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Studies on the bio-efficacy of newer insecticides against sucking insect pests and fruit borer of tomato

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Abstract
The present study entitled "Studies on the bio-efficacy of newer insecticides against sucking insect pests and fruit borer of tomato" was carried out at the Research cum Instructional farm, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (C.G.). during *Rabi* 2024-25. The present investigation was carried out against sucking pest (whitefly, thrips and aphid) and fruit borer on tomato variety Kaveri-143 to evaluate the bio-efficacy of newer insecticides *viz.* Spiromesifen 22.90% SC, Flubendiamide 39.35% SC w/w, Novaluron 10%EC, Pongamia soap, Insecticides were applied twice at 10 days interval. Most effective treatment was Flubendiamide 39.35% SC w/w @ 100 ml/ha against the management of fruit borer, followed by Novaluron 10% EC @ 750 ml/ha, Pongamia soap @ 5000ml/ha and Spiromesifen 22.90% SC @ 625 ml/ha. For sucking pest most effective treatment was Spiromesifen 22.90% SC @ 625 ml/ha followed by Pongamia soap @ 5000ml/ha, Novaluron 10% EC @ 750 ml/ha and Flubendiamide 39.35% SC w/w @ 100 ml/ha. All the above treatments were found to be superior over control. The highest net profit and cost benefit ratio was observed from the plot treated with Pongamia soap (Rs 1800/ha and 1:2.02). The maximum fruit yield of 307.03q/ha was recorded with the application of Pongamia soap which was 61.38% higher than control.

Keywords: Tomato, insecticides, sucking pests, fruit borer, Pongamia soap, yield

Introduction
Tomato (*Lycopersicon esculentum* Mill.) belongs to family Solanaceae. It is one of the most important and remunerative vegetable crops due to its immense commercial and nutritive value and wide range of climatic adoptability, grown in tropical and subtropical regions, round the year in the world. It can be used both in fresh or processed form. It is world's largest vegetable crop after potato and sweet potato. The leading tomato growing countries, in the world are China, India, United States, Turkey, Egypt, Iran, and Italy. Highest production of tomato in world is from China (56.80 million tonnes) followed by India (19.60 million tonnes) (2017-18). India is second largest producer of vegetables in the world next to china. In India tomato is cultivated on 808.54 thousand-hectare area with annual production and average productivity of 19696.92 thousand tonnes and 24.36 tonnes ha-1, respectively. Andhra Pradesh, Bihar, Karnataka, Uttar Pradesh, Odisha, Maharashtra, Madhya Pradesh and Assam are the largest producer of tomato in our country.

As per the Ministry of Agriculture and Farmers' Welfare, India had 848.71 thousand hectares under tomato cultivation. The total tomato production was recorded at 20, 425.32 thousand metric tons, with an average productivity of 24.06 metric tons per hectare. While in Chhattisgarh with total tomato cultivation area of 61.63 thousand hectares in 2022-23. The state produced approximately 1, 070.05 thousand metric tons of tomatoes, with an average productivity of 17.36 metric tons per hectare.

The production quality of tomato fruits are considerably affected by array of insect pests infesting at different stages of crop growth. All parts of the plants offer shelter, food and reproduction site for insects. The major insect pests which play most important role in the economic losses of tomato crop are leaf miner, aphid, jassid, whitefly and fruit borer, total of 41 insect species, belonging to 21 families attack on tomato crop (Reddy and Kumar, 2004) [6]

Tomato being a commercial vegetable crop, farmers have a tendency to overuse and even abuse insecticide in an over ambitious approach to knock down this destructive pest. As a result, it has caused turbulence in the Agri-ecosystem.

It has led to many problems like buildup of insecticide resistance, pest resurgence, reduction or killing of natural enemies and insecticide residue in the tomato fruit. In such situation, newer group of insecticide and biological insecticide offer great scope as they maintain higher toxicity to insects at lower doses and are not persistent like conventional group of insecticides. Several new group of insecticides like Indoxacarb, Fipronil, Imidacloprid and Spinosad belonging to a novel class of insecticide have been introduced which have unique chemical structure and have been reported effective against insect pest of many crops (Gavkare O *et al*., 2013) [3]

Materials and Methods

Field experiment was conducted during *Rabi* 2024-25 at Research cum Instructional farm, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (C.G.). The experiment was laid out in randomized block design (RBD) with Five treatments (including untreated control) with four replications. The transplanting was done on 05th October, 2024. Seedling of Tomato variety Kaveri-143 were transplanted in 3×3 m^2 plots with spacing of 60 x 50 cm along with recommended standard agronomical practices except crop protection measures. To study the efficacy of these insecticides against major insect pests like whitefly, thrips and aphid and fruit borer attacking tomato field, two consecutive sprays of the insecticides mentioned above at recommended doses were done at 10 days interval. The spraying was done with a knapsack sprayer with a hollow cone nozzle.

