EFFICACY OF DIFFERENT INSECTICIDES AGAINST CITRUS LEAF MINER (*Phyllocnistis citrella* Stainton) ON ACID LIME (*Citrus aurantifolia*)

by

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(Reg. No. -019/169)

AGRICULTURAL ENTOMOLOGY SECTION
COLLEGE OF AGRICULTURE, DHULE

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RAHURI-413722, DIST-AHMEDNAGAR
MAHARASHTRA, INDIA

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A Thesis submitted to the

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MAHARASHTRA, INDIA

In partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)
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2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted by
me or other person to any other
University or Institute
for a Degree or
Diploma

Place : College of Agriculture, Dhule (Are Vaishnavi Chandrakant)

Date : / / 2021

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFICACY OF DIFFERENT INSECTICIDES AGAINST CITRUS LEAF MINER (*Phyllocnistis citrella* Stainton) ON ACIDLIME (*Citrus aurantifolia*)"** submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY**, is a record of a bonafide research work carried out by **MISS. ARE VAISHNAVI CHANDRAKANT** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation and sources of literature referred to have been duly acknowledged.

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Place : College of Agriculture, Dhule (**C. D. Deokar**)

Date : / / 2021

1. INTRODUCTION

Acid lime *(Citrus aurantifolia*) is believed to have originated from South-East Asia. In India acid lime is grown commercially in Maharashtra Akola, Andhra pradesh, Karnataka, Gujrat, Rajasthan, Orissa, Jharkhand, Tamilnadu, etc. In Maharashtra- Akola, Ahmednagar, Pune, Solapur, Jalgaon, Buldhana, Beed, Parbhani, Osmanabad, Aurangabad, Jalna districts are under Acid lime cultivation. It is one of the best fruit that is grown and used in India. It is appreciable not only for its appearance and pleasing flavour, excellent fruit quality but also for the preparation of value- added products viz. squash, syrup, cordials, pickles, manufacture of citric acid, cosmetic uses and for culinary uses in the daily diet of Indians. The best part of it is having plenty of vitamin 'C' which can provide antioxidants. Improved varieties of Acid lime are Pramalini, Vikram, Sai Sarbati, Phule Sharbati, Balaji have been introduced in Maharashtra State. They are also good source of fibre. Fibre has several health benefits, including improving digestive health and adding weight loss. Citrus fruits are low in calories. They may reduce the risk of kidney stone. They help to fight or protect against cancer. Fruits contain nutrients which boost heart health. They may protect brain-flavonoids in citrus fruits may help ward off neurodegenerative diseases such as Alzheimer's and Parkinson's, which result from the breakdown of cells in the nervous system. (Bhut and Jethva, 2019)

Citrus is the third important fruit crop in India. It occupies about 9 % area, of total fruit crop. In India area under citrus fruit crop is about 1078 thousand hectares and its production is 115.15 million tonnes. In India, it occupies 14.93% area of the total area and 12.52 per cent production of the total fruit production in India. The productivity of citrus is 12.35 MT/hectare. The leading state in citrus fruit production is Andhra Pradesh which rank first with 39.46 per cent of total fruit production of India. Maharashtra ranks second with 15.79 per cent of total citrus fruit production. The area under acid lime fruit crop is 286.2 thousand hectares, of which 3148.5 thousand MT citrus fruit produced. The productivity of citrus in Maharashtra is 5.57 MT/ha, while India's productivity is 11.00 MT/ha. (Saxena 2018)

Evergreen and densely foliated citrus trees afford favourable conditions for virtually continuous development of diseases and pests. The citrus crop was found to be infested by 823 species of insect and mite pests of the world. In India, these crops are found to be infested by 250 pests. Though a large number of insect pests infest the citrus and bring about qualitative deterioration in orchards, there are few pests which play important role and leads to citrus decline, important among them are citrus leaf miner (*Phyllocnistis citrella*), psylla (*Diaphorina citri),* lemon butterfly (*Papillio demoleus*) and black fly (*Aleurocanthus woghlumi*).

Citrus leaf miner (*Phyllocnistis citrella*) is a serious pest in both young crops and nurseries. It has four stages of development: eggs, larvae, pupae, and adults. Adults do not harm plants and only live for a few weeks. Adult moths are most active in the morning and evening hours, and they rest on the undersides of leaves throughout the day. As a result, it is uncommon to see. The female moth releases a sex pheromone that attracts males soon after emerging from the pupal case. Following mating, the female lays eggs individually on the underside of newly sprouting leaves, especially along the mid vein. Within one week, the eggs hatch. Freshly born larvae (grubs) begin feeding inside the leaf, producing tiny, practically invisible mines on the leaves. Leaf miners are most commonly seen on young citrus trees, and they have become a severe citrus pest in Vidarbha over the previous two decades. The larvae of the leaf miner, *Phyllocnistis citrella*, destroy immature leaves by producing mine. The earliest symptoms are twisted and curled leaves. When larvae cause damage to leaves, it is considered a severe infestation, and the plant's growth and yield can be hampered as a result. However, the effect on mature trees is less severe than on nursery plants, and such infestations typically occur in the summer. They are rarely seen in the spring because new growth is abundant and synchronised, and the plants quickly become immune to attack. (Grafton *et al*. 2010)

Because of its overlapping generations, this pest's activity can be seen throughout the year. Citrus canker infestation and severity is more prevalent in leaf mined leaves. Citrus leaf miner causes indirect harm to immature leaves, which makes them more susceptible to canker infection. As a result, citrus leaf miner control is an important part of canker management. Citrus leaf miner infestation rates ranged from 17 to 35 per cent on average. During the year, the pest had about 5 to 9 generations, with a peak phase in early summer and early autumn. (Patil, 2013)

Chemical control is still the first line of defence against various insect pests of citrus. However, injudicious and indiscriminate use have posed problem such as the development of resistance, resurgence of minor pests adverse effects on natural enemies and persistence of toxic residue in soil and agricultural produce.

Effective chemical control of citrus leaf miners is difficult because of high migration ability from outside the orchards, High fecundity, present epidermis of citrus leaves as substantial protection and the difficulty of direct contact of chemicals to the larval body. However, many pesticides belonging to different chemical groups were tested and found effective in its management. Now a days large number of insecticides are available in the market and they have been used extensively in other crop for managing internal feeder and sucking pests. Commonly used insecticides are not able to manage it completely.

Therefore, under present investigation, was planned and selected, insecticides which have broad spectrum activity for managing this pest with the following objectives.

1. To study the efficacy of different insecticides against citrus leaf miner (*Phyllocnistis citrella* Stainton) on acid lime.
2. To study the effect of insecticides on natural enemies.

2. REVIEW OF LITERATURE

Citrus leaf miner (*Phyllocnistis citrella* Stainton) is an important pest of citrus. It causes economic losses in both quality and quantity. Hence, to manage the infestation of citrus leaf miner is most essential thus, the present experiment entitled, “Efficacy of insecticides against citrus leaf miner (*Phyllocnistis citrella* Stainton) on acidlime” was conducted for which the following literature is reviewed.

2.1 To Study the Efficacy of Different Insecticides Against Citrus Leaf Miner.

Chen *et al.* (1989) recorded the duration of different stages of *Chrysopa boninensis* in the laboratory. On average 149.1 *Phyllocnistis citrella* larvae were consumed by each individual.

Bhatia and Joshi (1991) performed experiment for leaf miner control on Kinnow, among tested insecticides monocrotophos, dimethoate, phosphamidon, methyl parathion, cypermethrin, and fenvalerate. Fenvalerate, deltamethrin, cypermethrin, and monocrotophos were shown to be most effective.

Neem, Mahua (*Madhuka longifolia*), and Pongamia oil were tested against Citrus leaf miner reported on lime in Karnataka. They showed that, treatments reduced the insect population, with neem seed extract proved to be the most effective (Jothi *et al.* 1993)

Katole *et al.* (1993) conducted a field trial in Nagpur to assess the efficacy of different botanical and synthetic pesticides against the leaf miner. Diamethoate, mahua, and neem oil were the most effective treatments, followed by monocrotophos, fish oil resin soap, phosphamidon, and pongamia oil.

Argov and Rossler (1996) found that, citrus leaf miner was first discovered in Israel in 1994. A biological control project was launched immediately and six species of natural enemies of pests were imported from Thailand, reared, and released in citrus groves, and a biological control effort was immediately initiated. Semilacher petiolatus and Quadrastichus spp. appear to have established themselves, with a relatively high parasitism rate.

Bene *et al.* (1999) conducted experiment on citrus leaf miner in a Florensic historic garden and discovered that the development time from egg to adult varies from 16 to 18 days in the midst of summer to 39 days in the middle of November.

Mungroo and Abeeluck (1999) tested imidacloprid (Confidor 200 SL) and acetamiprid (Mospilan 20 SP) on citrus tree trunks and found that imidacloprid prevented citrus leaf miner attack for three months.

Vargas *et al.* (1999) evaluated the percent efficiency of three pesticides for selective control of citrus leaf miners and concluded that abamectin was superior to the treatments imidachloprid and tebufinazoid.

Buchelos and Foudoulakis (2000) conducted research to suppress the leaf miner *Phyllocnistis citrella* while also safeguarding the ecological balance and, in particular, beneficial insects. They discovered that fenoxycarb 25 %n WP provided adequate protection against *P. citrella* without harming the population of *C. naocki.* During the trial, no indications of phtotoxicity were noticed.

Monocrotophos, fenvalerate 0.05 %, and neem seed bitter 1 % were evaluated in different combinations for control of *P. citrella.* in a field experiment. Sprays of monocrotophos 0.05 % was determined to be the most effective, followed by fenevalerate and monocrotophos in order of effectiveness. (Chaterjee et al. 2000)

Pena and Duccan (2000) performed an experiment to control the population of citrus leaf miners. Abamectin + FC 435 mineral oil + imidacloprid + methomyl were the insecticides used. In compared to the control treatments, abamectin + FC 435 mineral oil + imidachloprid (1.9%) and abamectin + FC 435 mineral oil (2.30%) treatments showed the least amount of leaf area damage (10-21 %).

Citrus leaf miner control was effectively controlled with systemic insecticides such as acephate, vamidothion, monocrotophos, acetamiprid, and imidachloprid, although with various residual periods ranging from 12-14 days. The most effective insecticides were reported to be acetamiprid SL (1.0 g a.i./plant) and imidachioprid. (Yamamoto *et al.* 2000).

In a field experiment conducted in 1999 to control citrus leaf miner *Phyllocnistis citrella*, Raga *et al.* (2001) found that, abamectin + petroleum oil and lufenuron + petroleum oil provided significantly greater Citrus leaf miner larval mortality, with 86.8% and 93.3 % larval density reduction, respectively.

Zhang and Keming (2001) tested various pesticides for citrus leaf miner control. They discovered that, acetamiprid 3 % was effective, killing 97.8% of the miners at 3 DAS.

Garcia *et al*. (2002) According to Garcia et al. (2002), Phyllocnistis citrella damages just 5-15 percent of the yearly new leaf area of mature trees in Mediterranean climates, and yield is usually unaffected.

Rao *et al.* (2002) conducted a comprehensive survey in central India's citrus *(Citrus spp.)* growing areas during 1999-2001 and recorded the incidence of citrus leaf miner

(Phyllocnistis citrella) and its natural enemies. Abamectin and spinosad were found to be more effective in controlling citrus leaf miners.

