reduction over control) and soil application with fipronil 0.3 % GR @ 20 kg/ha at 35 DAS with 69.10 per cent reduction over control. These are followed by seed treatment with cyantraniliprole 19.8% + thiamethoxam 19.8% @10 ml/kg, seed treatment with thiamethoxam 30 FS @ 10 ml/kg, seed treatment with imidacloprid 600 FS @ 10ml/kg and soil drenching with chlorpyriphos 20% EC @ 3 ml/l at 35 DAS, these treatments registered a maximum reduction of agromyzid fly *viz*., 69%, 58.03%, 56.79% and 58.03%, respectively.

Keywords: Carrot, Chlorantraniliprole, Management, *Melanagromyza* sp., *Metarhizium anisopliae*

1.INTRODUCTION

Carrot *Daucus carota* L. is an important vegetable belongs to the family Apiaceae (Peirce 1987). It is thought to be a native of the Mediterranean region (Shinohara 1984) and is primarily grown in temperate climates, but it is also cultivated

in tropical and subtropical regions (Rubatzky *et al.* 1999). Carrot is an essential root crop from a nutritional perspective (Yawalkar 1985). Carrot is used in pickles, preserves, sweets, carrot powder, kanji, salads, cooked vegetables and other delectable beverages (Chadha 2003). Carrot is planted throughout India, with a total area of 0.6433 million hectares and a production of 4.14 million tonnes. Karnataka holds a 5.06% share with respect to total production with a production of 96.63 million tonnes (Anonymous 2021). The major carrot-growing districts in Karnataka are Belagavi, Gadag, Dharwad, Bengaluru, Bagalkot and other districts (Neeru 2021).

Various insect pests are known to attack carrot crop, among these insect pest complex, root bores cause significant economic damage to the crop especially during *rabi/summer*. Some of the most serious insect pests which attack carrot are as follows: carrot weevil, *Listronotus oregonensis* LeConte; carrot rust fly, *Psila rosae* Fabricius; carrot psyllid *Trioza apicalis* Forster; aster leaf hopper, *Macrosteles quadrilineatus* Forbes; willow carrot aphid, *Cavariella aegopodii* Scopoli; cutworm, *Agrotis segetum* Denis; pale striped flea beetle, *Systena blanda* Melsheimer; aphid *Myzus persicae* sulzer, from United States of America (Delahaunt and Newenhouse 1998); semilooper, *Thysanoplusia orichalcea* Fabricius; and thrips, *Aeolothrips meridionalis* Bagnall from Jammu and Kashmir (Bhat and Ahangar 2018). However, none of the studies ascertained the economic damage caused by these pests on carrot.

During present studies, significant economic yield loss of carrot due to infestation by an agromyzid fly was noticed. The damage caused by the maggot of the fly led to severe injury to the taproot, resulting in the production of inferior quality carrots with lower marketable prices. To address this issue, a study was conducted to determine efficacy of different insecticide molecules on agromyzid fly.

2. MATERIALS AND METHODS

An experiment was carried out at Nagaral village of Ron taluk in Gadag district, Karnataka to assess the field efficiency of different insecticide molecules against agromyzid fly. The experiment was laid out in randomized block design with 11

treatments replicated thrice in 1.83 × 1.23 m plot size. The carrot was cultivated during 1st January 2022 as per the recommended package of practices (Anonymous 2013) except the insect protection measures. The village, Nagaral is situated at 15º 25' North latitude and 75º 37' East longitude with an altitude of 655 meters above mean sea level which lies in northern dry zone of Karnataka (Zone III). The average annual rainfall was 650 mm. The treatments are, Seed treatment with thiamethoxam 30% FS @ 10 ml/kg/kg (T_1), Seed treatment with cyantraniliprole 19.8 % + Thiamethoxam 19.8% @ 10 ml/kg (T_2), Seed treatment with imidacloprid 600 FS 10 ml/kg (T_3), Soil drenching with chlorpyrifos 20% EC @ 3 ml/l at 35 DAS (T_4), Soil application of chlorantraniliprole 0.4% GR 10 kg/ha at 35 DAS (T_5), Soil application with fipronil 0.3% GR 20 kg/ha at 35 DAS(T_6), Foliar spray with chlorantraniliprole 18.5% @ 0.3 ml/l at 25 DAS (T_7), Soil application of *Metarhizium anisopliae* (cfu 2×10^8/g) @ 7.50 kg/ha at sowing (T_8), Soil application of pongamia cake @ 250 kg/ha at sowing (T_9), Soil application of neem cake @ 250 kg/ha at sowing (T_{10}) and Untreated control (T_{11}). Observation on per cent infestation/damage by agromyzid fly was recorded in each treatment by adopting a destructive sample technique from 40 DAS to 100 DAS. Three spots were selected and in each spot five plants were selected randomly and per cent infestation was calculated.

