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RESEARCH ARTICLE

THE EFFICACY OF DIFFERENT PESTICIDES FOR MANAGEMENT OF TOMATO LEAF MINER IN TOMATO AT GOKULESHWOR BAITADI

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ABSTRACT

Tomatoes are an important produce in the Solanaceae family, and their productivity is heavily influenced by insect pests. Pesticide application is a common approach of pest management in Nepal's local and large-scale vegetable farms. A field experiment was conducted using seven treatments, namely: T1 (*Metarhizium anisopiliae* at 2 g/liter), T2 (Neembicide at 5 ml/liter), T3 (Jholmol at 1:4 (Jholmol: water), T4 (Imidacloprid at 0.3 ml/liter), T5 (Control), T6 (Emamectin benzoate at 2 g/liter), and T7 (Chlorantraniliprole at 0.3 ml/liter) to control Tomato leaf miner. In a Randomized Complete Block Design (RCBD), these treatments were replicated three times in the field of Gokuleshwor Agriculture and Animal Science College in Gokuleshwor, Baitadi. The effect of different treatments on the population of Tomato leaf miner was studied using the number of infested leaves per plant, the number of live larva per plant (leaves and buds), and the number of infested terminal buds per plant from four plants forsaking the corner plants in each plot. The study findings revealed that the Control had the maximum number of live larvae per plant as well as the lowest damage in Emamectin benzoate (0.16 per plant), followed by Chlorantraniliprole (0.33 per plant) and Neembicide (0.42 per plant). The highest number of infested leaves per plant was recorded in Control (3.25 per plant) and the lowest in Chlorantraniliprole (1.66 per plant), followed by Emamectin benzoate (1.86 per plant) and Neembicide (2.08 per plant). The number of infested terminal buds per plant was recorded as highest in Control (0.58 per plant) and lowest in Chlorantraniliprole (0.08 per plant), followed by Imidacloprid (0.25 per plant) and Emamectin benzoate (0.33 per plant). So for the management of tomato leaf miners, the insecticides Chlorantraniliprole and Emamectin benzoate would be the best alternatives.

KEYWORDS

Tomato, Tomato leaf miner, Pesticides, Management, Efficacy

1. INTRODUCTION

Tomato (*Lycopersicum esculentum*) is a self -pollinating plant belonging to the Solanaceae family which is one of the highly consumed vegetable in the world with more than 90 billion USD annual production value (FAOSTAT, 2019). It originated in Western South America. Among major commercial horticultural crops grown in Nepal *Lycopersicum esculentum* ranks third in terms of total productivity and cultivated area (MOALD, 2020). About 22911 hectares of land were used for Tomato growing in Nepal in the fiscal year 2021/2022 with production scale of 422703 metric tons and yield of 18.45 tons per hectares. In Sudurpaschim province in subtotal of 1915 hectare land, with the subtotal production scale 29474 metric tons and subtotal yield of 15.39 tons per hectares was reported. In context of Baitadi in around 110-hectare land, with the production scale 1650 metric tons and yield of 15 tons per hectares was reported (MOALD 2021/ 2022).

It is an important source of human nutrition, because it provides minerals, dietary fiber, and other compounds like thiamine, riboflavin, niacin, and vitamin C (Perveen et al., 2015). It is known as poor man's orange and is said to be good remedy for constipation patient The most frequently consumed edible vegetable crop in terms of nutritional value is Tomatoes, which are a good source of vitamins A, B, and C and the farmers use them as a source of income in addition. It has been demonstrated that eating Tomato fruit is linked to a decreased risk of inflammatory disease, cancer, and non-communicable chronic illnesses. Aside from that, it can reduce the risk of obesity, diabetes, and heart disease additionally hypertension (Raiola et al., 2014)

Number of biotic and abiotic constraints has hampered Tomato production. For a variety of reasons, Nepal's tomato productivity is less than half that of the global average. Seasonal variations in temperature, humidity, illness, and insect pests are the main causes of the low quality of the fruit and the reduced yield of tomatoes. Foreign trade and agriculture regularly brought in new pests to the nation. The arrival of Tuta absoluta, a South American tomato pinworm, to Nepal is quite recent (Simkhada et al., 2018). Pest infestation is a serious concern for Tomatoes. With the emergence of a new pest, Tuta absoluta, a new issue has arisen (Saidov et al., 2018; Simkhada and Thapa, 2019).