Studies on the evaluation of different doses of systemic pesticides to control citrus leaf miner *Phyllocnistis citrella* Stainton revealed that, imidacloprid 0.35 a.i./plant and 0.25 g a.i. thiamethoxam controlled citrus leaf miner up to 100 days after planting. (Salas and Goane 2003).

Shivankar *et al.* (2003) conducted experiment on the predatory potential and development of *Mallada boninensis* and indicated that during its larval development, each chrysopid larvae ingested a total of 149.3 140.3 140.3,110.5,104.8 larvae of citrus leaf miner grown on acidlime, roughlemon, and rangpur lime. *M. boninensis* larvae preferred acid lime and Nagpur mandarin to rough lemon and rangpur lime, according to the findings.

Shivankar and Rao (2003) conducted research and revealed that, the incidence of citrus leaf miner (*Phyllocnistis citrella)* was higher on rough lemon than on Rangpur lime in terms of percent infestation. Spring and summer flushes had greater infestation rates on rough lemon (61.8-65.5 per cent) and (53.9-58.4 %) and (35.6-52.7 %) and (34.3-61.8 %) on Rangpur lime, respectively, than autumn flushes (9.4-21.9 %) on rough lemon and (15-18.8 % on Rangpur lime. Citrus leaf miner infestation was found to be positively corelated with maximum and minimum temperatures, rainfall, and wind speed, but negatively correlated with relative humidity.

Jayanthi and Verghese (2004) conducted research on acid lime (*Citrus aurantifolia*) orchard to compare the efficacy of new insecticides to commonly used insecticides, as well as neem-based formulations, against the citrus leaf miner *P. citrella,* and found that, cypemethrin effectively prevented fresh mining by *P. citrella*. All synthetic neonicotinoids and neem seed kernel extract-treated plants had the lowest adult emergence. Furthermore, this study clearly shown that synthetic insecticides were required to prevent leaf miner reinfestation in areas where there were a severe infestation. The neem formulations, on the other hand, can be used as allow-up sprays under heavy infestation and prophylactic spray during new flush emergence.

In April 2002, Agril. Research Institute Tarnab (Peshawar) conducted studies on the efficiency of various insecticides against the citrus leaf miner *Phyllocnistis citrella* Stainton. The best treatment at first application was spinosad, which revealed 4.41% leaf miner infestation, followed by actara 25 WG (thiamethoxam), and Match 0.50 EC (difenthuron). With infestations of 4.41, 5.67, 6.93, and 9.62 % of leaf miner per 6" tender shoot, Supracide 40 EC (methidiothin) and Laser 25 EC (dimethoate, cypermethrin) were used. Whereas the control

exhibited 19.84 %, the minimum per cent infestation was reported in Actara 25 WG (3.84 percent) followed by Match 050 EC after the second spray. Supracide 40 EC and Laser 25 EC, respectively, 3.84, 5.15-6.16, and 7.74 %, with leaf miner infestation in check at 13.38 per cent. (Farman *et al.*, 2005).

Shaban and Obayshi (2005) performed an experiment to investigate the toxicity of pesticides against two citrus leaf miner parasite wasps, *Phyllocnistis citrella* during 2003, the toxicity of 12 prominent pesticides against the eggs and first instar larvae of the pest and its parasitoids of the leading species in Ehime Prefecture, *Chrysocharis pentheus* and *Sympiesis striatipes*, were compared. For the citrus leaf miner eggs and larvae, corrected mortalities were assessed using dipping or spraying procedures, and for the parasitoid wasps, a clip-cage bioassay. They discovered that, all the insecticides tested killed nearly all the first instar larvae of the citrus leaf miner, but had a lesser effect on the eggs. Furthermore, the adult parasitoids of the nicotinoide insecticides imidacloprid (a.i. 0.005 percent), thiamethoxam (a.i. 0.003 percent), and acetamiprid (a.i. 0.005 %) were less toxic.

Saravanan and Savithri (2005) discovered that of the insecticides tested, polythrin 44 EC protected the crop from leaf miners for ten days after spraying, but cypermethrin and prophenphos only provided protection for one week.

Thomazini and Albuquerque (2005) performed an experiment to track the presence of *P. Citrella*, a citrus leaf miner. The parasitic Horismenus spp. was also seen emerging from leaf miner pupae.

According to Waldir *et al.* (2006), an increase in the number of new plants infected with citrus canker has been recorded in Sao Paulo state following the introduction of citrus leaf miner.

In Tahiti limes, there was a citrus canker. Citriculture was established in Sao Paulo State, Brazil, by Asiatic citrus canker (*Xanthomonas axonopodis p.v. citri*). The introduction of the Asian citrus leaf miner (*Phyllocnistis citrella* increased the number of disease foci and altered the citrus canker spatial pattern. 2007 (Christiano *et al.)*

Powell *et al.* (2007) used a replicated citrus plot to study the population density of the citrus leaf miner, *Phyllocnistis citrella* Stainton, over a 5-year period. Admire (imidacloprid) was shown to be more effective at controlling the insects. Further, the number of leaf miners was largest in the spring (April to September) and lowest in the fall (October to December) (November to March). In each of the five years studied, population peaked in June.

Efron *et al.* (2007) investigated the diversity of Citrus leaf miner parasitoids and their relationship to biotic and abiotic parameters. They discovered that the highest temperature has the greatest impact on the miner and its parasitoids.

Jesus and Redaeli (2008) determined the spatial distribution of *Phyllocnistis citrella* Stainton larvae in three scales, the citrus leaf miner, in leaves, shoots, and tree crowns of Montenegrina tangerine (*Citrus deliciasa Tenore*) and (*Citrus sinensis*), using fortnightly samplings.

Hall *et al.* (2010) studied the damage caused by the citrus leaf miner and discovered that 79 percent of leaves with canker had lesions that were connected directly with citrus leaf miners damage.

Lad *et al.* (2010) showed that, treatment with imidacloprid 0.005 % resulted in a larval reduction of 81.45 %. The next best treatments were fenalvarate 0.005% and acephate 0.1125 %. The highest per cent larvae reduction was observed on the 7th day after treatment with imidacloprid.

Patil (2013) conducted an experiment to determine the efficiency of various new group insecticides for citrus leaf miner control on acid lime. Abamectin 1.9 EC @ (0.0007 %), spinosad 45 SC @ (0.002 %), novaluron 10 (0.005 %), diafenthiuron 50 WP @ (0.05 %), triazophos 40 EC @ (0.06 %), acephate 75 SP @ (0.1125 per cent), and untreated control were the treatments used in the trial. Abamectin was found to be superior, followed by spinosad and novaluron.

(Sarda *et al.* 2014) conducted research on citrus leaf miner *P. citrella* revealed that, citrus leaf miner cause damage to young flush, plants in nurseries and new plant because of which growth of young plant is retarded.

Citrus leaf miner *P. citrella* caused damage to young plants in nurseries, and new plants, according to study conducted. As a result, the growth of young plants is retarded. (Sarda et al. (2014).

Shinde *et al.* (2014) performed experiment to evaluate efficacy of different newer insecticide molecules against citrus leaf miner in nursery on Nagpur mandarin grafts. Total eight different treatments were used viz. abamectin 1.9 EC (0.003%), acetamiprid 20 SP (0.04%), diflurobenziron 25 WP (0.08%), dimethoate 30 EC (0.04%), imidacloprid 17.8 SL (0.005%), spinosad 45 SC (0.03%), thiamethoxam 25 WG (0.06%), and Control (water spray). They discovered that thiamethoxam 25 WG (0.06 %) was considerably superior to all treatments at 3 DAS and 7 DAS of each application, with the lowest average (4.50 %) leaf

miner infection, followed by abamectin 1.9 EC (0.003 %) with a 6.22 percent leaf miner infestation.

Ahmed *et al*. (2015) studied the effects of eight different pesticides chloropyrifos, methomyl, lambda cyhalothrine, imidachloprid, abamectin, chlorfenphos, chlorantroniliprole, and emamectin benzoate. Which reduce infestation of *Tuta absoluta* in the laboratory in the field conditions. According to its potency, abamectin, chlorophenphos, and chlorantroniliprole were recommended for controlling citrus leaf miners.

Gharib *et al.* (2015) evaluated four insecticides Viz., imidacloprid (Confidor 20% OD), abamectin (Vertimec 1.8% E.C), a mineral oil (KZ oil 95% EC) and a mixture of Vertimec and KZ oil (1: 10 V/V) to control the larvae of citrus leaf miner in mandarin orchard. Result shown from larval mortality recorded at 3, 5, 7, 10 and 21 days after spraying. Imidacloprid provided effective control.

Muhammad *et al.* (2015) evaluated the toxicity of various insecticides against pea leaf miners, including chlorfenapyr 360 SL, spinosad 240SC, chlorantraniliprole 20SC, bifenthrin + abamectin 56 EC, and spintoram 120 SE, and indicated that spinetoram provides the best control, followed by spinosad and abamectin.

Mane *et al.* (2016) carried out investigation with eight treatments on citrus leaf miners, dimethoate 30 EC @ 0.03 percent, abamectin 1.8 EC @ 0.003%, spinosad 45 SC @ 0.03 %, acetamiprid 20 SP @ 0.04 %, imidacloprid 17.8 SL @ 0.005 %, neem oil 2%, NSKE 5%, and control (water spray) were used. Overall, three cumulative applications of all the treatments revealed that, abamectin, spinosad, and acetamiprid offered the best results.

Hussain *et al.* (2017), found that all the insecticides were effective, but thiamethoxam provided better control after 24 and 48 hours, while bifenthrin and spinetoram effectively controlled citrus leaf miner after 72 and 96 hours.

Insecticides to control leaf miners were tested by George *et al.* (2017). Abamectin, fenvalerate, acephate, dimethoate, and imidacloprid were found to be superior.

Shinde *et al.* (2017) conducted investigation during the kharif 2016-2017, in Bharat Nagar, Horticulture Section, College of Agriculture, Nagpur's Centre of Excellence for Citrus (Indo-Israel Project). The treatments diafenthiuron 50 EC (0.05%), triazophos 40 EC (0.06%), spinosad 45 SC (0.03%), imidacloprid 17.8 SL (0.06%), acetamiprid 20 SP (0.04%), chlorpyriphos 20 EC (0.06%), thiamethoxam 25 WG (0.06%), diflubenzuron 25 WP (0.08%), diflubenzuron 25 W The (Thiamethoxam 25 WG (0.06 %) exhibited the lowest 5.47 % leaf infection of leaf miner after three applications of all the treatments. Spinosad 45 SC (0.03

percent) showed 7.23 % leaf infestation, which was comparable to Imidacloprid 17.8 SL (0.06 %) which showed 8.52 % leaf miner infestation, and Diflubenzuron 25 WP (0.08 %) which showed 11.99 % leaf miner infestation.

Thakre and sonii (2017) tested pesticides for the control of leaf miner (*Phyllocnistis citrella*) on 6-year-old Nagpur Mandarin plants. The observations were made on the total number of leaves and the number of leaves injured by the leaf miner on 8-inch long twig before and after treatment. The pesticides were sprayed on the leaves twice, beginning with the emergence of a new flush. During the months of February and March, the bug caused the most leaf damage. As a result, imidacloprid 0.005 % followed by imidacloprid 0.005 % as a second spray after 15 days caused the least amount of damage compared to the control.