$$\text{Per cent infestation} = \frac{\text{Number of infested plants}}{\text{Total number of plants}} \times 100$$

The yield of carrot was recorded from each treatment plot by excluding the damaged roots and then expressed in tonnes/hectare. Based on the yield data, cost of plant protection, total cost of production, gross returns and net returns were calculated for each treatment. The selling price of the carrot was used to calculate the gross returns and the net returns of the various treatments was calculated by subtracting the total cost of production from the gross returns. Finally, benefit cost ratio (B: C ratio) was calculated for each treatment.

$$\text{B: C Ratio} = \frac{\text{Net Returns (Rs/ha)}}{\text{Cost of control measures in the treated plot (Rs/ha)}}$$

Net Returns (Rs/ha) = Gross Returns (Rs/ha) - the cost of control measures in the treated plot (Rs/ha). Cost of control measures in the treated plot (Rs/ha) = cost of insecticide (Rs/ha) + cost of application (Rs/ha). The data on per cent infestation of agromyzid fly and mean number of sucking pests and yield parameters as stated above were subjected to one-way ANOVA, after angular and square root transformation, respectively. The differences in the observations among the different treatments were compared by following Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

The soil application with chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS (10.00%), soil application with fipronil 0.3% GR @ 20 kg/ha at 35 DAS (10.00 %) and seed treatment with cyantraniliprole 19.8% + thiamethoxam 19.8% @ 10 ml/kg (10.00%) recorded significantly lowest per cent infestation and were on par with each other. The next best treatments in the order of efficacy were seed treatment with thiamethoxam 30 FS @ 10 ml/kg (13.33%), this was on par with soil drenching with chlorpyriphos 20% EC @ 3 ml/l at 35 DAS (13.33%) followed by seed treatment with imidacloprid 600 FS @ 10 ml/kg (16.69%). The foliar spray with chlorantraniliprole 18.5% @ 0.3 ml/l at 25 DAS (23.33%), soil application of neem cake @ 250 kg/ha at sowing (23.33%) and pongamia cake @ 250 kg/ha at sowing (23.33%) were moderately effective and on par with each other. The soil application of *Metarhizium anisopliae* (cfu 2×10^8/g) @ 7.50 kg/ha at sowing (43.33%) had the least efficacy as compared to all other treatments However, untreated control recorded highest per cent infestation (46.67%) at 40 days after sowing. Same trend was followed in the efficacy of different treatments at 55, 70. 85 and 100 days after sowing. However, all the treatments found significantly superior over control (Table 1).

The results pertaining to the mean indicated that, lowest % mean infestation of agromyzid fly was recorded in soil application with chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS (15.20%) followed by seed treatment with cyantraniliprole 19.8% + thiamethoxam 19.8% @ 10 ml/kg (16.73 %) and soil application with fipronil 0.3% GR @ 20 kg/ha at 35 DAS (16.74%). However, the highest mean population of agromyzid fly was recorded in untreated control (54%) followed by soil application of

Metarhizium anisopliae (cfu 2 × 10^8/g) @ 7.50 kg/ha at sowing (46.67%), soil application of pongamia cake @ 250 kg/ha at sowing (29.33%) and soil application of neem cake @ 250 kg/ha at sowing (28.68%). Overall efficacy of tested treatments indicated that, the most effective treatment was soil application with chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS with 71.86% reduction over control followed by soil application with fipronil 0. % GR @ 20 kg/ha at 35 DAS with 69.10% reduction over control (Table 1).