In production of Tomato either in green house or open field condition Tomato leaves miner is the major biotic constraint. *T. absoluta* is acknowledged by its other names as South American Tomato moth, South American Tomato pinworm in South America, Tomato borer, Phthorimaea absoluta in Peru, Gnori-moschema absoluta, Scrobipalpula absoluta, and Scro-bipalpuloides absoluta around the globe .Tomato leaves miner (Lepidoptera: Gelechiidae) is the most destructive pest that possess significant threat to Tomato crops worldwide (Cherif and Verheggen, 2019). The primary host of Tuta absoluta was the tomato (*Solanum lycopersicum L.);* however, the pest also used wild plants like *Solanum nigrum L.* and *Datura stramonium L.* as well as solanaceous cultivated plants like potato (*Solanum tuberosum L.)*, eggplant (*S. melongena L.*), pepper, and hot pepper (*Capsicum spp.*) (Estay, 2000). *Medicago sativa*, *Phaseolus vulgaris*, *Vicia faba*, and *Vigna unguiculata* plants that are often

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grown in Nepal have also been reported to contain it (Bajracharya et al., 2016; الرضا et al., 2012).

It was initially recorded in 2016 from Kavrasthali in the Kathmandu Valley of Nepal, and it was subsequently dispersed throughout the majority of the nation (Bajracharya et al., 2016). Tomato leaves miner was reported in 16 district of Nepal among which 14 were mid hill districts and Terai consisting of 4 district i.e. Kailali, Saptari, Banke and Dang (Sah, 2017). Native to South America, Tuta absoluta, or tomato leaf miner, poses a major danger to global tomato production in both open-air and greenhouse settings (Chidege et al., 2016).

Tuta absoluta is a holometabolous insect that develops into an adult in 24 days at 27°C after going through four phases of development: egg, larva, pupa, and adult (NAPPO, 2013). The adult lays its egg singly or in groups on the underside of the leaves, buds, stems, and calyx of immature fruits. According to Estay, the freshly laid eggs are round and creamy white in color. Before hatching, they change to yellow and eventually black (Estay, 2000; Salama et al., 2014). Pupation can occur in the soil, on the surface of leaves, stems, flowers, fruits, or even inside of mines (Torres et al., 2001). The adult moth's body length is approximately 5-7 mm, and its wingspan is approximately 8-10 mm. Adults are colored brown or silver, or mottled grey (Estay, 2000). It generates 10–12 generations year as a result of its high reproductive potential (Tropea Garzia et al., 2012). The larval stage is the most harmful. The larvae consume the leaf's mesophyll, leaving only the epidermis with its excrement intact. The injured tissue then dries and widens as a result. When a plant is severely attacked, its fruits perish, its damaged leaves turn yellow and senescent, and it eventually dies (Maluf et al., 1997).

This causes heavy losses, particularly when management strategies are not effectively developed (Desneux et al., 2010; González-Cabrera et al., 2011; Caparros Megido et al., 2013). They lead visible blotch mines on the leaves surface from both the abaxial and adaxial directions, which causes the leaves to turn brown and die (Bajracharya et al., 2016). Tomato leaves miner invaded a field and then spread from one to the next through seedlings, vines with infected Tomato fruit and containers that have been used (Arnó and Gabarra, 2010; Amizadeh et al., 2015). Young fruits are most affected by it (MOAD,2016). The pest expected to cause 80-100% Tomato yield loss and financial loss of over 50 million USD (Sah, 2017).

2. Materials and Methods

2.1 Site Selection and Research Site

The research was conducted in Baitadi district which lies in the midhills of Sudurpaschim province. The research was carried out in the research field of Gokuleshwor Agriculture and Animal Science College (GAASC) in the academic year of 2079/02/17 -2079/09/12. It is located at an elevation of 700 meters above mean sea level and lies between the latitude and longitude of 29.66° north and 80.54° east. A visual display of a map of Nepal indicating the research site is shown below.