Treatment details

Treatment No.	Treatment	Dose		Dilution (L/ha)
		Technical (g a.i./ha)	Formulation (g or ml/ha)	
T_1	Spiromesifen 22.90% SC	90	450	500
T_2	Flubendiamide 39.35% SC w/w	48	100	500
T_3	Novaluron 10%EC	75	750	500
T_4	Pongamia soap	-	5000	500
T_5	Untreated control	--	--	500

Observations

I. Sucking pests: Whitefly incidence was monitored weekly at morning. Five randomly selected plants per plot were observed. Three leaf each from the top, middle, and lower canopy was examined. A small hand-held mirror was placed under each leaf to facilitate unobstructed
observation of whiteflies settling on the leaf surface. Counts per leaf were recorded without disturbing the insects. The population of aphid recorded at weekly interval during morning hours on five randomly selected plants/plot. Population was counted on three leaves (top, middle and bottom) and expressed as mean population. To assess the population of thrips on tomato plants, the paper tapping method as described by various researchers was followed. In this method, plants are gently tapped over a white paper sheet or plastic tray. The thrips get dislodged from the foliage and fall onto the paper, where they can be easily observed and counted (Kumar, V *et al.* 2023) [5].

II. Fruit borer: The pre-treatment observations were recorded one day before each spray and subsequently post treatment observations was recorded at 5^{th} and 10^{th} days after each spraying from randomly five selected plants on every plot. The percentage of fruit damage was calculated by the following formula:-

$$\text{Fruit damage (\%)} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits (Damaged + Healthy)}} \times 100$$

(Kashyap and Verma)

Results and Discussion

Against whitefly

At three days after the first application of insecticides data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 3.46 whiteflies/plant which differed significantly from other treatments. Second most effective treatment was T_3, Novaluron 10% EC @ 150 g. a.i./ha with 5.07 whiteflies/plant, followed by T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 5.97 whiteflies/plant and T_4, Pongamia soap @ 5000 ml/ha with 6.91 whiteflies/plant. The highest mean population of whitefly of 12.24 whiteflies/plant was recorded in the control.

At five days after the first application of insecticides, data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 3.20 whiteflies/plant, which differed significantly from other treatments. Second most effective treatment was T_3, Novaluron 10% EC @ 750 ml/ha with 4.92 whiteflies/plant, followed by T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 5.47 whiteflies/plant and T_4, Pongamia soap @ 5000 ml/ha with 6.73 whiteflies/plant. The highest mean population of whitefly of 12.01 whiteflies/plant was recorded in the control.

Seven days after the first application of insecticides, data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 3.12 whiteflies/plant, which differed significantly from other treatments. Second most effective treatment was T_3, Novaluron 10% EC @ 750 ml/ha with 4.23 whiteflies/plant, followed by T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 4.85 whiteflies/plant and T_4, Pongamia soap @ 5000 ml/ha with 5.95 whiteflies/plant. The highest mean population of whitefly of 11.40 whiteflies/plant was recorded in the control.

At ten days after the first application of insecticides, data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 3.95 whiteflies/plant, which differed significantly from other treatments. Second most effective treatment was T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 4.34 whiteflies/plant, followed by T_4, Pongamia soap @ 5000

ml/ha with 5.43 whiteflies/plant and T_3, Novaluron 10% EC @ 750 ml/ha with 6.20 whiteflies/plant. The highest mean population of whitefly of 11.20 whiteflies/plant was recorded in the control. Among the various treatments, Spiromesifen 22.90% SC was statistically at par with Flubendiamide 39.35% SC w/w.