Significantly highest carrot yield of 17.78 t/ha was obtained in the treatment of soil application with chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS which was on par with soil application of fipronil 0.3% GR @ 20 kg/ha at 35 DAS with 16.44 tonnes per hectare. Significantly the highest B: C ratio of 3.00 was obtained in soil application of chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS followed by soil application of fipronil 0.3% GR @ 20 kg/ha at 35 DAS (2.67). The maximum net returns were encountered from soil application of chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS with 1,99,916.67 Rs/ha this was followed by soil application of fipronil 0.3% GR @ 20 kg/ha at 35 DAS (179526.67 Rs/ha) as evident from table 2.

The highest reduction in the % infestation of agromyzid fly was recorded in soil application with chlorantraniliprole 0.4 % GR @ 10 kg/ha at 35 DAS with 71.86% reduction over control and next best treatment was soil application with fipronil 0.3% GR @ 20 kg/ha at 35 DAS with 69.10% reduction over control.

Table 1: Efficacy of insecticides against agromyzid fly (*Melanogromyza* sp.) in carrot during *rabi/summer* 2021-22

Treatment details	Per cent infestation of *Melanogromyza* sp.					Mean	ROC (%)
	40 DAS	55 DAS	70 DAS	85 DAS	100 DAS		
T_1 - ST with thiamethoxam 30% FS @ 10 ml/kg	13.33 (21.39)[b]	20.00 (26.54)[b]	23.33 (28.85)[b]	26.67 (31.06)[b]	30.00 (33.18)[b]	22.67	58.03
T_2 - ST with cyantraniliprole 19.8% + thiamethoxam 19.8% @ 10 ml/kg	10.00 (18.41)[a]	13.33 (21.39)[a]	16.67 (24.07)[a]	20.00 (26.54)[a]	23.67 (29.08)[a]	16.73	69.00
T_3 - ST with imidacloprid 600 FS @ 10 ml/kg	16.69 (24.07)[b]	20.00 (26.54)[b]	23.33 (28.85)[b]	26.67 (31.06)[b]	30.00 (33.18)[b]	23.33	56.79
T_4 - Soil drenching with chlorpyrifos 20% EC @ 3 ml/l at 35 DAS	13.33 (21.39)[b]	20.00 (26.54)[b]	23.33 (28.85)[b]	26.67 (31.06)[b]	30.00 (33.18)[b]	22.67	58.03
T_5 - Soil application with chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS	10.00 (18.41)[a]	13.33 (21.39)[a]	15.22 (22.76)[a]	17.43 (24.65)[a]	20.00 (26.54)[a]	15.20	71.86
T_6 - Soil application with fipronil 0.3 % GR @ 10 kg/ha at 35 DAS	10.00 (18.41)[a]	13.33 (21.39)[a]	16.69 (24.07)[a]	20.00 (26.54)[a]	23.67 (29.08)[a]	16.74	69.10
T_7 - Foliar spray with chlorantraniliprole 18.5% @ 0.3 ml/l at 25 DAS	23.33 (28.85)[c]	26.67 (31.06)[c]	30.00 (33.18)[c]	33.33 (35.23)[c]	33.33 (35.23)[c]	29.33	45.68
T_8 - Soil application with *Metarhizium anisopliae* (cfu 2 × 10^8/g) at sowing	43.33 (41.15)[d]	46.67 (43.08)[d]	46.67 (43.08)[d]	50.00 (45.00)[d]	46.67 (43.08)[d]	46.67	13.58
T_9 - Soil application with pongamia cake @ 250 kg/ha at sowing	23.33 (28.85)[c]	26.67 (31.06)[c]	30.00 (33.18)[c]	33.33 (35.23)[c]	33.33 (35.23)[c]	29.33	45.68
T_{10} - Soil application with neem cake @ 250 kg/ha sowing	23.33 (28.85)[c]	26.67 (31.06)[c]	28.82 (32.44)[c]	31.24 (33.95)[c]	33.33 (35.23)[c]	28.68	46.89
T_{11} - Untreated control	46.67 (43.08)[e]	50.00 (45.00)[e]	56.67 (48.87)[e]	56.67 (48.87)[e]	60.00 (50.83)[e]	54.00	0.00
S. Em. ±	1.10	1.41	1.65	1.50	1.10	-	
C.D. at 5 %	3.32	4.17	4.85	4.52	3.32	-	
C.V. (%)	10.82	10.36	10.45	11.15	10.92	-	