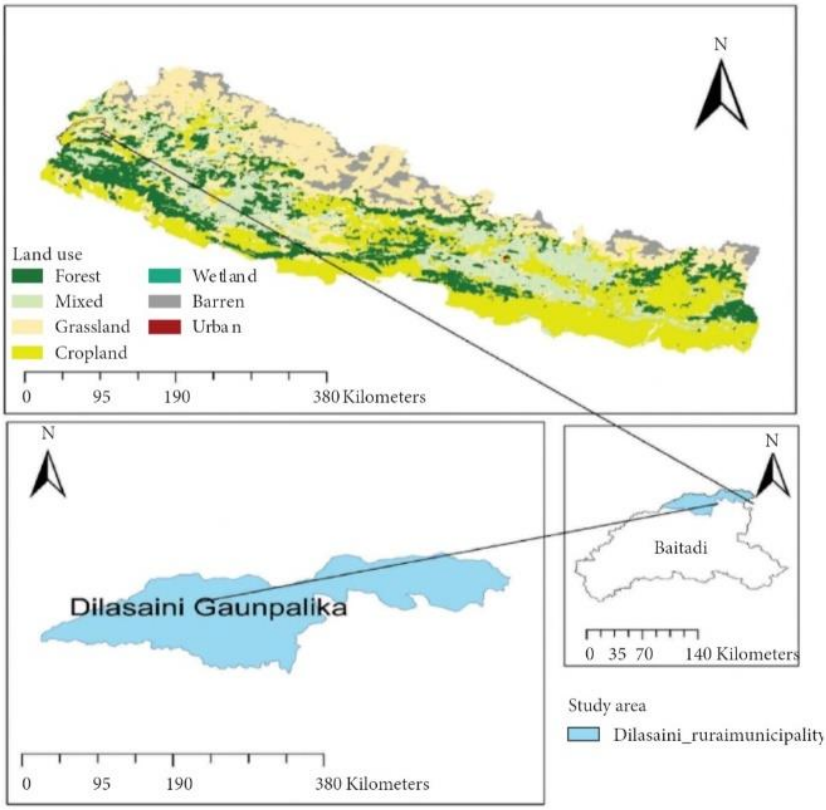

Figure 1: Experimental site

2.2 Nursery Bed Preparation

The nursery bed of size 1 sq.m was prepared on 2079/02/10 by ploughing the land manually with help of a spade followed by harrowing and leveling. In order to prevent the problem of damping off treatment was done with ½ liter of 40% formalin/sq.m soil.

2.3 Seed Sowing

Line sowing of the seed was done on 2079/02/17 maintaining the space between line 10cm. About 20-25 seeds per line was sown at the depth of 2-3 cm in the nursery bed

2.4 Land preparation and Transplanting

The land was prepared on 2079/02/27 by ploughing with the help of power tiller. After 15 days, the field was again ploughed twice with the help of mini power tiller followed by harrowing and leveling. Farmyard manure was applied 4 kg/m² with ½liter of 40% formalin/sq.m soil. Transplanting was done manually on 2079/03/12 along with that 2-gram Pseudomonas and Trichoderma per plant were placed by maintaining row to row distance of 60 cm and a plant-to-plant distance of 60 cm. Clean tillage was done to remove unwanted weeds and overwintering stages of pathogen.

2.5 Experimental Layout

The experiment was carried out in a Randomized block design (RCBD) with three replication and seven treatments. Different botanical pesticides, biological pesticides, and soft synthetic pesticides were assigned as treatment and each treatment was replicated three times. The total area of the experimental field was 130.8 sq.m under Polyhouse. The area was divided into three blocks representing replication and each block was divided into seven small plots of size 2.4*1.2 m. The distance between each block was 0.8 m and the distance between each plot was 0.5 m. The number of plants per plot was Eight.