An experiment to test the efficacy of insecticides found that foliar sprays of tracer 480 SC (spinosad), Karate 5 percent EC (lambda cyhalothrin), and Nembicedine 0.03 percent EC (azadirachtin), as well as soil drench of Actara 25 WG (thiamethoxam) and Confidor 200 SL (imidacloprid) were effective in Tracer 480 SC proved to be the best foliar spray, with substantial results on lemon seedlings during two weeks, followed by Karate 5% EC and Nembicedine 0.03 percent EC. Actara 25 WG and Confidor 200 SL treated lemon and grafted grapefruit seedlings were nearly free of miner attack for more than a month, suggesting the superiority of the two soil applied pesticides over those sprayed. (Muhammad *et al.* 2018)

Mubashar *et al.* (2018) undertook an experiment to monitor insect pest infestations in citrus orchards from November 2014 to April 2015 in Keren, Eritrea, and to manage important insect pests with botanicals and chemicals, as well as the natural enemies' position. Whitefly (*Aleurothrixus spp),* cottony cushion scale (*Icerya purchasi),* citrus leaf miner *(Phyllocnistis spp),* diaspine black scale (*Parlatoria spp),* and brown scale (*Coccus spp*.) were all found in the research area. Locally synthesised botanicals (5 % neem seed kernel extract, 5 per cent balanites kernel extract) and imidacloprid 17.8 % SL were found to be efficient in controlling *Aleurothrixus spp.* and *I. purchasi* at three weeks post-foliar spray. They also stated that no natural enemies have been identified to keep insect pest populations in check.

During 2017, a field experiment was conducted at Horticultural Research Station, Junagadh Agricultural University, Junagadh to test the different combinations of pesticides against the leaf miner, *Phyllocnistis citrella,* which infested sweet orange. Leaf miner was controlled by spinosad 45 SC (14.42 %) and imidacloprid 17.8 SL (16.11 %) and determined to be the most superior pesticide against this pest, according to results based on pooled across periods over sprays. Deltamethrin + triazophos 36 EC (20.10 %), emamectin benzoate 5 SG (21.46 %), and diafenthiuron 50 WP (22.90 %) were shown to be less efficient in controlling

the pest. In addition, thiodicarb 75 WP (25.28 %), dichlorvos 76 EC (27.37%), chlorpyriphos 20 EC (28.61 %), and cartap hydrochloride 75 WG (29.01 %) provided the least effective protection against *P. citrella* for citrus crops. (Rathod *et al.* 2018)

Muhhamad *et al.* (2018) investigated the efficacy of synthetic pesticides and essential oils against citrus leaf miner larvae. When a topical bioassay was done it found that, abamectin caused considerable citrus leaf miner mortality. Furthermore, Azardirachtin indica oil was found to have the highest mortality rate of Citrus leaf miner larvae among all botanical oils tested.

One of the more recent insecticides for the control of tomato leaf miners. After three successive sprays, it was discovered that cyantraniliprole 18.5 % SC, emamectin benzoate 5% SG, spinetoram 11.7 % SC, and spinosad 45 % SC were significantly comparable. 2018 (Sapkal *et al*.)

Reddy *et al.* (2018) tested bio-rational pesticides against leaf miners over the course of two seasons (2015-16 and 2016-17). (*Liriomyza trifolii*). The study discovered that, abamectin 1.9 EC @ 0.3ml/L and spinosad 45 SC @ 0.32 ml/L, among other pesticides, produced a significant yield.

Bhut and Jethva (2019) conducted research and found that, the lowest leaf damage percentage caused by *P. citrella* infesting kagzi lime was detected in the treatment with spinosad 45 SC 0.0135 per cent, which was statistically comparable to difenthiuron 50 WP 0.05 percent and imidacloprid 17.8 SL 0.0072 percent after seven and fifteen days of the first and second sprays of the two seasons. Furthermore, thiamethoxam 25 WG 0.0125 percent, profenophos 40 + cypermethrin 4 EC 0.044 percent, and profenophos 50 EC 0.05 percent were deemed mediocre, while buprofezin 25 EC 0.025 percent and nuvaluron 10 EC 0.01 percent were found ineffective.

Jewel *et al.* (2019) assessed the bio-efficacy of several bio-pesticides for suppressing the tomato leaf miner, Tuta absoluta, at Bangladesh Agricultural University (BAU) in Mymensingh during the Rabi season. The study found that, neem leaf extract at a concentration of 2.0 ml/L can be used as a biopesticide against tomato leaf miners.

During the 2018-2019 academic year, Kumbhar *et al.* (2021) did research at the AICRP on Fruit Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth Rahuri. In descending order of bio-efficacy, spinetoram appeared to be similarly promising with the standard check, ethion 40 % + cypermethrin, followed by cypermethrin, cyantraniliprole, abamectin, spinosad, and imidachloprid.

3. MATERIALS AND METHODS

The present investigation entitled, “Efficacy of insecticides against citrus leaf miner (*Phyllocnistis citrella* Stainton) on acid lime (*Citrus aurantifolia*) was carried out in the month of September -October, 2020 at Horticultural farm of Krishi Vigyan Kendra, Dahigaon ne, Tehsil- Shevgaon, District- Ahmednagar, Maharashtra. This was done with a view to evaluate efficacy of insecticides against leaf miner on acid lime and to study effect insecticides on natural enemies. The material used and methodology adopted during the course of this experiment are as follows.

3.1 Climatic Conditions

Geographically, the Central Campus of Krishi Vigyan kendra, Dahigaon ne, is situated between Longitude -75.18, Latitude-19.5, Altitude-473m above the sea level. Climatically, this area falls in semiarid tropics with annual rainfall varying from 350 to 400 mm, distributed 15 to 45 rainy days in different months. Nearly 80% of rainfall receives from South-West monsoon from June to September.

The annual average maximum temperature is 39°C which range from 33°C to 43°C and minimum temperature 27°C which range between 13°C to 21.4°C and average minimum and maximum relative humidity ranged from 45 to 55%.

3.2 Materials

The material consisted of various agricultural equipments required for experiment such as knapsack sprayer, measuring equipments, weighing balance, labels, insecticides, syringe (to take small quantity of liquid insecticide) were used during the experiment.

3.3 Methods:

3.3.1 Method of Recording Observations of citrus leaf miner

A single plant per treatment per replication have been selected for observation. The leaf miner observations were recorded on 15 cm terminal shoot by counting total number of leaves and leaf miner infested leaves to work out per cent infestation. Five terminal shoots were counted from each plant. The observations were recorded at 0 day as pre count and a post count at 3rd, 7th and 14th days after each application. First application was given at economic threshold level of pest population and second at 15 days after the first application. Mean % leaf miner infestation was computed by using the following formula.

$$\% \text{ Leaf miner infestation} = \frac{\text{Leaf miner infested leaves per 15 cm terminal shoots}}{\text{Total number of leaves per 15 cm terminal shoot}} \times 100$$

3.3.2 Observation on Larval Mortality:

The larval count was taken from selected 15cm five terminal shoots from each plant. The larval count was taken at 0 days as a pre count and post count at 3rd, 7th, and 14th days after 1st and 2nd spray. The % larval mortality was worked out from the following formula,

$$\text{Per cent larval mortality} = \frac{\text{Number of leaf miner dead larvae}}{\text{Initial larval count}} \times 100$$

3.3.3 Method of Recording Observations of Natural Enemies

3.3.3.1 *Mallada* spp:

The *Mallada* population was counted per plant at 0 day as pre count and post count at 14th days after Second spraying.

3.3.3.2 Spider:

The spiders were counted per plant at 0 day as pre count and post count at 14th days after second spraying.

3.4 Studies on Efficacy of Insecticides on Acid Lime for Management of Citrus Leaf Miner

The studies on efficacy of insecticides against leaf miner was carried out on acid lime orchard at Krishi Vigyan Kendra, Dahigaon ne, Tehsil-Shevgaon, District- Ahmednagar during September -October, 2020

3.4.1 Experimental Details-

1. Year and season : 2020, September -Hast bahar
2. Crop and variety : Acid lime Variety: Phule Sharbati
3. Design : Randomized Block Design
4. Replications : 3
5. Number of plants per replication : 2
6. Plant spacing : 6×6m
7. Treatments : 10
8. Date of insecticide application : a) 16th September, 2020
   : b) 1st October, 2020.
9. Age of tree : 7 years

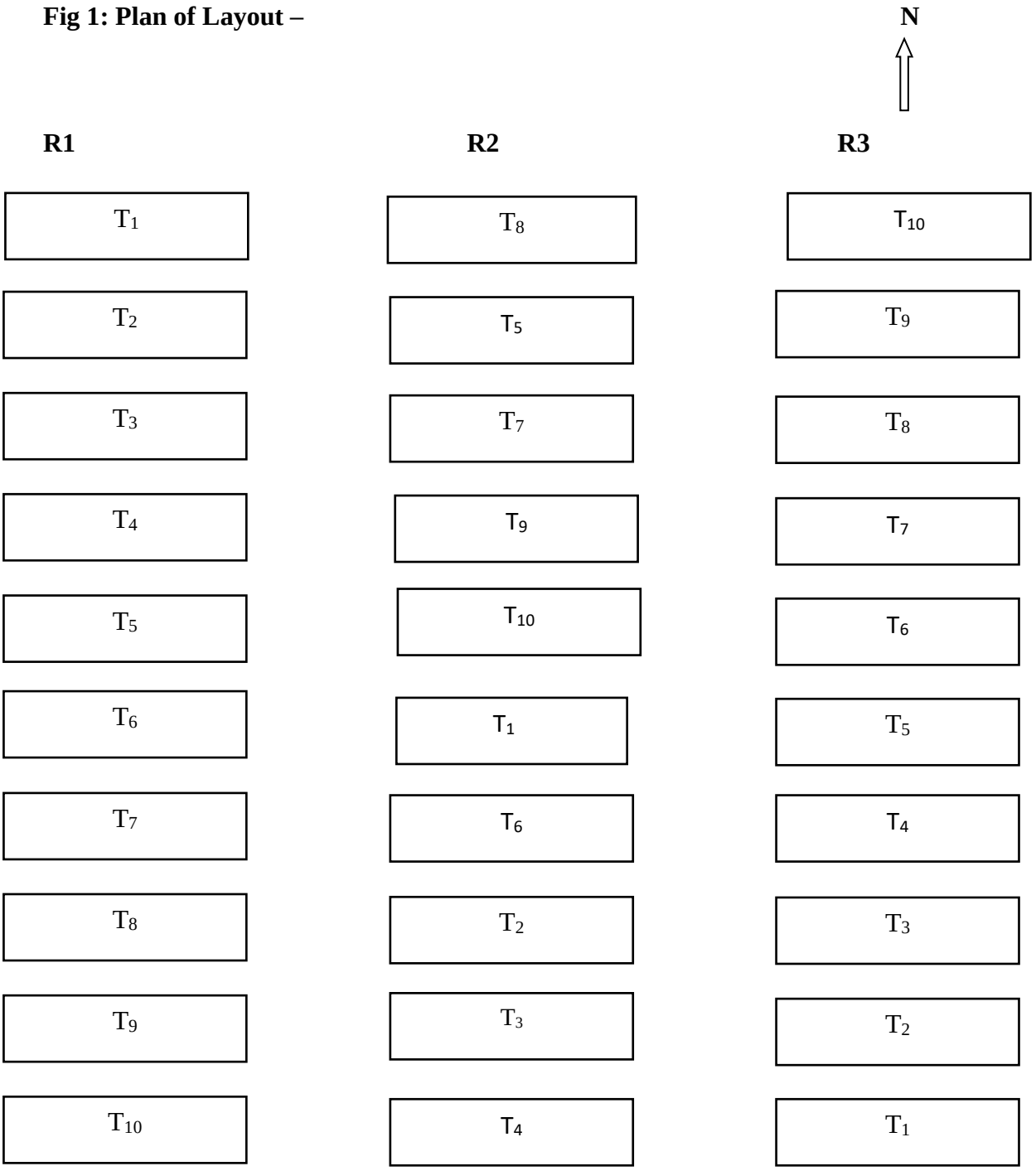
3.4.2Treatment Details

Treatments	Name of Biopesticides / Insecticides	Dosage / ha (g/ml per l).
T_1	Spirotetramat 120 SC + Imidacloprid 120 SC	0.5
T_2	Cyantraniliprole 10.26% OD	1.8
T_3	Abamectin 0.15 % EC	0.37
T_4	Spinetoram 11.7% SC	0.5
T_5	Buprofezin 25%SC	1.25
T_6	Spinosad 45% SC	0.3
T_7	Acetameprid 20% SP	0.3
T_8	Neem formulation (Azadirachtin)10000 ppm	3
T_9	Emamectin benzoate 5% SG	0.25
T_{10}	Untreated control (water spray)	-

Field evaluation of different insecticides were carried out for the efficacy against leaf miner on acid lime. The experiment was conducted on acid lime variety Phule Sharbati variety having age of 7 years planted at a distance of 6×6m from row to row and same distance between plant to plant. Experiment was laid out in randomized block design with 3 replications and 10 treatments including untreated control.