Three days after the second application of insecticides, data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 3.14 whiteflies/plant, which differed significantly from other treatments. Second most effective treatment was T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 3.93 whiteflies/plant, followed by T_3, Novaluron 10% EC @ 750 ml/ha with 4.80 whiteflies/plant and T_4, Pongamia soap @ 5000 ml/ha with 4.97 whiteflies/plant. The highest mean population of whitefly of 11.10 whiteflies/plant was recorded in the control. Among the various treatments, Spiromesifen 22.90% SC was statistically at par with Flubendiamide 39.35% SC w/w.

At five days after the second application of insecticides, data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 2.90 whiteflies/plant, which differed significantly from other treatments. Second most effective treatment was T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 3.86 whiteflies/plant, followed by T_3, Novaluron 10% EC @ 750 ml/ha with 4.21 whiteflies/plant and T_4, Pongamia soap @ 5000 ml/ha with 4.76 whiteflies/plant. The highest mean population of whitefly of 10.72 whiteflies/plant was recorded in the control. Among the various treatments, Spiromesifen 22.90% SC was statistically at par with Flubendiamide 39.35% SC w/w.

Seven days after the second application of insecticides, data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 2.55 whiteflies/plant, which differed significantly from other treatments. Second most effective treatment was T_3, Novaluron 10% EC @ 750 ml/ha with 3.73 whiteflies/plant, followed by T_4, Pongamia soap @ 5000 ml/ha with 3.84 whiteflies/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 4.17 whiteflies/plant. The highest mean population of whitefly of 10.05 whiteflies/plant was recorded in the control. Among the various treatments, Spiromesifen 22.90% SC was statistically at par with Novaluron 10% EC.

At ten days after the second application of insecticides, data showed significant differences in the mean whitefly population among various treatments are given in Table 1. Treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was found most effective with mean number of whitefly 2.15 whiteflies/plant, which differed significantly from other treatments. Second most effective treatment was T_4, Pongamia soap @ 5000 ml/ha with 3.41 whiteflies/plant, followed by T_3, Novaluron 10% EC @ 750 ml/ha with 4.13 whiteflies/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 4.32 whiteflies/plant. The highest mean population of whitefly of 9.70 whiteflies/plant was recorded in the control.

After two application of insecticides data indicated that treatment T_1, Spiromesifen 22.90% SC @ 625 ml/ha was the most effective against whitefly, as it recorded lowest overall mean population of 3.05 whitefly/plant, followed by T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 4.61 whitefly/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 4.66 whitefly/plant and T_4, Pongamia soap @ 5000 ml/ha with 5.25 whitefly/plant. The highest overall mean population of whitefly of 11.25 whitefly/plant was recorded in control (Table 1).

Thus, based on the overall mean population of whitefly on tomato, after two application of insecticides during *Rabi* 2024-25, the order of effectiveness was noted as $T_1>T_2>T_3>T_4>T_5$.

Table 1: Effect of newer insecticide molecules against whitefly on Tomato during *Rabi* 2024-25

Tr. No.	Treatment	Dose (g or ml/ha)	PTO	Average no. of Whitefly/plants								Over All Mean
					I SPRAY			II SPRAY				
				3 DAS	5 DAS	7 DAS	10 DAS	3 DAS	5 DAS	7 DAS	10 DAS	
T_1	Spiromesifen 22.90% SC	625	11.45 (3.52)	3.46 (2.11)	3.20 (1.98)	3.12 (2.02)	3.95 (2.22)	3.14 (2.02)	2.90 (2.02)	2.55 (1.91)	2.15 (1.77)	3.05
T_2	Flubendiamide 39.35% SC w/w	100	10.10 (3.33)	5.97 (2.63)	5.47 (2.54)	4.85 (2.41)	4.34 (2.30)	3.93 (2.15)	3.86 (2.17)	4.17 (2.26)	4.32 (2.30)	4.61
T_3	Novaluron 10%EC	750	10.33 (3.36)	5.07 (2.47)	4.92 (2.42)	4.23 (2.31)	6.20 (2.63)	4.80 (2.40)	4.21 (2.27)	3.73 (2.14)	4.13 (2.25)	4.66
T_4	Pongamia soap	5000	9.73 (2.77)	6.91 (2.81)	6.73 (2.77)	5.95 (2.63)	5.43 (2.53)	4.97 (2.44)	4.76 (2.38)	3.84 (2.39)	3.41 (2.09)	5.25
T_5	Untreated control	-	12.84 (4.34)	12.24 (4.26)	12.01 (4.23)	11.40 (4.17)	11.20 (4.14)	11.10 (3.88)	10.72 (3.96)	10.05 (3.88)	9.70 (3.84)	11.25
	S.E. m±		0.12	0.11	0.07	0.08	0.09	0.10	0.06	0.08	0.07	
	C.D. at 5%		NS	0.35	0.24	0.27	0.28	0.31	0.21	0.27	0.25	