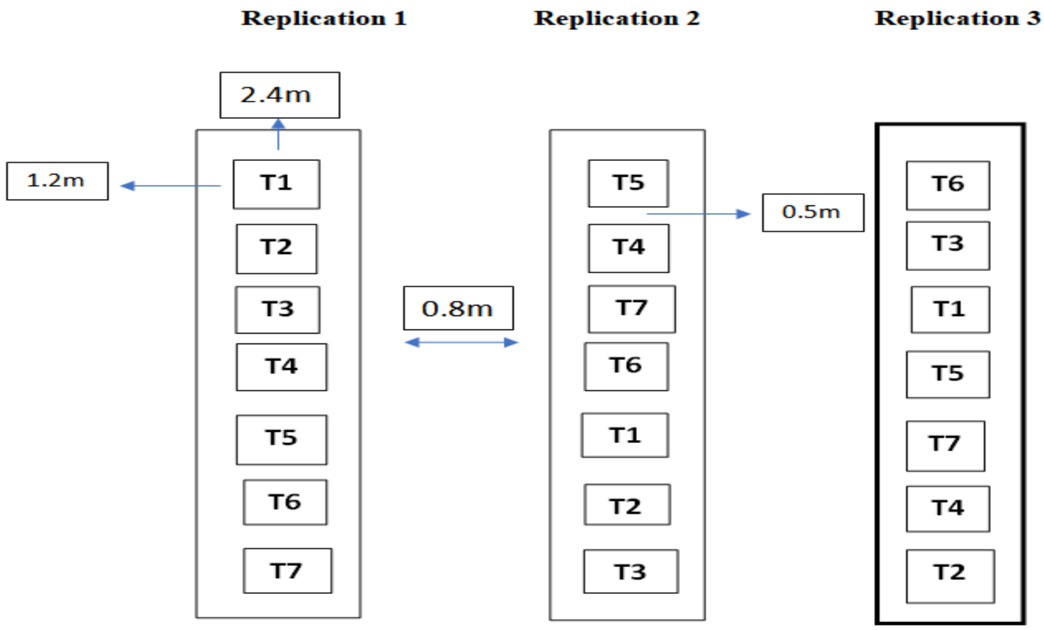

Figure 1: Experimental plot

2.6 Treatment Combination

Table 1: Treatment Combination

Treatment	Chemical/ Scientific Name	Trade Name	Formulation	Dose	Mode of Action
T1: Entomopathogenic Fungus	*Metarhizium anisopiliae*	Kalichakra	2.0% A.S (2*10^8) CFU	2gm/litre	Extrusion & Sporulation
T2: Botanical Insecticide	Neembicide	Neemix	300 ppm	5ml/litre	Systemic
T3: Botanical Insecticide	Jholmol	-	-	1:4 (Jholmol: water)	Repellent
T4: Synthetic Insecticide	Imidacloprid	Acemepride	17.8 % SL	0.3ml/litre	Systemic
T5: Control	-	-	-	-	-
T6: Synthetic Insecticide	Emamectin benzoate	Kingstar	5% SG	2 gm/litre	Contact& stomach Toxicity
T7: Synthetic Insecticide	Chlorantraniliprole	All chlora	18.5% SC	0.3 ml/litre	Contact& ingestion toxicity

2.7 Fertilizer Application

Recommended dose of fertilizer NPK was @ 10:9:4 kg\ropani whereas farmyard manure 1500 kg/ropani (source: Krishi Diary, 2079). One third of Nitrogen and entire dose of Phosphorus, Potash and FYM was applied during field preparation. The remaining dose of Nitrogen was applied in equal doses i.e., 25-30 and 45-50 days after transplanting by making a ring around the seedlings. Recommended dose of FYM was incorporated in the soil manually during land preparation.

2.8 Nutrient Supplements

Micronutrients containing a high percentage of Zinc and Boron, Calcium & Molybdenum was applied before flowering and 30 days after first application. These were supplied for facilitating the proper growth of Tomato.

2.9 Irrigation

The first irrigation was done after the transplanting of the seedling. Firstly, irrigation was done regularly for one week as frequent watering is necessary in root zone. Sprinkler irrigation was given for 25 days at 5 days interval to the Tomato after seven days of transplantation. After one month of transplantation, light sprinkler irrigation was given according to the need of the plant.