Figures in parenthesis are angular transformed values, Means showing similar alphabets do not differ significantly by DMRT, DAS – Days after sowing, ROC - Reduction over control, ST - Seed treatment

These were followed by seed treatment with cyantraniliprole 19.8% + thiamethoxam 19.8 % @ 10 ml/kg with, seed treatment with thiamethoxam 30 FS @ 10 ml/kg, seed treatment with imidacloprid 600 FS @ 10 ml/kg and soil drenching with chlorpyriphos 20% EC @ 3 ml/l at 35 DAS, these treatments registered maximum reduction of agromyzid fly *viz*., 69%, 58.03%, 56.79% and 58.03% reduction over untreated control, respectively (Fig 1).

Very limited studies have been documented on the management of insect pests of carrot with insecticide molecules *i.e.*, the information regarding above studies are scanty. However, available literatures indicated that chlorantraniliprole, a novel insecticide belongs to the anthranilic diamide class of insecticides, it activates ryanodine receptors and stimulates Ca_2^+ release from muscle cells leading to feeding cessation, lethargy, muscle paralysis and ultimately death in vulnerable species (Cordova *et al*. 2006). Kumar *et al.* (2009) reported that seed treatment with imidacloprid was free from stem fly, *Melanagromyza sojae* incidence and was on par with seed treatment with thiamethoxam 25 WG at 100 ml/ha at 10 days after germination and on par with soil application of granular insecticides at 10 days after germination. Raghunandan and Manjunatha (2023) reported the feeding damage and symptoms caused on carrot by the carrot fly *Melanagromyza* sp. for the first time on carrot from India. The adult fly activity was commenced at 25-27 days after sowing (DAS) and peak activity recorded during 34 to 40 DAS. Damage commenced from 41 to 60 days old and prevailed till 70 to 90 days old crop and caused an economic loss of rupees 18.30/kg of good quality carrots. Further, suggested that the pest could be managed through the application of soil insecticide effectively.

4. CONCLUSION

Among the insecticides, chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS and fipronil 0.3% GR @ 20 kg/ha at 35 DAS were proved effective in controlling root borer, *Melanagromyza* sp. The treatment with soil application of chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS registered the maximum yield and benefit cost ratio.

Table 2: Cost economics of insect pest management in carrot during *rabi/summer* 2021-22

Treatment details	Yield (t/ha)	Total production cost (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B: C ratio
T_1 - ST with thiamethoxam 30% FS @ 10 ml/kg	14.52[b]	65088	217777.78	152689.78	2.35
T_2 - ST with cyantraniliprole 19.8% + thiamethoxam 19.8% @ 10 ml/kg	15.26[b]	72122	228888.89	156766.89	2.17
T_3 - ST with imidacloprid 600 FS @ 10 ml/kg	13.93[b]	66000	208888.89	142888.89	2.16
T_4 - Soil drenching with chlorpyrifos 20% EC @ 3 ml/l at 35 DAS	13.63[b]	65450	204444.44	138994.44	2.12
T_5 - Soil application with chlorantraniliprole 0.4% GR @ 10 kg/ha at 35 DAS	17.78[a]	66750	266666.67	199916.67	3.00
T_6 - Soil application with fipronil 0.3% GR @ 10 kg/ha at 35 DAS	16.44[a]	67140	246666.67	179526.67	2.67
T_7 - Foliar spray with chlorantraniliprole 18.5% @ 0.3 ml/l at 25 DAS	12.74[c]	67595	191111.11	123516.11	1.83
T_8 - Soil application with *Metarhizium anisopliae* (cfu 2×10^8/g) at sowing	6.20[e]	66575	93000.00	26425.00	0.39
T_9 - Soil application with pongamia cake @ 250 kg/ha at sowing	8.95[d]	72200	122222.22	50022.22	0.69
T_{10} - Soil application with neem cake @ 250 kg/ha sowing	10.96[c]	69950	164444.44	94494.44	1.35
T_{11}- Untreated control	5.04[e]	64000	75555.56	11555.56	0.18
S. Em. ±	0.83				
C. D. at 5 %	2.46				
C.V. (%)	11.67				