DAS = Days after spray, PTO = Pre-treatment observation, () Figures in parentheses are square root transformed value, NS = Non significant

Against Thrips

At three days after the first application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective with mean number of thrips 4.87 thrips/plant, which differed significantly from other treatments. Second most effective treatment was T_4, Pongamia soap @ 5000 ml/ha with 5.87 thrips/plant, followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 7.61 thrips/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 8.32 thrips/plant. The highest mean population of thrips of 12.24 thrips/plant was recorded in the control.

Five days after the first application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found

most effective with mean number of thrips 4.52 thrips/plant, which differed significantly from other treatments. Second most effective treatment was T_4, Pongamia soap @ 5000 ml/ha with 5.67 thrips/plant, followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 7.23 thrips/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 8.02 thrips/plant. The highest mean population of thrips of 12.01 thrips/plant was recorded in the control.

At seven days after the first application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective with mean number of thrips 4.13 thrips/plant, which differed significantly from other treatments. Second most effective treatment was T_4, Pongamia soap @ 5000 ml/ha with 5.23 thrips/plant, followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.95 thrips/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 7.82 thrips/plant. The highest mean population of thrips of 11.40 thrips/plant was recorded in the control.

At ten days after the first application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective with mean number of thrips 3.83 thrips/plant, which differed significantly from other treatments. Second most effective treatment

was T_4, Pongamia soap @ 5000 ml/ha with 4.92 thrips/plant, followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.26 thrips/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 7.26 thrips/plant. The highest mean population of thrips of 11.20 thrips/plant was recorded in the control.

Three days after the second application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective with mean number of thrips 3.80 thrips/plant, which differed significantly from other treatments. This was followed by T_4, Pongamia soap @ 5000 ml/ha with 5.67 thrips/plant, T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.67 thrips/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 7.65 thrips/plant. The highest mean population of thrips of 12.10 thrips/plant was recorded in the control.

At five days after the second application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective with mean number of thrips 3.21 thrips/plant, which differed significantly from other treatments. This was followed by T_4, Pongamia soap @ 5000 ml/ha with 5.23 thrips/plant, T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 5.96 thrips/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 7.42 thrips/plant. The highest mean population of thrips of 13.72 thrips/plant was recorded in the control.

At seven days after the second application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective with mean number of thrips 3.06 thrips/plant, which differed significantly from other treatments. This was followed by T_4, Pongamia soap @ 5000 ml/ha with 4.74 thrips/plant, T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 5.37 thrips/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 6.67 thrips/plant. The highest mean population of thrips of 13.05 thrips/plant was recorded in the control.

Ten days after the second application of insecticides, data showed significant differences in the mean population of thrips among various treatments are given in Table 2. Treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective with mean number of thrips 2.93 thrips/plant, which differed significantly from other treatments. This was followed by T_4, Pongamia soap @ 5000 ml/ha with 4.13 thrips/plant, T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 4.98 thrips/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 6.17 thrips/plant. The highest mean population of thrips of 13.70 thrips/plant was recorded in the control.

After two application of insecticides data indicated that treatment T_3, Novaluron 10% EC @ 750 ml/ha was found most effective against thrips, as it showed lowest overall mean population of 3.79 thrips/plant, which was statistically significant followed by T_4, Pongamia soap @ 5000 ml/ha with 5.18 thrips/plant, T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.37 thrips/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 7.41 thrips/plant. The highest overall mean population of thrips (12.50 thrips/plant) was noticed in control (Table 2).

Thus, based on the overall mean population of thrips on tomato, after two application of insecticides during *Rabi* 2024-25, the order of effectiveness was noted as $T_3>T_4>T_1>T_2>T_5$.