2.10 Data Collection

Data were collected from four plants and corner plants were neglected from each treatment. Data were collected with regular monitoring of the field from the date of transplanting to the harvesting of Tomato. Data were collected before the use of treatment i.e., pretreatment and after the spray treatment. The identification of insects and counting of their population were done for all plots. Two sprays were applied in 12 days at regular intervals and data were collected for the insect population after the spray of pesticides. Insect population was observed and data were collected at 5 DAS and 10 DAS in each treatment. Data were collected following destructive method i.e. the infected parts were picked out of the plant for counting.

2.11 Data Analysis

First, the data was entered into an Excel sheet then it was analyzed with the help of the statistical tool R Studio/RSTAT. The output of analysis is presented in forms of table and findings are interpreted with relevant literatures.

3. Result

Table 1: Effect of treatments on the number of infested leaves per plant at different intervals during the first and second spray of pesticide at Gokuleshwor, Baitadi 2022/23

Treatments	Number of infested leaves per plant				
	Pre- Treatment	5DAFS	10 DAFS	5 DASS	10 DASS
Chlorantraniliprole	6.08^{a}	4.75^{b}	2.91^{c}	2.25^{c}	1.66^{c}
Control	7.08^{a}	7.25^{a}	6.66^{a}	6.25^{a}	3.25^{a}
Emamectin benzoate	5.33^{a}	5.00^{ab}	3.25^{bc}	3.08^{bc}	1.83^{c}
Imidachloropid	4.75^{a}	3.66^{b}	2.83^{c}	3.25^{bc}	2.25^{bc}
Jholmol	5.08^{a}	5.83^{ab}	5.08^{ab}	4.08^{b}	2.75^{ab}
Metarhizium anisopiliae	4.66^{a}	4.58^{b}	4.58^{bc}	3.83^{b}	3.00^{a}
Neembicide	6.08^{a}	4.25^{b}	3.08^{c}	3.00b^{c}	2.08^{bc}
Grand Mean	5.58	5.04	4.059	3.67	2.40
SEM (±)	3.38	1.69	1.26	0.35	0.15
CV	32.97	25.75	27.65	16.24	16.48
LSD	3.27	2.31	1.99	1.06	0.70
F test	NS	NS	**	***	**

Mean in the column followed by same letters don't differ significantly with each other at 5 % level of significance whereas * and ** represents significant at p<0.05 and 0.01 respectively.

Table 2 shows the effect of several treatments on the control of Tuta absoluta infested leaf number. Data reported as pre-treatment and data recorded in pre-treatment were non-significant prior to the first pesticide spray. The control treatment had the most affected leaves per plant, followed by the Neembicide treatment. Metarhizium anisopiliae had the fewest afflicted leaves per plant, followed by an Imidachloropid-treated plot. In pre-treatment, the average number of affected leaves per plant was (5.58). And this demonstrated the need for management techniques to limit insect damage to plants. At 5 days after the first treatment, the minimum number of infested leaves per plant was recorded in Imidachloropid (3.66), which is statistically similar to Neembicide (4.25), Metarhizium anisopiliae (4.58), and Chlorantraniliprole (4.75), and the maximum number of infested leaves per plant was in control (7.25), which is similar to Jholmol (5.83) (Table 2).

Significant findings were discovered 10 days following the initial result. After 10 days, the highest leaf damage per plant was found in Control (6.66), which is statistically equal to Jholmol (5.08), and the lowest leaf damage per plant was found in Imidachloropid (2.83), which is statistically equal to Chlorantraniliprole (2.91), Neembicide (3.08), Emamactin benzoate (3.25), and Metarhizium anisopiliae (4.58) (Table 2).

Similarly, two days after the second insecticide application, a highly significant result was observed at five days, with maximum leaf infestation recorded in control (6.25) followed by Jholmol (4.08), and minimum infestation recorded in Chlorantraniliprole (2.25), which is statistically equivalent to Neembicide (3.00), Emamactin benzoate (3.08), and Imidachloropid (3.25) (Table 2).