First application of insecticide was done on 16th September, 2020 and 2nd after 15th days interval on 1st October, 2020.

Fig 1: Plan of Layout –



Whereas,

T_1- Spirotetramag 120 SC + Imidachloprid 120 SC- 0.5 T_2- Cyantraniliprole 10.26% OD

T_3- Abamectin 0.15% EC T_4- Spinetoram11.7 SC- 0.5

T_5- Buprofezin 25% Sc- 1.25 T_6- Spinosad 45% SC – 0.3

T_7- Acetameprid 20% SP -0.3 T_8- (Azadirachtin) 10000 ppm- 3.0

T_9- Emabectin benzoate 5% SG -0.25 T_{10}- Untreated control (water spray)

Table 2: Details of insecticides applied under field condition are given below.

Sr. no	Technical name	Concentration of form	Trade name	Insecticide class	Source	IRAC MOA Group
01	Spirotetramat+ Imidacloprid	120 % SC	Movento Energy	-	M/S Buyer crop science India Ltd, Pune	-
02	Cyantraniliprole	10.26 % OD	Benevia	Diamides	FMC India Private Ltd, Bandra, Mumbai	28
03	Abamectin	0.15 % EC	Agrimec	Avermectins	Syngenta India Ltd, Pune	6
04	Spinetoram	11.7 % SC	Largo	Spinosynes	Dhanuka Agritech Ltd, Gurgaon, Hariyana.	5
05	Buprofezin	25 % SC	Apple	Buprofezin	Dhanuka Agritech Ltd, Gurgaon, Hariyana.	16
06	Spinosad	45 % SC	One up	Spinosynes	Dhanuka Agritech Ltd, Gurgaon, Hariyana.	5
07	Acetameprid	20 % SP	Dhanpreet	Neonicotinoids	Dhanuka Agritech Ltd, Gurgaon, Hariyana	4A
08	Neem formulation	10000 ppm	Neemcare	Azadirachtin	Vijaya Agro industries Sangamner, Ahmednagar	UN
09	Emamectin benzoate	5 % SG	EM-1	Avermectins	Dhanuka Agritech Ltd, Gurgaon, Hariyana	6

3.4.3 Methods of Application of Insecticides

Two trees were selected per replication per treatment for insecticide application. The insecticidal applications per treatments were taken at peak incidence of citrus leaf miner at an interval of 15 days during hast bahar of year 2020. Application of each insecticide was done for predetermined concentration

3.5 Preparation of Spray Solution

The insecticidal spray solution of desired concentration was freshly prepared every time at the site of experiment that was prepared just before the spraying operation. The quantity of spray solution required for coverage of crop was gradually increase as crop growth advances.

The volume or amount of commercial insecticide formulation required for different insecticides active ingredient at desired concentrations, the spray solution was prepared by adopting the following formula,

$$\{N1V1 = N2V2\}$$

Where,

N1 = Concentration of chemical formulation in per cent or grams

V1 = Volume or amount of commercial insecticide formulation required in ml or grams.

N2 = Desired conc. of spray fluid (%) V2 =Volume or amount of spray fluid required (ml)

$$V1 = N2V2/ N1$$

For preparation of unit spray suspension, calculated amount of insecticide was mixed in 1 litre water and stirred with wooden stick then this prepared solution was taken in sprayer and sprayed on acid lime plants.

3.6 Calibration and Preparation of Spray Solution.

The insecticidal spray solution of desired concentration as per each treatment were freshly prepared every time at experimental site just before the start of spraying operation. The quantity of spray material required for coverage of tree is calculated by spraying the control plot with water.

$$\text{Quantity of insecticidal formulation} = \frac{\text{Desired strength Quantity of water required}}{\text{\% Insecticide in formulation}}$$

3.7 Time of Application of Treatment

Earlier ETL was noticed in orchard spraying was initiated in all 2 applications were undertaken at 15 days interval in month of September-October 2020. Observation of leaf miner infestation were recorded at 0 day as pre count and after 3rd, 7th and 14th day of spraying of each application.

3.8 Statistical Analysis

The data generated in respect of per cent leaf infestation due to citrus leaf miner were transformed into arc sin values and for larval count in to square root transformation as per Panase and Sukhatme (1985) and then subjected to statistical analysis to test the significance of treatment.

4. RESULTS AND DISCUSSION

The present investigations were undertaken to study 'Efficacy of insecticides on citrus leaf miner (*Phyllocnistis citrella* Stainton*)* on Acid lime (*Citrus aurantifolia)'* at horticulture farm of Krishi Vigyan Kendra Dahigaon ne and College of Agriculture, Dhule during 2020-21 in the month of September-October.

The data collected during the investigation, were appropriately transformed and subjected to the statistical analysis by standard procedure. Results obtained on different parameters are presented separately and discussed here under different headings and subheadings. They are as follows.

The results obtained during the course of investigation are presented separately under different heads and discussed in the line of earlier findings.

- Efficacy of insecticides against citrus leaf miner
- Efficacy of insecticides on natural enemies.

As per set objectives of the research studies, the data generated on efficacy and effect on natural enemies conducted during 2020 is compiled and results based on the same are presented in the chapter.

4.1 Efficacy of Insecticides against Citrus Leaf Miner

The data on per cent leaf miner infestation/ 15 cm terminal twig one day before spray and post count at 3rd, 7th and 14th days after first, second spray and mean of two sprays are presented in Tables 4.1, 4.2 and 4.3, respectively.

4.1. 1 Per Cent Infestation of Citrus Leaf Miner after First Spray

The data presented in Table 4.1 and depicted in fig.4.1 revealed that per cent leaves infestation was non significant and recorded in range of 22.33 to 28.40 one day before first spray.

At 3 days after first spray, the results showed that all treatments were significantly superior over untreated control in recording the lowest percentage of citrus leaf miner infestation. The treatment with spinosad 45 SC @ 0.3 ml/l recorded lowest (19.93 per cent) leaf infestation and it was found at par with spinetoram11.7 SC @ 0.5 ml/l, cyantraliniprole10.26 OD @ 1.8 ml/l, and spirotetramat120 SC + imidacloprid 120SC @ 0.5ml/l, which recorded 21.50, 22.00 and 22.40 per cent leaf infestation respectively. These treatments were followed by abamectin 0.15 EC @ 0.37ml/l, which recorded 24.00 per cent leaf miner infestation. Acetamiprid 20 SP @ 0.39ml/l was next better treatment which recorded 24.47 per cent leaf miner infestation. Following these treatments, buprofezin 25 SC @ 1.25 ml/l, emamectin benzoate 5 SG @ 0.25

g/l, and azadirachtin (10000 ppm) @ 3.0 ml/l, recorded 24.93, 25.30, and 25.33 per cent leaf miner infestation, respectively. However, the untreated control recorded the highest (23.67 per cent) leaf miner infestation.

All the treatments were significantly superior over untreated control for recording minimum per cent leaf miner infestation at 7 days after first spraying. Among various treatments spinosad 45 SC @ 0.3 ml/l recorded lowest 15.93 per cent leaf infestation of leaf miner. This was found at par with the spinetoram 11.7 SC @ 0.5 ml/l, spirotetramat 120 SC + imidacloprid 120 SC @ 0.5ml/l and cyantraniliprole 10.26 OD @ 1.8 ml/l recording 16.13, 16.40 and 17.40 per cent leaf miner infestation on 15 cm apical twig. Abamectin 0.15 EC @ 0.37ml/l and acetamiprid 20 SP @ 0.39ml/l were the next best treatments, with 20.33 and 20.73 per cent leaf miner infestation respectively. Buprofezin 25 SC @ 1.25 ml/l, emamectin benzoate 5 SG @ 0.25 g/l, and azadirachtin (10000 ppm) @ 3.0 ml/l were the next better treatments, with 19.67, 21.07 and 21.20 % leaf miner infestations, respectively. However, the untreated control recorded the highest (25.73 %) leaf miner infestation.

At 14 days after first spray all the treatments were significantly better than the untreated control. Citrus leaf miner infestation was lowest in treatment spinosad 45 SC @ 0.3 ml/l, which recorded 13.33 per cent leaf miner infestation. This Treatment was found at par with the spinetoram 11.7 SC @ 0.5 ml/l, spirotetramat 120 SC + imidacloprid 120 SC @ 0.5ml/l and cyantraniliprole 10.26 OD @ 1.8 ml/l recording 14.00, 14.47, 15.60 per cent leaf miner infestation respectively. The next better treatments were abamectin 0.15 EC @ 0.37ml/l and acetamiprid 20 SP @ 0.39ml/l recorded 18.00 and 18.20 per cent leaf miner infestation respectively. The next better treatments were buprofezin 25 SC@ 1.25 ml/l, emamectin benzoate 5 SG @ 0.25 g/l and azadirachtin (10000 PPM) @ 3.0 ml/l which recorded 18.27,17.00 and 18.93 per cent leaf miner infestation respectively. However maximum per cent leaf miner infestation was found in untreated control which was 27.10 per cent.