Table 2: Effect of newer insecticide molecules against thrips on Tomato during *Rabi* 2024-25

Tr. No.	Treatment	Dose (g or ml/ha)	PTO	Average no. of Thrips/plants								Over All Mean
					I SPRAY			II SPRAY				
				3 DAS	5 DAS	7 DAS	10 DAS	3 DAS	5 DAS	7 DAS	10 DAS	
T_1	Spiromesifen 22.90% SC	625	9.33 (3.21)	7.61 (2.93)	7.23 (2.86)	6.95 (2.81)	6.26 (2.81)	6.67 (2.67)	5.96 (2.57)	5.37 (2.54)	4.98 (2.43)	6.37
T_2	Flubendiamide 39.35% SC w/w	100	10.10 (3.33)	8.32 (3.05)	8.02 (3.00)	7.82 (2.96)	7.26 (2.88)	7.65 (2.94)	7.42 (2.90)	6.67 (2.76)	6.17 (2.67)	7.41
T_3	Novaluron 10%EC	750	10.33 (3.36)	4.87 (2.42)	4.52 (2.34)	4.13 (2.26)	3.83 (2.19)	3.80 (2.18)	3.21 (2.04)	3.06 (1.99)	2.93 (1.91)	3.79
T_4	Pongamia soap	5000	9.00 (3.16)	5.87 (2.72)	5.67 (2.71)	5.23 (2.67)	4.92 (2.63)	5.67 (2.62)	5.23 (2.49)	4.74 (2.38)	4.13 (2.33)	5.18
T_5	Untreated control	-	11.84 (3.58)	12.24 (3.60)	12.01 (3.60)	11.40 (3.52)	11.20 (3.49)	12.10 (3.61)	13.72 (3.80)	13.05 (3.76)	13.70 (3.83)	12.50
	S.E. m±		0.14	0.09	0.11	0.12	0.14	0.12	0.14	0.12	0.13	
	C.D. at 5%		NS	0.29	0.35	0.39	0.43	0.36	0.44	0.38	0.40	

DAS = Days after spray, PTO = Pre-treatment observation, () Figures in parentheses are square root transformed value, NS = Non significant

Against Aphid

At three days after the first application of insecticides, data showed significant differences in the mean population of aphid among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with mean number of aphid 5.99 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 7.61 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 9.98 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 1021 aphids/plant. The highest mean population of aphid of 13.24 aphids/plant was recorded in the control.

At five days after the first application of insecticides, data showed significant differences in the mean population of aphid among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with mean number of aphid 5.65 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 7.19 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 9.67 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 10.03 aphids/plant. The highest mean population of aphid of 12.01 aphids/plant was recorded in the control.

Seven days after the first application of insecticides, data showed significant differences in the mean population of aphid among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with mean number of aphid 4.75 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.70 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 8.56 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 9.61 aphids/plant. The highest mean population of aphid of 12.40 aphids/plant was recorded in the control. Among the various treatments, Pongamia soap @ 5000 ml/ha was statistically at par with Spiromesifen 22.90% SC.

At ten days after the first application of insecticides, data showed significant differences in the mean population of aphid among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with mean number of aphid 5.63 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.16 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 8.21 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 9.34 aphids/plant. The highest mean population of aphid of 11.20 aphids/plant was recorded in the control.

Three days after the second application of insecticides, data showed significant differences in the mean population of aphids among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with a mean number of aphids of 4.82 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.89 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 7.57 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 9.43 aphids/plant. The highest mean population of aphids of 12.10 aphids/plant was recorded in the control.

At five days after the second application of insecticides, data showed significant differences in the mean population of aphids among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with a mean number of aphids of 4.22 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.23 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 6.85 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 8.67 aphids/plant. The highest mean population of aphids of 13.52 aphids/plant was recorded in the control.

At seven days after the second application of insecticides, data showed significant differences in the mean population of aphids among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with a mean number of aphids of 3.64 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 5.69 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 6.25 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 7.88 aphids/plant. The highest mean population of aphids of 13.05 aphids/plant was recorded in the control.