Similarly, after 10 days of second application, a significant result was obtained, with the highest leaf damage found in Control (3.25), which is statistically comparable to Metarhizium anisopiliae (3.00) and similar to Jholmol (2.75), and the lowest infestation found in Chlorantraniliprole (1.66), which is statistically comparable to Emamactin benzoate (1.83) (Table 2).

Table 2: Effect of treatments on the number of live larva per plant (leaves & buds) at different intervals during the first and second spray of pesticide at Gokuleshwor, Baitadi 2022/23

Treatments	Number of live larva per plant (leaves and buds)				
	Pre-Treatment	5DAFS	10 DAFS	5DASS	10 DASS
Chlorantraniliprole	2.00^{ab}	1.66^{b}	0.50^{c}	0.50^{c}	0.33^{cd}
Control	2.50^{ab}	2.83^{a}	1.75^{a}	1.58^{a}	1.08^{a}
Emamectin benzoate	1.75^{ab}	1.41^{b}	0.83^{bc}	0.67^{bc}	0.16^{d}
Imidacloprid	1.66^{b}	1.50^{b}	0.83^{bc}	0.92^{bc}	0.75^{ab}
Jholmol	2.66^{a}	2.25^{ab}	1.83^{a}	1.16^{ab}	0.67^{bc}
Metarhizium anisopiliae	2.16^{ab}	2.16^{ab}	1.42^{ab}	0.92^{bc}	0.58^{bc}
Neembicide	2.33^{ab}	2.00^{b}	1.08^{abc}	0.83^{bc}	0.42^{bcd}
Grand Mean	2.15	1.97	1.17	0.94	0.57
SEM (±)	0.21	0.18	0.17	0.08	0.04
CV	21.70	21.99	35.95	32.68	36.95
LSD	0.83	0.77	0.75	0.530	0.37
F test	NS	*	*	*	**

Mean in the column followed by same letters don't differ significantly with each other at 5 % level of significance whereas * and ** represents significant at p<0.05 and 0.01 respectively.

The result shows that the average live larval population per plant was found to be influenced by the application of treatments on all days after spray. At 5 days after the first spray, the lowest larval population on leaves was found in Emamactin benzoate (1.41), which was statistically at par with Imidacloprid (1.50), Chlorantraniliprole (1.66), and Neembicide (2.00), and the highest larval population was found in Control (2.83) .Similar results were found 10 days after the first spray, with the lowest larval population obtained in Chlorantraniliprole (0.50), followed by Imidacloprid (0.83) and Emamactin benzoate (0.83), which were also statistically similar. The highest larval population was found in Jholmol (1.83) (Table 3).

Similarly, four days following the second insecticide application, at 5 days after the second spray, the lowest larval population on leaves was found in Chlorantraniliprole (0.50), which was statistically similar with Imidacloprid (0.92) and Emamectin benzoate (0.67), with the highest larval population per leaf found in Control (1.58). At 10 days after the second spray, the highest larval population was found in Control (1.08). The lowest larval population was found in Emamectin benzoate (0.16), which was statistically similar to Chlorantraniliprole (0.33)

Table 3: Effect of treatments on the number of infested terminal buds per plant at different intervals during the first and second spray of pesticide at Gokuleshwor, Baitadi 2022/23

Treatments	Number of infested terminal buds per plant				
	Pre-Treatment	**5DAFS**	**10 DAFS**	**5DASS**	**10 DASS**
Chlorantraniliprole	0.75[a]	0.42[c]	0.16[c]	0.08[c]	0.08[b]
Control	0.58[a]	0.83[ab]	0.67[a]	0.58[a]	0.41[a]
Emamectin benzoate	0.67[a]	0.58[abc]	0.42[abc]	0.33[abc]	0.17[ab]
Imidacloprid	0.75[a]	0.50[bc]	0.33[bc]	0.25[bc]	0.16[ab]
Jholmol	0.83[a]	0.67[abc]	0.58[ab]	0.42[ab]	0.41[a]
Metarhizium anisopiliae	0.92[a]	0.92[a]	0.67[a]	0.33[ab]	0.25[ab]
Neembicide	0.75[a]	0.58[abc]	0.25[c]	0.41[ab]	0.16[ab]
Grand Mean	0.75	0.64	0.44	0.34	0.23
SEM (±)	0.07	0.04	0.02	0.02	0.02
CV	36.49	31.18	32.37	41.30	70.00
LSD	0.486	0.356	0.25	0.25	0.29
F test	NS	NS	**	*	NS