Table 4.1.: Efficacy of Insecticides on Per Cent Infestation of Citrus Leaf Miner after First Application

TR. NO	Treatments	Dose (g/ml/ L)	Pre count	Per cent infestation of citrus leaf miner on 15 cm apical twig after 1st spray at		
				3 DAS	7 DAS	14 DAS
1	Spirotetramat 120 + Imidacloprid 120SC	0.5	27.33 (31.52)	22.40 (28.25)	16.40 (23.89)	14.47 (22.36)
2	Cyantraniliprole 10.26 OD	1.8	27.30 (31.50)	22.00 (27.97)	17.40 (24.65)	15.60 (23.26)
3	Abamectin 0.15 EC	0.37	27.83 (31.84)	24.00 (29.33)	20.33 (26.80)	18.00 (25.10)
4	Spinetoram 11.7 SC	0.5	27.50 (31.63)	21.50 (27.62)	16.13 (23.68)	14.00 (21.97)
5	Buprofezin 25 SC	1.25	26.67 (31.09)	24.93 (29.95)	19.67 (26.33)	18.27 (25.30)
6	Spinosad 45 SC	0.3	26.90 (31.34)	19.93 (26.51)	15.93 (23.52)	13.33 (21.41)
7	Acetamiprid 20 SP	0.3	27.97 (31.93)	24.47 (29.65)	20.73 (27.08)	18.20 (25.25)
8	Neem formulation Azadirachtin (10000ppm)	3.0	27.40 (31.56)	25.33 (30.22)	21.20 (27.42)	18.93 (25.79)
9	Emamectin benzoate 5 SG	0.25	28.40 (32.20)	25.30 (30.20)	21.07 (27.32)	17.00 (24.35)
10	Untreated control (water spray)	-	22.33 (28.20)	25.67 (30.44)	25.73 (30.48)	27.10 (31.37)
F test			NS	SIG	SIG	SIG
SE (M) ±				0.83	0.82	0.96
CD at 5%				2.47	2.44	2.78

*Figures in the parentheses are corresponding values of arc sin transformation.

4.1. 2 Second Spray

The data presented in Table 4.2 and depicted in Fig. 4.2 revealed that all the insecticide treatments were significantly superior over untreated control at 3rd, 7th and 14th days after second spray.

At 3 days after second spray the treatment with spinosad 45 SC was found most superior and recorded lowest 10.20 per cent leaf miner infestation and found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC recording 11.93, 12.00 and 12.27 per cent leaf miner infestation, respectively. The next best treatment was abamectin 0.15 EC which recorded 13.60 per cent infestation. Following that, the treatment with acetamiprid 20 SP recorded 13.93 per cent infestation. Buprofezin 25 SC, emamectin benzoate 5 SG, and Neem formulation azadirachtin (10000 ppm) were next better treatments, with 14.07, 13.60, and 14.33 per cent leaf miner infestation, respectively. The untreated control recorded the highest (29.00 per cent) leaf miner infestation.

At 7 days after second spray the treatment with Spinosad 45 SC recorded the lowest infestation, with (8.50 %) leaf miner infestation, which was superior to all other treatments except spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC which recorded 9.73, 9.73 and 9.80 per cent leaf miner infestation, respectively. The next best treatments were abamectin 0.15 EC and acetamiprid 20 SP which recorded 11.27 and 11.47 per cent leaf miner infestation respectively. Then next better treatments were buprofezin 25 SC, emamectin benzoate 5 SG and neem formulation Azadirachtin (10000 ppm) which recorded 11.60, 11.67 and 12.07 per cent infestation, respectively. Maximum leaf miner infestation was recorded in untreated control (29.60 %).

At 14 days after second spray the treatment with spinosad 45 SC found significantly superior and recorded lowest 5.80 per cent per cent leaf miner infestation. It was found at par with the treatments spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC recording 7.33, 6.13 and 6.60 per cent infestation respectively. Following that, abamectin 0.15 EC and acetamiprid 20 SP showed 8.07 and 8.40 per cent leaf miner infestation, respectively. Buprofezin 25 SC, emamectin benzoate 5 SG, and azadirachtin (10000 ppm) followed the above treatments indicate 8.47, 8.50 and 9.08 per cent leaf miner infestation, respectively. Highest infestation of citrus leaf miner was recorded in untreated control (33.35).

Table 4. 2. Efficacy of Insecticides on Per Cent Infestation of Citrus Leaf Miner after Second Spray

Tr No.	Treatments	Dose (g/ml/L)	Per cent infestation of citrus leaf miner on 15 cm apical twig after 2nd spray at		
			3 DAS	7 DAS	14 DAS
1	Spirotetramat120SC+ Imidacloprid 120SC	0.5	12.00 (20.27)	9.73 (18.18)	6.13 (14.33)
2	Cyantraniliprole 10.26 OD	1.8	12.27 (20.50)	9.80 (18.24)	6.60 (14.89)
3	Abamectin 0.15 EC	0.37	13.60 (21.64)	11.27 (19.62)	8.07 (16.50)
4	Spinetoram 11.7 SC	0.5	11.93 (20.21)	9.73 (18.18)	7.33 (15.71)
5	Buprofezin 25 SC	1.25	14.07 (22.03)	11.60 (19.91)	8.47 (16.92)
6	Spinosad 45 SC	0.3	10.20 (18.63)	8.50 (16.95)	5.80 (13.94)
7	Acetamiprid 20 SP	0.3	13.93 (21.91)	11.47 (19.80)	8.40 (16.85)
8	Neem Formulation Azadirachtin (10000 ppm)	3.0	14.33 (22.24)	12.07 (20.33)	9.08 (17.54)
9	Emamectin benzoate 5 SG	0.25	13.60 (21.64)	11.67 (19.98)	8.50 (16.95)
10	Untreated Control (water spray)	-	29.00 (32.58)	29.60 (32.96)	33.35 (35.27)
F test			SIG	SIG	SIG
SE (M) ±			0.77	0.72	0.84
CD at 5%			2.28	2.13	2.50

*****Figures in the parentheses are corresponding values of arc sin transformation

4.3 Average Effect of Two Applications on Per Cent Infestation of Citrus Leaf Miner

The data of average of two sprays on per cent infestation of citrus leaf miner on 15 cm apical twig presented in table 4.3 and depicted in Fig. 4.3 revealed that all the insecticidal treatments were significantly superior over untreated control in recording lowest percentage of leaf miner infestation.

The observations on average leaf miner infestation recorded at 3 days after first and second spray revealed that all the treatments were significantly superior over untreated control and recorded infestation in the range of 15.03-27.33 per cent, respectively.

Spinosad 45 SC was significantly superior over all the treatments recording lowest 15.03 per cent leaf infestation of citrus leaf miner on 15 cm apical twig. This treatment found at par

with the spinetoram 11.7 SC and cyantraniliprole 10.26 OD. recording 16.87 and 17.20 per cent infestation, respectively. Spirotetramat 120 SC + imidacloprid 120 SC recorded 18.80 leaf miner infesration was next better treatment. Next better treatment was abamectin 0.15 EC which recorded 19.20 per cent leaf miner infestation was next better treatment. This was followed by the acetamiprid 20 SP, buprofezin 25 SC, emamectin benzoate 5 SG and azadirachtin (10000 ppm) recording 19.45, 19.50, 19.83 and 20.77 per cent leaf infestation of citrus leaf miner, respectively. Highest per cent leaves infestation 27.33 per cent was recorded in untreated control.

At 7 days minimum per cent infestation recorded in spinosad 45 SC that was 12.20 per cent which is superior over all the treatments except spinetoram 11.7 SC, spirotetramat 120 SC + imidacloprid 120 SC and cyantraniliprole 10.26 OD recording 12.77, 13.07 and 13.63 per cent infestation, respectively. The next better treatment was abamectin 0.15 EC recorded 15.80 per cent leaf miner infestation. It was superior over acetamiprid 20 SP 16.10, buprofezin 25 SC 16.33, emamectin benzoate 5 SG 15.67 and azadirachtin (10000 ppm) 16.63 per cent leaf miner infestation, respectively. Whereas highest (27.67 %) leaf miner infestation were recorded in untreated control.

At 14 days results showed that spinosad 45 SC recorded least (9.27 per cent) leaf infestation. It was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC recorded 10.30, 10.67 and 11.10 per cent leaf infestation, respectively. The next better treatment was abamectin 0.15 EC which showed 12.73 per cent leaf infestation. Followed by acetamiprid 20 SP 13.03, buprofezin 25 SC 13.37, emamectin benzoate 5 SG 13.40 and azadirachtin (10000 ppm) 14.00 per cent leaf infestation, respectively. Whereas highest (30.32%) leaf miner infestation found in untreated control.

Table 4.3: Efficacy of Insecticides on Citrus Leaf Miner

Tr No.	Treatments	Dose (g/ml/L)	Per cent infestation of citrus leaf miner on 15 cm apical twig (after average of two sprays)		
			3 DAS	7 DAS	14 DAS
1	Spirotetramat 120 + Imidacloprid 120SC	0.5	18.80 (25.70)	13.07 (21.19)	11.10 (19.46)
2	Cyantraniliprole 10.26 OD	1.8	17.20 (24.50)	13.63 (21.67)	10.67 (19.07)
3	Abamectin 0.15 EC	0.37	19.20 (25.99)	15.80 (23.42)	12.73 (20.90)
4	Spinetoram 11.7 SC	0.5	16.87 (24.25)	12.77 (20.94)	10.30 (18.72)
5	Buprofezin 25 SC	1.25	19.50 (26.21)	16.33 (23.84)	13.37 (21.45)
6	Spinosad 45 SC	0.3	15.03 (22.81)	12.20 (20.44)	9.57 (18.02)
7	Acetamiprid 20 SP	0.3	19.45 (26.17)	16.10 (23.66)	13.03 (21.16)
8	Neem Formulation Azadirachtin (10000 ppm)	3.0	20.77 (27.11)	16.63 (24.07)	14.00 (21.97)
9	Emamectin benzoate 5 SG	0.25	19.83 (26.47)	15.67 (23.32)	13.40 (21.47)
10	Untreated Control (Water spray)	-	27.33 (31.52)	27.67 (31.74)	30.32 (33.40)
F test			SIG	SIG	SIG
SE (M) ±			0.69	0.67	0.62
CD at 5%			2.07	1.99	1.84

*Figures in the parentheses are corresponding values of arc sin transformation

In an experiment conducted by Bhut and Jethva (2019) it was discovered that, lowest per cent leaf damage were found in spinosad 45 SC, which was significantly superior over all the treatments. Findings of these writers are comparable to present investigation in related to spinosad. This gives strong support to present data.

Kumbhar *et al.* (2021) conducted research on acid lime and observed that spinetoram 11.7 SC appears to be promising as the standard check as observed in this study. Results with spinosad, cyantraniliprole, and abamectin are also similar, according to the study. As a result, this conclusion is consistent with the current investigation and provides strong support to present studies.

Similar findings for spinosad were reported by Rathod *et al.* (2018). They found that, spinosad 45 Sc reduced leaf miner infestation in a similar way. Shinde *et al.* (2017) found comparable results with spinosad 45 SC, demonstrating that spinosad provided better control of citrus leaf miner infestation. Acetameprid 20 SP was also found to be an effective pesticide for controlling per cent citrus leaf miner infestations.

Shinde *et al.* (2014) found that, spinosad 45 SC is a better insecticide for controlling leaf miner infestation. They also discovered that acetamiprid 20 SP, a neonicotinoid, was an effective insecticide. Abamectin and spinosad were found to be more effective in controlling citrus leaf miners by Rao *et al.* (2002)

Mohammad *et al.* (2015) found that, spinosad, spinetoram and abamectin were better insecticides to control citrus leaf miner. Jothi and Tondon (1993) proved that, neem formulation provided good control of citrus leaf miner.

4.4 Efficacy of Insecticides against Citrus Leaf Miner Larvae in Acid lime after First Spray

The data on number of citrus leaf miner larvae / 15cm terminal twig reported at pre count and at 3^{rd},7^{th} and 14^{th} day after first and second spray and mean of two sprays are presented in Table 4.4, 4.5, and 4.6, respectively.