Means showing similar alphabets do not differ significantly by DMRT (p .05)

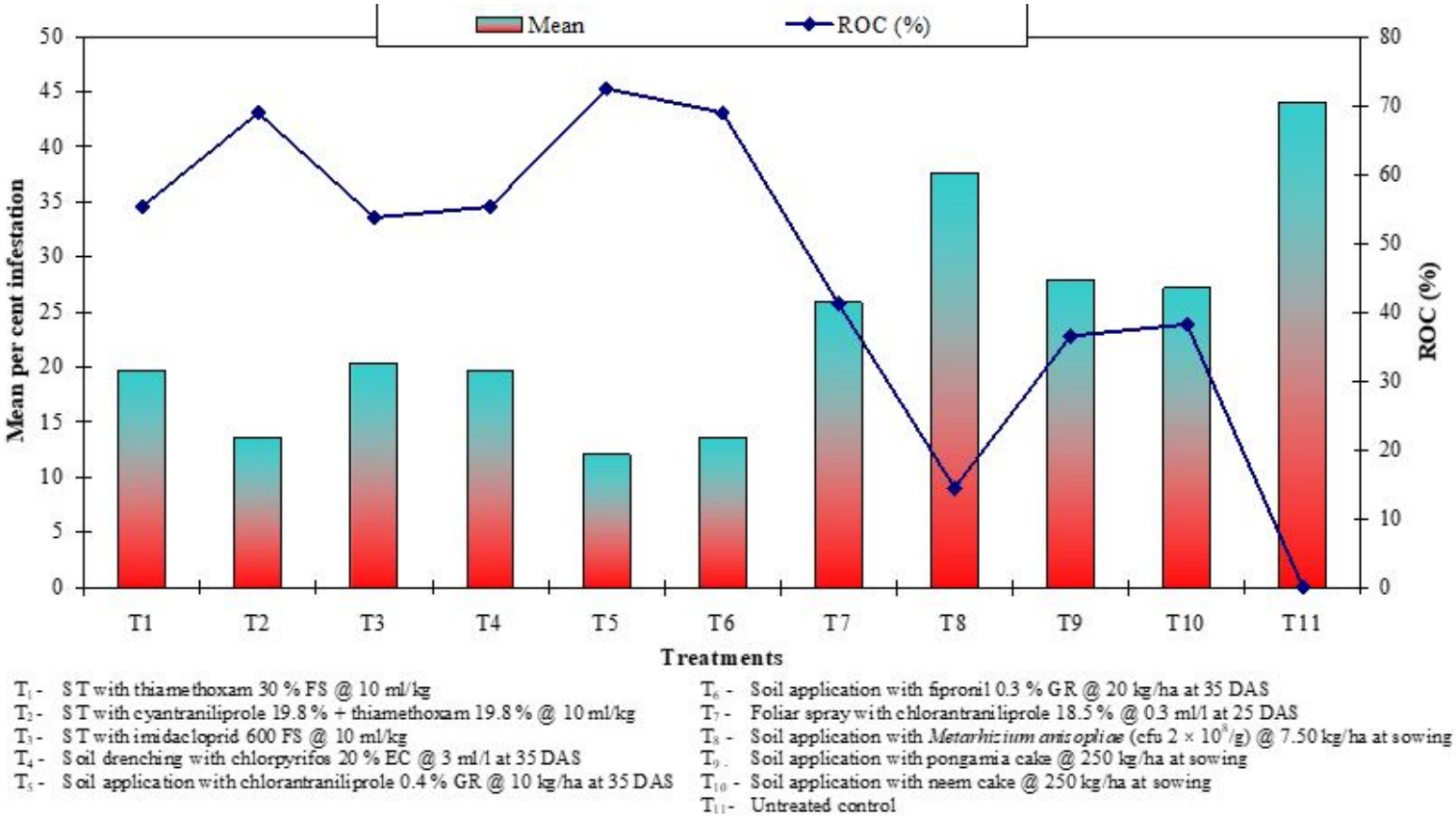

Fig 1: Mean per cent infestation and per cent reduction of agromyzid fly, *Melanagromyza* sp. in different treatments

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