Mean in the column followed by same letters don't differ significantly with each other at 5 % level of significance whereas * and ** represents significant at p<0.05 and 0.01 respectively.

There was no significant difference in the number of terminal bud infestations at 5DAFS among the different treatments. There was the highest infestation on Metarhizium anisopiliae treatment (0.92) and the lowest in Chlorantraniliprole (0.42). At 10 days after the first treatment applications, there was a significant difference between treatments regarding the mean number of infestations on terminal buds. The effect of insecticides 10 days after first application found that Chlorantraniliprole (0.16) had the best results in reducing terminal bud infestation, followed by Neembicide (0.25), which has a statistically similar effect. Imidacloprid and Emamactin benzoate showed mild efficacy (0.33) and (0.42), respectively. Whereas the effect of Metarhizium (0.67) was the least effective, resulting in the highest number, which was statistically similar to the effect of Control (0.67).

Likewise, after the second spray, the effectiveness of treatments five days after the second spray was significant compared to that of the Control plot (0.58) with a minimum in Chlorantraniliprole (0.08) and significantly at par but statistically different with Imidacloprid (0.25) and Emamactin benzoate (0.33). There was a non-significant result observed 10 days after the second spray, but a reduction in the mean infestation from 0.35 to 0.23. The minimum number of infested terminal buds was recorded in Chlorantraniliprole (0.08) and the maximum in Control (0.41), which is statistically at par with Jholmol (0.41) (Table 4).

4. Discussion

4.1 Number of Infested Leaves

From the result of Table 2, it is clear that Chlorantraniliprole and Imidacloprid were found most effective for reducing the leaf damage due to Tomato leaf min in the farmer's field condition. Neembicide and Emamactin benzoate also give good results. No significant result was observed at 5 DAFS, which may be due to the short time for insecticide effectiveness. Chlorantraniliprole insecticide was effective against *T. absoluta* up to 18 days after a single foliar application. According to a study, the diamide component of chlorantraniliprole, which works by altering the ryanodine receptor, is what makes it the most effective against T. absoluta (Ayalew, 2011). Because these insecticides may penetrate the leaf surface and reach the mining larvae inside the leaf, it has been observed that they are more effective against leaf miners. The study's findings indicate that in the field testing conducted, spinosad exhibited the lowest proportion of leaf damage, with Emamectin benzoate and chlorantraniliprole following closely behind (Bastola et al., 2020).

Metarhizium anisopiliae gave a non-significant result in this study; this may be due to the appearance of handling and the lower concentration of formulation. Metarhizium anisopiliae ICIPE20, administered at a rate of 10 ml in 20 l of water at 400 ml/ha, considerably reduces leaf damage from April to July when compared to an untreated plot, according to (Kabaale et al., 2022). The results of **s**howed that the efficacy of Chlorantraniliprole and Spinosad was higher than that of Indoxacarb and Imidacloprid on the third, seventh, tenth, and fourteenth days after spraying, which also supported this result (Ashtari, 2022).