The data presented in tables revealed that the initial larval count of leaf miner was non significant and recorded in the range of 14.63 to 16.56 larvae/ 15 cm terminal twig at pre count. The post count of larval population showed that, all the insecticide treatment were significantly superior over the untreated control in recording lower larval population of citrus leaf miner at 3^{rd}, 7^{th} and 14^{th} day after first spray.

At 3 days after first spray the data presented in table 4.4 and Fig. 4.4 revealed that lowest larval population recorded in spinosad 45 SC (10.33 larvae/ 15 cm terminal twig). This treatment was significantly superior over all the treatments and found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + Imidacloprid 120 SC which recorded 10.80, 11.00 and 11.13 larval population/ 15 cm terminal twig, respectively. The next better treatment was abamectin 0.15 EC recording 12.80 larval population. This was followed by acetamiprid 20 SP (13.07), buprofezin 25 SC (13.26), emamectin benzoate 5 SG (13.53), azadirachtin (10000 ppm) (13.66 citrus leaf miner larvae / 15cm terminal shoots), respectively. The highest larval count was recorded in untreated control (16.40).

At 7 days after first spray minimum larval population observed in spinosad 45 SC (7.8 larvae/ 15cm terminal shoot) and it was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC+ imidacloprid 120SC recorded 8.53, 9.06

and 9.33 larvae / 15 cm terminal twig, respectively. The next best treatments were abamectin 0.15 EC (10.13), acetamiprid 20 SP (10.47), buprofezin 25 SC (10.80), emamectin benzoate 5 SG (11.00), azadirachtin (10000 ppm) (11.33 citrus leaf miner larvae / 15cm terminal shoots), respectively. The maximum larval count was recorded in untreated control (20.87).

After 14 days after first spray similar trend was observed. Lowest larval count observed in Spinosad 45 SC recording 5.6 larvae / 15cm terminal twig which was significantly superior over the other treatments except spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120SC with 6.13, 6.60 and 6.86 larvae/ 15 cm apical twig respectively. The next better treatments were abamectin 0.15 EC (7.73), acetamiprid 20 SP (7.87), buprofezin 25 SC (8.00), emamectin benzoate 5 SG (8.27), azadirachtin (10000 ppm) (11.33 citrus leaf miner larvae / 15cm shoots), respectively. The maximum larval count was recorded in untreated control (22.40).

Table 4.4: Efficacy of Insecticides against Citrus Leaf Miner Larvae after First Spray

TR. NO	Treatments	Dose (g/ml/ L)	Pre count	Larval count of citrus leaf miner on 15 cm terminal twig after first spray at		
				3 DAS	7 DAS	14 DAS
1	Spirotetramat 120 + Imidacloprid 120SC	0.5	15.9 (4.04)	11.13 (3.40)	9.33 (3.13)	6.86 (2.70)
2	Cyantraniliprole 10.26 OD	1.8	16.56 (4.13)	11.00 (3.38)	9.06 (3.08)	6.60 (2.65)
3	Abamectin 0.15 EC	0.37	15.66 (4.02)	12.80 (3.62)	10.13 (3.25)	7.73 (2.86)
4	Spinetoram 11.7 SC	0.5	14.63 (3.88)	10.80 (3.33)	8.53 (3.00)	6.13 (2.57)
5	Buprofezin 25 SC	1.25	15.43 (3.99)	13.26 (3.67)	10.80 (3.34)	8.00 (2.89)
6	Spinosad 45 SC	0.3	14.63 (3.89)	10.33 (3.27)	7.8 (2.87)	5.6 (2.46)
7	Acetamiprid 20 SP	0.3	15.93 (4.05)	13.07 (3.65)	10.47 (3.30)	7.87 (2.87)
8	Neem Formulation Azadirachtin (10000 ppm)	3.0	15.97 (4.06)	13.66 (3.72)	11.33 (3.42)	8.47 (2.98)
9	Emamectin benzoate 5 SG	0.25	15.40 (3.98)	13.53 (3.73)	11.00 (3.39)	8.27 (2.94)
10	Untreated control (Water spray)	-	15.27 (3.96)	16.40 (4.05)	20.87 (4.61)	22.40 (4.77)
F test			NS	SIG	SIG	SIG
SE (M) ±				0.10	0.12	0.12
CD at 5%				0.30	0.36	0.36

*Figures in the parentheses are corresponding values of square root +0.5 (√x+0.5) transformed values.

Table 4.5 Efficacy of Insecticides against Citrus Leaf Miner Larvae after Second Spray

Tr No.	Treatments	Dose (g/ml/L)	Larval count of citrus leaf miner after second spray		
			3 DAS	7 DAS	14 DAS
1	Spirotetramat 120 SC + Imidacloprid 120SC	0.5	4.06 (2.12)	2.90 (1.81)	1.46 (1.35)
2	Cyantraniliprole 10.26 OD	1.8	3.73 (2.05)	2.76 (1.78)	1.20 (1.27)
3	Abamectin 0.15 EC	0.37	4.66 (2.24)	3.73 (1.98)	2.00 (1.50)
4	Spinetoram 11.7 SC	0.5	3.66 (2.02)	2.06 (1.59)	1.06 (1.24)
5	Buprofezin 25 SC	1.25	5.02 (2.34)	4.00 (2.07)	2.80 (1.73)
6	Spinosad 45 SC	0.3	2.66 (1.76)	1.56 (1.43)	0.46 (0.97)
7	Acetamiprid 20 SP	0.3	5.06 (2.33)	3.87 (2.05)	2.27 (1.59)
8	Neem Formulation Azadirachtin (10000 ppm)	3.0	5.80 (2.46)	4.67 (2.22)	3.33 (1.88)
9	Emamectin benzoate 5 SG	0.25	5.47 (2.40)	4.26 (2.12)	2.93 (1.78)
10	Untreated control (water spray)	-	23.27 (4.87)	24.83 (5.02)	25.77 (5.13)
F test			SIG	SIG	SIG
SE (M) ±			0.16	0.17	0.17
CD at 5%			0.47	0.51	0.50

*Figures in the parentheses are corresponding values of square root +0.5 (√x+0.5) transformed values.

Efficacy of Insecticides against Citrus Leaf Miner after Second Spray

The data presented in a Table 4.5 and depicted Fig 4.5 revealed that all the treatments were significantly superior over untreated control in recording minimum larval population of citrus leaf miner / 15 cm twig.

At 3 days after 2nd spray, the result showed that treatment spinosad 45 SC recording least (2.66 larvae / 15 cm apical twig) was significantly superior over all treatments. Treatment with

spinosad was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120SC recording 3.66, 3.73 and 4.06 larvae / 15cm apical twig, respectively. The next better treatments were abamectin 0.15 EC (4.66), acetamiprid 20 SP (5.06), buprofezin 25 SC (5.02), emamectin benzoate 5 SG (5.47) and azadirachtin (10000 ppm) (5.80) citrus leaf miner larvae / 15cm shoots, respectively. The highest larval population was recorded in untreated control. (23.27 larvae / 15cm apical twig.)

After 7th days of second spray least population of citrus leaf miner larvae observed in spinosad 45 SC 1.56 larvae / 15cm apical twig. This were followed by spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + Imidacloprid 120 SC recorded 2.06, 2.76 and 2.90 larvae/ 15cm terminal twig, respectively. The next better treatments were abamectin 0.15 EC (3.73), acetamiprid 20 SP (3.87), buprofezin 25 SC (4.00), emamectin benzoate 5 SG (4.26), azadirachtin (10000 ppm) (4.67) citrus leaf miner larvae / 15cm terminal shoots, respectively. The highest (24.83) larval population was recorded in untreated control.

At 14 days after 2nd spray significantly lowest larval count observed in spinosad 45 SC (0.46 larvae / 15cm terminal twig). This were followed by the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC recording 1.06, 1.20 and 1.46 larvae / 5cm twig and found at par with spinosad 45 SC respectively. The next better insecticides were abamectin 0.15 EC (2.00), acetamiprid 20 SP (2.27), buprofezin 25 SC (2.80), emamectin benzoate 5 SG (2.93), azadirachtin (10000 ppm) (3.33 citrus leaf miner larvae / 15cm shoot), respectively.

4.6 Efficacy of Insecticides against Citrus Leaf Miner Larvae on Acid Lime

The data presented in Table 4.6 and depicted in Fig 4.6. revealed that all the treatments were significantly better over untreated control. At average of three days larval count found in range of 6.5-19.83 larvae/ 15cm apical twigs. Lowest larval count recorded in spinosad 6.5 larvae/ 15 cm twig which is significantly superior over all the treatments. This treatment was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120SC recording 7.23, 7.37 and 7.76 larvae / 15 cm terminal twigs, respectively.

The next better treatments were abamectin 0.15 EC (8.8), acetamiprid 20 SP (9.06), buprofezin 25 SC (9.23), emamectin benzoate 5 SG (9.50), azadirachtin (10000 ppm) (9.70) citrus leaf miner larvae / 15cm apical shoots, respectively. The maximum larval population was found in untreated control (19.83 larvae/ 15cm apical twig).

Average of 7 days follows similar trend. Least larval count of citrus leaf miner registered in spinosad 4.66 larvae/ 15 cm apical twigs. This was found at par with the spinetoram 11.7 SC,

cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC recording 5.5, 5.9 and 6.1 larvae / 15 cm twigs, respectively.

The next better treatments were abamectin 0.15 EC (6.93), acetamiprid 20 SP (7.17), buprofezin 25 SC (7.35), emamectin benzoate 5 SG (7.63) and azadirachtin (10000 ppm) (8.00) citrus leaf miner larvae / 15cm shoots, respectively. The maximum (22.85) larval population was found in untreated control.

Average data collected after 14 days of first and second spray revealed that treatment with spinosad 45 SC recording significantly least count (3.03 larvae / 15cm twig) and it was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 + imidacloprid 120SC recording 3.60, 4.16 and 4.23 larvae / 15cm terminal twig, respectively. The next better treatments were abamectin 0.15 EC (4.86), acetamiprid 20 SP (5.06), buprofezin 25 SC (5.40), emamectin benzoate 5 SG (5.60) and azadirachtin (10000 ppm) (5.90) citrus leaf miner larvae / 15 cm terminal shoots, respectively. The highest larval poulation was found in untreated control (23.10 larvae / 15 cm apical twig).

Table 4.6: Efficacy of Insecticides against Citrus Leaf Miner Larvae on Acid Lime

Tr No.	Treatments	Dose (g/ml/L)	Larval count of Citrus leaf miner on 15 cm apical twig (Average of two sprays)		
			3 DAS	7 DAS	14 DAS
1	Spirotetramat 120 SC + Imidacloprid 120SC	0.5	7.76 (2.86)	6.1 (2.55)	4.23 (2.17)
2	Cyantraniliprole 10.26 OD	1.8	7.37 (2.39)	5.9 (2.51)	4.16 (2.15)
3	Abamectin 0.15 EC	0.37	8.8 (3.02)	6.93 (2.70)	4.86 (2.30)
4	Spinetoram 11.7 SC	0.5	7.23 (2.76)	5.3 (2.40)	3.60 (2.02)
5	Buprofezin 25 SC	1.25	9.23 (3.08)	7.35 (2.78)	5.40 (2.39)
6	Spinosad 45 SC	0.3	6.5 (2.63)	4.66 (2.26)	3.03 (1.87)
7	Acetamiprid 20 SP	0.3	9.06 (3.06)	7.17 (2.75)	5.06 (2.33)
8	Neem Formulation Azadirachtin (10000 ppm)	3.0	9.70 (3.15)	8.00 (2.89)	5.90 (2.49)
9	Emamectin benzoate 5 SG	0.25	9.50 (3.13)	7.63 (2.83)	5.60 (2.43)
10	Untreated control (water spray)	-	19.83 (4.50)	22.85 (4.82)	23.10 (4.85)
F test			SIG	SIG	SIG
SE (M) ±			0.09	0.12	0.12
CD at 5%			0.26	0.36	0.34

*Figures in the parentheses are corresponding values of square root +0.5 (√x+0.5) transformed values.