At ten days after the second application of insecticides, data showed significant differences in the mean population of aphids among various treatments are given in Table 3. Treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective with a mean number of aphids of 3.23 aphids/plant, which differed significantly from other treatments. This was followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 5.23 aphids/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 5.86 aphids/plant, and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 7.28 aphids/plant. The highest mean population of aphids of 12.70 aphids/plant was recorded in the control.

After two application of insecticides data indicated that treatment T_4, Pongamia soap @ 5000 ml/ha was found most effective against aphid, showed lowest overall mean population of 4.74 aphid/plant and followed by T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 6.08 aphid/plant, T_3, Novaluron 10% EC @ 750 ml/ha with 7.86 aphid/plant and T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha with 9.05 aphid/plant. The highest overall mean population of aphid 12.52 aphid/plant was recorded in control (Table 3).

Thus, based on the overall mean population of aphid on tomato, after two application of insecticides during *Rabi* 2024-25, the order of effectiveness was noted as $T_4>T_1>T_3>T_2>T_5$.

Table 3: Effect of newer insecticide molecules against aphid on Tomato during *Rabi* 2024-25

Tr. No.	Treatment	Dose (g or ml/ha)	PTO	Average no. of Aphid/plants								Over All Mean
					I SPRAY			II SPRAY				
				3 DAS	5 DAS	7 DAS	10 DAS	3 DAS	5 DAS	7 DAS	10 DAS	
T_1	Spiromesifen 22.90% SC	625	14.85 (3.96)	7.61 (2.93)	7.19 (2.86)	6.70 (2.77)	6.16 (2.67)	6.89 (2.80)	6.23 (2.68)	5.69 (2.67)	5.23 (2.49)	6.08
T_2	Flubendiamide 39.35% SC w/w	100	14.25 (3.90)	10.21 (3.34)	10.03 (2.32)	9.61 (3.25)	9.34 (2.21)	9.43 (3.23)	8.67 (3.13)	7.88 (3.10)	7.28 (3.00)	9.05
T_3	Novaluron 10%EC	750	14.94 (3.99)	9.98 (3.31)	9.67 (3.26)	8.56 (3.09)	8.21 (3.03)	7.57 (2.88)	6.85 (2.79)	6.25 (2.69)	5.86 (2.61)	7.86
T_4	Pongamia soap	5000	14.50 (3.93)	5.99 (2.68)	5.65 (2.61)	4.75 (2.43)	5.63 (2.61)	4.82 (2.40)	4.22 (2.28)	3.64 (2.17)	3.23 (2.05)	4.74
T_5	Untreated control	-	14.84 (3.98)	13.24 (3.77)	12.01 (3.60)	12.40 (3.62)	11.20 (3.49)	12.10 (3.61)	13.52 (3.81)	13.05 (3.75)	12.70 (3.66)	12.52
	S.E. m+		0.14	0.16	0.09	0.17	0.12	0.11	0.10	0.16	0.14	
	C.D. at 5%		NS	0.48	0.28	0.52	0.39	0.34	0.33	0.49	0.43	

DAS = Days after spray, PTO = Pre-treatment observation, () Figures in parentheses are square root transformed value, NS = Non significant

Against fruit borer

Five days after the first application of insecticides, data showed significant differences in the mean fruit damage (%) of fruit borer among various treatments are given in Table 4. The plot treated with T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha was found most effective with mean fruit damage of 10.45% fruit damage/plant, which differed significantly from other treatments. This was followed by T_3, Novaluron 10% EC @ 750 ml/ha with 6.25% fruit damage/plant, T_4, Pongamia soap @ 5000 ml/ha with 8.50% fruit damage/plant, and T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 10.45% fruit damage/plant. The highest fruit damage of 16.90% fruit damage/plant was recorded in the control.

At ten days after the first application of insecticides, data showed significant differences in the mean fruit damage (%) of fruit borer among various treatments are given in Table 4. The plot treated with T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha was found most effective with mean fruit damage of 05.16% fruit damage/plant, which differed significantly from other treatments. This was followed by T_3, Novaluron 10% EC @ 750 ml/ha with 06.22% fruit damage/plant, T_4, Pongamia soap @ 5000 ml/ha with 07.64% fruit damage/plant, and T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 09.26% fruit damage/plant. The highest fruit damage of 19.20% fruit damage/plant was recorded in the control.