4.2 Live Larva

It was evident from the above results that Chlorantraniliprole were most effective for reducing the larval population in both leaves and terminal buds which was supported by followed by Emamectin benzoate (Bastola et al., 2020). Because it acted quickly to stop feeding and reduced feeding harm, Chlorantraniliprole proved effective against Tuta absoluta (Bastola et al., 2020). Chlorantraniliprole has been shown by to be effective in halting the larvae's feeding within a short period of time (a few minutes to many hours) following consumption (Bassi et al., 2009). Emamectin benzoate is a macrocyclic lactone insecticide developed to control Lepidoptera pests in several vegetable crops. It is a non-systemic insecticide that penetrates leaf tissues by translaminar movement. Larvae stop feeding within hours and die after 2-4 days. A group researchers found that the three foliar applications made at a 7-day interval in a tomato greenhouse showed good activity on Tuta absoluta larvae, with a mortality rate of 87% (Gacemi and Guenaoui, 2012). This result is also supported by Deleva and Harizanova (2014), who found that larval mortality was due to the contact action of the insecticides and not their ability to penetrate and move in the plant.

Similarly, according to the Emamectin Benzoate, Spinosad, and Tolfenpyrad used were effective in controlling this leaf miner, with efficacy percentages above 60% against young larvae and above 50% against old larvae, which follows the findings of this study (Chouikhi et al., 2022). *Metarhizium anisopiliae has a* significant effect under lab conditions on larval mortality as it is a contact entomopathogenic fungus. This study also finds a significant effect with respect to *Metarhizium anisopiliae*. Under field conditions after 10 days of application, Challenger 36% SC (Chlorfenapyr), Voliam flexi 40% WG (mixture of Thiamethoxam and Chlorantraniliprole), and Coragen 20% SC (Chlorantraniliprole) were the most efficacious insecticides for *T. absoluta* larvae control and significantly reduced the larvae population by 92.74%, 83.46%, and 82.97%, respectively (Hassan, 2021).

4.3 Terminal Buds

Tomato leaf miner larvae are hidden inside different parts of the leaves, stems, shoots, and flowers of host plants. This feeding behavior allowed the pest to be safe from chemical insecticides; hence, systematic insecticides are an alternative to contact ones to reduce the infestation of this insect.

The effectiveness of treatments 10 days after the second spray was non-significant due to the pruning of terminal buds and the decline in atmospheric temperature. With the decrease in temperature, the biological activities of Tomato leaf miner also reduce, and there is nearly no emergence of adults at temperatures less than 100 °C (Krechemer and Foerster, 2015). From Table 4, Chlorantraniliprole is the best among the other treatments applied. Consistent with the results of this study, a study reported that Spinosad had the best effect in reducing the number of Tuta absoluta larvae count on terminal buds (0.11 larvae/terminal buds), followed by a statistically similar effect of Chlorantraniliprole (0.14 larvae/terminal buds) (Simkhada et al., 2018).

5. Conclusion

Tomato leaf miner is the most serious insect pest of Tomato and responsible for causing the yield losses ranging from 80- 100 % depending upon weather condition. In Nepal yield losses upto 80- 100 % was recorded in Tomato by Tomato leaf miner. In research areas decrease in crop production were due to various factors such as Late Monsoon and infestation of major disease and pest. In the agricultural landscape of Baitadi district, Nepal, Tomato cultivation plays a pivotal role, covering a substantial area of 110 hectare land, with the production scale 1650 metric tons and yield of 15 tons per hectares (MOALD 2021/ 2022). The main reason behind the low production is: poor agricultural practices, only local innovation and majority of infestation by disease and insect pest. Tomato leaf miner infestation is severe in Nepal as result yield losses in Tomato production faced by farmers are unaware of effective management of Tomato leaf miner on Tomato. Thus, the study on management of Tomato leaf miner in Tomato allow to know the intensity of infestation of Tomato leaf miner on Tomato and it's extend of damage along with evaluating the effectiveness of control tactics and finding out best option for the management of Tomato leaf miner. The experiment was conducted at Gokuleshwor Agriculture And Animal Science College (GAASC). The experiment was laid out in Randomized Block Design (RCBD) including seven treatment and three replications. The treatments were *Metarhizium anisopiliae,* Neembicide, Jholmol, Imidacloprid, Emamectin benzoate, Chlorantraniliprole and Control. Total two sprays were done and data collected at 12 days at regular interval, collected data were entered in Ms- Excel and analyzed by R- Studio. The management of Tomato leaf miner, the insecticide Chlorantraniliprole and Emamectin benzoate would be best alternative.

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