An experiment conducted on citrus leaf miners in acidlime by Bhut and Jethva (2019) discovered that, spinosad 45 SC had the lowest larval count after two sprays. It was superior over all other treatments in terms of larval population reduction. As a result, the current findings are in the line of above results. Mungroo and Abbeluck (1999) observed that good control of leaf miner provided by acetamiprid 20 SP. This is in agreement with present investigation.

Vargas *et al.* (1999) demonstrated that abamectin 0.15 EC controlled citrus leaf miners effectively. Yammout *et al.* (2000) showed that acetamiprid 20 SP was effective in controlling leaf miner. Shinde *et al.* (2014) found Abamectin was good insecticide to reduce leaf miner infestation. Sapkal *et al.* (2018) performed a leaf miner experiment and discovered that cyantraniliprole 10.26 OD provided improved leaf miner control. Spinetoram 11.7 Sc and Spinosad 45 SC both yielded similar results. The results of this study are identical to those of the current investigation. As a result, our information is more useful.

Reddy *et al.* (2018) gave similar result related to spinosad and abamectin. They proved spinosad 45 SC is most effective in controlling citrus leaf miner. These findings are similar to present investigations. Raga *et al.* (2001) conducted research on citrus leaf miner and found that abamectin is superior insecticide to cause highest larval mortality. This Results supports present findings. Pena and Duccan (2000) conducted experiment to control larval population of citrus leaf miner. They proved that abamectin gave better control.

Zang *et al.* (2001) found abamectin was better. These results are concurrent with present findings.

Jayanthi and Vargheese (2004) carried out investigation on acid lime. They found that neem formulation could be used as to allow up sprays under heavy infestation and prophylactic spray during new flush emergence. Ahmed *et al.* (2015) studied the effect of insecticides on citrus leaf miner and found that emamectin benzoate is effective for controlling leaf miner. Gharib *et al.* (2015) studied effect of insecticides on leaf miner. They prove that abamectin was good insecticides for controlling leaf miner.

Muhhamad *et al.* (2018) conducted research to assess the effectiveness of some synthetic insecticides and essential oils against citrus leaf miner larvae. Result revealed that abamectin shown significant mortality of CLM when topical bioassay performed. Further it was found that among all botanical *Azardirachtin indica* oil gave better mortality of citrus leaf miner larvae. This finding is more similar to present investigation which make our data much effective.

Table 4.7.1 Effect of insecticides on *Mallada* spp *(Mallada boninensis*)

TR.NO	Treatments	Dose	Pre count	Mallada count/ plant after 14th days of second spray
1	Spirotetramat 120 SC + Imidacloprid 120SC	0.5	3.06 (1.88)	1.80 (1.49)
2	Cyantraniliprole 10.26 OD	1.8	3.13 (1.90)	1.86 (1.47)
3	Abamectin 0.15 EC	0.37	2.80 (1.81)	2.40 (1.58)
4	Spinetoram 11.7 SC	0.5	3.20 (1.91)	1.93 (1.68)
5	Buprofezin 25 SC	1.25	2.80 (1.80)	2.20 (1.58)
6	Spinosad 45 SC	0.3	3.13 (1.90)	1.40 (1.36)
7	Acetamiprid 20 SP	0.3	2.60 (1.73)	1.53 (1.40)
8	Neem Formulation Azadirachtin (10000 ppm)	3.0	3.53 (1.98)	2.47 (1.71)
9	Emamectin benzoate 5 SG	0.25	2.53 (1.72)	2.00 (1.54)
10	Untreated control	-	2.73 (1.79)	3.50 (1.99)
F test			NS	SIG
SE (M) ±				0.09
CD at 5%				0.28

*Figures in the parentheses are corresponding values of square root +0.5 ($\sqrt{x+0.5}$) transformed values.

The data presented in Table 4.7.1 showed that the numbers of *Mallada* were reduce after spraying of insecticides. The maximum number of *Mallada spp* were found in untreated control (3.50). Azadirachtin is most suitable to the *Mallada* recorded 2.47/tree.

This was followed by abamectin 0.15 EC (2.40), buprofezin 25 SC (2.20), emamectin benzoate 5 SG (2.00), spinetoram 11.7 SC (1.93), cyantraniliprole 10.26 OD (1.86), spirotetramat 120 SC+ imidachloprid 120 SC (1.80) and acetamiprid 20 SP (1.53). The lowest number of *mallada* were found in spinosad 45 SC. It was clear that spinosad proved least suitable to *Mallada spp.* Being recommended insecticides and doses they are supposed to be safer to natural enemies.

Table 4.7.2 Effect of Insecticides on Spider

TR.NO	Treatments	Dose	Pre count	Spider count/plant after 14th days of second spray
1	Spirotetramat 120 SC + Imidacloprid 120SC	0.5	3.23 (1.91)	2.00 (1.54)
2	Cyantraniliprole 10.26 OD	1.8	3.46 (1.98)	2.13 (1.56)
3	Abamectin 0.15 EC	0.37	3.33 (1.95)	2.73 (1.78)
4	Spinetoram 11.7 SC	0.5	3.80 (2.07)	2.40 (1.66)
5	Buprofezin 25 SC	1.25	4.00 (2.11)	2.53 (1.68)
6	Spinosad 45 SC	0.3	3.20 (1.91)	1.73 (1.46)
7	Acetamiprid 20 SP	0.3	4.00 (2.11)	1.86 (1.52)
8	Neem Formulation Azardirachtin (10000 ppm)	3.0	3.93 (2.09)	2.80 (1.79)
9	Emamectin benzoate 5 SG	0.25	4.40 (2.19)	2.33 (1.61)
10	Untreated control	-	4.37 (2.21)	3.60 (2.02)
F test			NS	SIG
SE (M) ±				0.11
CD at 5%				0.32

*Figures in the parentheses are corresponding values of square root +0.5 ($\sqrt{x}+0.5$) transformed values.

The data presented in Table 4.7.2 showed that the numbers of spider were reduce after spraying of insecticides. The maximum number of *Spider* were found in untreated control (3.60). Azadirachtin 10000 ppm is most suitable to the spider recorded 2.80/tree. This was followed by abamectin 0.15 EC (2.73), buprofezin 25 SC (2.53), emamectin benzoate 5 SG (2.33), spinetoram 11.7 SC (2.40), cyantraniliprole 10.26 OD (2.16), spirotetramat 120 SC +imidachloprid 120 SC (2.00), acetameprid 20 SG (1.86). The lowest number of spiders were found in spinosad 45 SC 1.73/ plant. It was clear thar spinosad 45 SC proved least suitable to the spider.

Table 4.8 Effect of Insecticides on Yield of Acid lime

TR. NO	TREATMENTS	YIELD (t/ha)			Mean (t/ha)
		R1	R2	R3	
1	Spirotetramat 120 SC + Imidacloprid 120 SC	22.2	23.2	24.8	23.4
2	Cyantraniliprole 10.26 OD	25.4	26.2	22.8	24.08
3	Abamectin 0.15 EC	26	24.2	19.1	23.10
4	Spinetoram 11.7 SC	26.4	25.2	22.2	24.6
5	Buprofezin 25 SC	22.6	20.4	23.00	22.00
6	Spinosad 45 SC	24.4	23.2	28	25.2
7	Acetamiprid 20 SP	24.6	25.4	18.4	22.80
8	Neem formulation (Azadirachtin 10000 ppm)	24.1	22.1	18.2	21.48
9	Emamectin benzoate 5 SG	23.2	24.2	16.2	21.20
10	Untreated control (Water spray)	21.08	19.4	16.8	19.9
F test					SIG
SE (M) ±					0.14
CD at 5%					0.30

Table 4.9: Cost of Insecticides and Spraying

Sr. No	Treatments	Quantity required for 2 sprays (ml/g/ha)	Rate of insecticide (/kg or L)	Cost of insecticide (Rs/ ha)	Application charges for two spray (Rs/ha)	Total cost of insecticide and spraying)
T1	Spirotetramat 120 SC+ Imidachloprid 120SC	500	3020	1510	1500	3010
T2	Cyantraniliprole 10.26 OD	1800	10000	18000	1500	19500
T3	Abamectin 0.15 EC	370	5720.1	2116.4	1500	3616.4
T4	Spinetoram 11.7 SC	500	13500	6750	1500	8250
T5	Buprofezin 25 Sc	1250	780	975	1500	2475
T6	Spinosad 45 SC	300	22875.1	6857.14	1500	8357.14
T7	Acetameprid 20 SP	300	18000	5400	1500	6900
T8	Neem formulation (Azardirachtin 10000 ppm)	3000	2000	6000	1500	7500
T9	Emamectin benzoate 5 SG	250	6000	1500	1500	3000
T10	Untreated control	-	-	-	-	-

*Labour charges -750/ spray.

For management of citrus leaf miner the application of suitable chemical insecticide could reduce the pest population and may increase the yield.

Table 4.9.1: Effect of treatment on Yield of acid lime and Incremental Cost Benefit Ratio

Sr. No	Treatments	Yield (t/ha)	Additional yield over control (t/ ha)	Additional returns over control (Rs)	Cost of insecticides And spraying (Rs)	Net profit (Rs)	ICBR
T1	Spirotetramat 120 SC+ Imidachloprid 120SC	23.40	3.5	105000	3010	101990	1:33.83
T2	Cyantraniliprole 10.26 OD	24.8	4.9	147000	19500	127500	1:6.53
T3	Abamectin 0.15 EC	23.10	3.2	96000	3616.4	92383.6	1:16.09
T4	Spinetoram 11.7 SC	24.6	4.7	141000	8250	132750	1:13.46
T5	Buprofezin 25 Sc	22.00	2.1	63000	2475	60525	1:16.09
T6	Spinosad 45 SC	25.2	5.3	159000	8357.14	150642.8	1:18.02
T7	Acetameprid 20 SP	22.80	2.9	87000	6900	80100	1:11.60
T8	Neem formulation (Azardirachtin 10000 ppm)	21.48	1.58	47400	7500	39900	1:5.32
T9	Emamectin benzoate 5 SG	21.20	1.3	39000	3000	36000	1:12
T10	Untreated control (Water spray)	19.9	-	-	-	-	-

*Market price of acid lime – Rs. 30000/ ton

4.9.1.1. Effect of insecticides on yield of acid lime

The yield data was presented in Table 4.8.1 showed that all the insecticidal treatments recorded significantly higher yield over untreated control.

It could be seen from table 4.8.1 that all the treatments were significantly superior and recorded higher yield over untreated control. The treatment with spinosad 45 SC recorded highest (25.2 t/ha). It was found at par with the treatments cyantraniliprole 10.26 OD, spinetoram 11.7 SC and spirotetramat 120 SC+ imidacloprid 120 SC which recorded 24.80, 24.60 and 23.40 t/ha, respectively. The next treatments which recorded good yield were abamectin 0.15 EC and acetamiprid 20 SP which recorded 23.10 and 22.80 t/ha yield, respectively. Followed by Buprofezin 25 SC (22,00 t/ha), emamectin benzoate 5 SG (21.20 t/ha) and azadirachtin 10000 ppm (21.48 t/ha). Whereas, untreated control recorded lowest yield of 19.9 t/ha.