Five days after the second application of insecticides, data showed significant differences in the mean fruit damage (%) against fruit borer among various treatments are given in Table 4. The plot treated with T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha was found most effective with mean fruit damage of 4.80% fruit damage/plant, which differed significantly from other treatments. This was followed by T_3, Novaluron 10% EC @ 750 ml/ha with 6.70% fruit damage/plant, T_4, Pongamia soap @ 5000 ml/ha with 7.45% fruit damage/plant, and T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 09.60% fruit damage/plant. The highest fruit damage of 23.60% fruit damage/plant was recorded in the control.

At ten days after the second application of insecticides, data showed significant differences in the mean fruit damage (%) of fruit borer among various treatments are given in Table 4. The plot treated with T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha was found most effective with mean fruit damage of 4.23% fruit damage/plant, which differed significantly from other treatments. This was followed by T_3, Novaluron 10% EC @ 750 ml/ha with 5.53% fruit damage/plant, T_4, Pongamia soap @ 5000 ml/ha with 7.03% fruit damage/plant, and T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 9.02% fruit damage/plant. The highest fruit damage of 25.9% fruit damage/plant was recorded in the control.

After two application of insecticides data indicated that treatment T_2, Flubendiamide 39.35% SC w/w @ 100 ml/ha was found most effective against tomato fruit borer, as it recorded lowest overall fruit damage (%) of 04.85% fruit damage/plant, followed by T_3, Novaluron 10% EC @ 750 ml/ha with 06.17% fruit damage/plant, T_4, Pongamia soap @ 5000 ml/ha with 07.65% fruit damage/plant and T_1, Spiromesifen 22.90% SC @ 625 ml/ha with 09.58% fruit damage/plant. The highest fruit damage of 21.40% fruit damage/plant was recorded in control (Table 4).

Thus, based on the overall mean fruit damage (%) of tomato fruit borer on tomato, after two application of insecticides during *Rabi* 2024-25, the order of effectiveness was noted as $T_2>T_3>T_4>T_1>T_5$.

Table 4: Effect of newer insecticide molecules against fruit borer on tomato during *Rabi* 2024-25

Tr. No.	Treatment	Dose (g or ml/ha)	PTO	Fruit Damage (%) per plant				Over All Mean
				I SPRAY		II SPRAY		
				5 DAS	10 DAS	5 DAS	10 DAS	
T_1	Spiromesifen 22.90% SC	625	12.30 (20.51)	10.45 (18.85)	9.26 (17.70)	9.60 (17.88)	9.02 (17.46)	09.58
T_2	Flubendiamide 39.35% SC w/w	100	10.50 (18.89)	05.24 (13.22)	05.16 (13.10)	4.80 (12.64)	4.23 (11.84)	04.85
T_3	Novaluron 10%EC	750	10.80 (19.17)	06.25 (14.46)	06.22 (14.42)	06.70 (14.98)	5.53 (13.59)	06.17
T_4	Pongamia soap	5000	12.50 (20.69)	08.50 (16.93)	7.64 (16.03)	7.45 (15.82)	7.03 (15.35)	07.65
T_5	Untreated control	-	14.00 (21.95)	16.9 (24.26)	19.20 (25.97)	23.6 (29.05)	25.9 (30.57)	21.40
	S.E. m+		0.12	0.24	0.17	0.18	0.21	
	C.D. at 5%		NS	0.82	0.58	0.59	0.67	

DAS = Days after spray, PTO = Pre-treatment observation, () Figures in parentheses are angular transformed value, NS = Non significant

Table 5: Yield and economics of different insecticide treatments in tomato during *Rabi* 2024-25

Treatment	Total cost of the plant protection (Rs/ha)	Operational+ fertilization +Labour charges & seed cost (Rs/ha)	Total cost (Rs/ha)	Yield (q/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	C:B Ratio
	a	b	c = a+b	d	e = (d x 100) x 10	f = e-c	g = e/c
T_1	2700	149595	152295	267.01	267010	114715	1:1.75
T_2	2100	149595	151695	259.00	259000	107305	1:1.70
T_3	3000	149595	152595	280.16	280160	127565	1:1.83
T_4	1800	149595	151395	307.03	307030	155635	1:2.02
T_5	-	149595	149595	190.26	190260	40665	1:1.27

Average selling price of tomato @ Rs. 10/Kg

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