4.9.1.2. Additional return of different treatments

The data presented in Table 4.8.1 showed that maximum additional return of 159000 Rs/ha was gained from the treatment of spinosad 45 Sc. This was followed by cyantraniliprole 10.26 OD (147000 Rs /ha), spinetoram 11.7 SC gave (141000 Rs /ha), spirotetramat 120 SC + imidachloprid 120 SC (100490Rs/ha), abamectin 0.15 EC 96000 Rs/ha, acetamiprid 20 SP (87000 Rs / ha), buprofezin 25 Sc (63000), emamectin benzoate 5 SG (39000) azadirachtin 10000 ppm (47400 Rs/ha) recorded comparatively lowest additional return over control.

4.9.1.3 Incremental Cost Benefit Ratio

Highest ICBR recorded in treatment spirotetramat 120 SC+ imidachloprid 120SC i.e. 1:33.83. This were followed by the treatments spinosad 45 SC (1:18.02), abamectin 0.15 EC (1:16.09), buprofezin 25 SC (1:16.09), spinetoram 11.7 SC (1:13.46), emamectin benzoate 5 SG (1:12), acetameprid 20 SP (1:11.60), cyantraniliprole 10.26 OD (1:6.53) and azadirachtin 10000 ppm (1:5.32).

5. SUMMARY AND CONCLUSIONS

Present experiment entitled 'Efficacy of insecticides against citrus leaf miner (*Phyllocnistis citrella* Stainton) on acid lime (*Citrus aurantifolia*)' was conducted at horticulture farm of Krishi Vigyan Kendra, Dahigaon ne and College of Agriculture, Dhule During 2020-2021 in September-October with the following objectives.

1. Efficacy of different insecticides against citrus leaf miner.
2. Effect of insecticides on natural enemies.

Total ten treatments were used in present investigation consisting of insecticides viz. spirotetramat 120 SC + imidacloprid 120 SC @ 0.5 ml/l, cyantraniliprole 10.26 OD @ 1.8 ml/l, abamectin 0.15 EC @ 0.37 ml/l, spinetoram 11.7 SC @ 0.5% ml/l, buprofezin 25 SC @ 1.25 ml/l, Spinosad 45 SC @ 0.3 ml/l, acetamiprid 20 SP @ 0.3% g/l, azadirachtin (10000 ppm) @ 3.0% ml/l, emamectin benzoate 5 SG @ 0. 25 g/l and untreated control as water spray.

The experiment was planned out in Randomized Block Design with ten treatments and three replications. The variety used for study is Phule Sharbati. During the course of investigation two plants per each treatment and given two applications at 15 days interval against citrus leaf miner. The first application was done on 16th September, 2020 whereas second application was done on 2nd October, 2020.

The first application was under taken at the occurrence of leaf miner infestation on newly emerged leaves. Overall two applications were given at 15 days interval. The data were collected on per cent leaves infestation of citrus leaf miner, larval population of CLM on 15 cm apical twig and count of natural enemies viz. *Mallada and spiders* from selected plant. Observation were recorded as pre count and at 14th days after 2nd spray. Per cent infestation were calculated by counting healthy leaves and infested leaves on 15 cm apical twig per plant. Larval count was calculated by counting number of dead leaf miner larvae. Natural enemies were recorded by counting *Mallada* and Spiders/ tree.

Thus, the obtained data was statistically analysed after appropriate transformation and the results obtained during the course of investigations are summarized below along with the conclusions.

5.1 Efficacy of Different Insecticides Against Citrus Leaf Miner in Acid Lime

5.1.1 Per Cent Infestation of Citrus Leaf Miner

The mean data of two sprays indicated that at 3 days revealed that spinosad 45 SC was significantly superior and which recorded lowest 15.03 per cent leaf infestation of citrus leaf miner on 15 cm apical twig. This treatment was found at par with the spinetoram 11.7 SC,

cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120SC recording 16.87, 17.20 and 18.80 per cent infestation on 15 cm apical twig, respectively. Abamectin 0.15 EC recorded 19.20 per cent infestation was next in order. The next better treatment was acetamiprid 20 SP recorded 19.45 per cent infestation. This was followed by the buprofezin 25 SC, emamectin benzoate 5 SG, azadirachtin (10000 ppm) recording 19.50, 9.83 and 20.77 per cent leaf infestation of citrus leaf miner, respectively. Highest per cent leaves infestation 27.33 per cent was recorded in untreated control.

At 7 days minimum (12.20 per cent) infestation recorded in treatment with spinosad 45 SC. It was found at par with the spinetoram 11.7 SC, spirotetramat 120 SC + imidacloprid 120 SC and cyantraniliprole 10.26 OD recording 12.77, 13.07, 13.63 per cent leaves infestation, respectively. The next better treatment was abamectin 0.15 EC recorded 15.80 per cent leaf miner infestation. It was superior over acetamiprid 20 SP 16.10, Buprofezin 25 SC 16.33, Emamectin benzoate 5 SG 15.67 and azadirachtin (10000 ppm) 16.63 per cent leaf miner infestation respectively.

At 14 days showed that spinosad 45 SC observed lowest 9.20 per cent leaf infestation. Which is significantly superior and found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC recorded 10.30, 10.67 and 11.10 per cent leaf infestation, respectively. The next in order were abamectin 0.15 EC showed 12.73 per cent leaf infestation. After that acetamiprid 20 SP 13.30, buprofezin 25 SC 13.37, emamectin benzoate 5 SG 13.40 and azadirachtin (10000 ppm) 14.00 per cent leaf infestation respectively.

5.2 Larval Population of Citrus Leaf Miner

Average effect at 3 days showed that after spraying of the two applications the lowest larval count observed in Spinosad 45 SC which recorded 6.5 larvae/ 15 cm apical twig. This was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC+ imidacloprid 120 SC recording 7.23, 7.37 and 7.76 larvae / 15 cm apical twigs, respectively.

The next better treatments in order were abamectin 0.15 EC (8.8), Acetamiprid 20 SP (9.06), buprofezin 25 SC (9.23), emamectin benzoate 5 SG (9.50), azadirachtin (10000 ppm) (9.70) citrus leaf miner larvae / 15cm shoots) respectively.

At 7 days follows similar trend. Least count of citrus leaf miner indicated in Spinosad 45 SC which recorded 4.66 larvae/ 15 cm apical twig which is statistically significant. This was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC + imidacloprid 120 SC recording 5.5, 5.9 and 6.1 larvae /5 cm twigs, respectively.

The next better insecticides in order were abamectin 0.15 EC (6.93), acetamiprid 20 SP (7.17), buprofezin 25 SC (7.35), emamectin benzoate 5 SG (7.63), azadirachtin (10000 ppm) (8.00) citrus leaf miner larvae / 15cm apical twig) respectively. The maximum larval population was recorded in untreated control 22.85 larvae/ 15cm apical twig.

Average effect at 14 days revealed that treatment spinosad 45 SC recording (3.03 larvae / 15 cm apical twig) was significantly superior and it was found at par with the spinetoram 11.7 SC, cyantraniliprole 10.26 OD and spirotetramat 120 SC+ imidacloprid 120SC recording 3.60, 4.26 and 4.23 larvae / 15cm twig respectively. The next better treatments in order were abamectin 0.15 EC (4.86), acetamiprid 20 SP (5.06), buprofezin 25 SC (5.40), emamectin benzoate 5 SG (5.60) and azadirachtin (10000 PPM) (5.90) citrus leaf miner larvae / 15cm apical shoots, respectively.

5.3 Effect of Insecticides on Natural Enemy

5.3.1. *Mallada* spp

The result showed that the numbers of *Mallada* were reduce after spraying of insecticides. The maximum number of *Mallada* spp were found in untreated control (3.50)/tree. Azadirachtin is most suitable to the *mallada* recording 2.47/tree.

This was followed by abamectin 0.15 EC (2.40/tree), buprofezin 25 SC (2.20/tree), emamectin benzoate 5 SG (2.00/tree), spinetoram 11.7 SC (1.93/tree), cyantraniliprole 10.26 OD (1.86/tree), spirotetramat 120 SC + imidachloprid 120 SC (1.80/tree), acetamiprid 20 SP (1.53/tree). The lowest number of *mallada* were found in spinosad 45 SC. The toxic insecticides used are more determined to Mallada as compared to IGR and plant product.

5.3.2. Spider

The result indicated that the numbers of spider were reduce after spraying of insecticides. The maximum number of *Spider* were found in untreated control (3.60/tree). Azadirachtin is most suitable to the mallada recording 2.80/tree. This was followed by abamectin 0.15 Ec (2.73/tree), buprofezin 25 SC (2.53/tree), emamectin benzoate 5 SG (2.33/tree), spinetoram 11.7 SC (2.40/tree), cyantraniliprole 10.26 OD (2.16/tree), spirotetramat 120 SC +imidachloprid 120 SC (2.00/tree), acetamiprid 20 SP (1.86/tree). The lowest number of spiders were found in spinosad 45 SC which recorded 1.73/tree. The spider population was drastically reduced due to toxic molecule as against insect growth regulators and plant products.

5.4 Conclusions

Result obtained in the present investigation concluded that

1. Infestation of citrus leaf miner was more in newly sprouted leaves than older one.
2. All the treatments were found superior over untreated control in reducing per cent leaf infestation and leaf miner larval population.
3. Minimum two spraying of different insecticides were required for keeping infestation of citrus leaf miner below EIL.
4. Among different insecticides tested against leaf miner Spinosad 45 SC was significantly superior followed spinetoram 11.7 SC, cyantraniliprole 10.26 OD, spirotetramat120 SC + imidachloprid 120 SC.
5. Insect growth regulators and plant products are most appropriate to build up the natural enemies population.

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7. Appendix I

7.1 Weekly Meteorological Data (Sept – March, 2020-2021) of Krishi Vigyan Kendra, Dahigaon.

Month	Week No.	Temperature (ºC)		Relative Humidity (%)		Rainfall (mm)
		Max.	Min.	I	II	
Sept 2020	37	34.12	20.00	90.54	38.43	0.00
	38	33.20	21.33	92.72	38.29	45.8
	39	31.12	22.59	95.53	48.57	92.6
	40	33.15	22.11	93.11	36.78	4.50
Oct 2020	41	30.20	20.61	94.69	54.00	30.7
	42	33.18	18.00	95.43	36.71	16.8
	43	34.85	16.71	86.87	19.00	6.00
	44	33.02	15.6	88.54	18.90	0.00
Nov 2020	45	32.20	13.84	84.20	15.57	31.7
	46	32.12	12.24	80.60	11.57	16.67
	47	31.71	11.00	82.18	17.86	0.00
	48	32.68	11.78	79.55	12.11	0.00
Dec 2020	49	32.00	12.00	85.57	18.14	0.00
	50	31.14	9.20	82.43	11.57	0.00
	51	31.54	10.71	81.29	19.43	0.00
	52	30.58	9.90	84.30	12.60	0.00
Jan 2021	1	34.40	9.57	85.57	11.29	0.00
	2	28.20	8.82	90.71	21.71	0.00
	3	29.55	10.71	87.00	23.57	0.00
	4	31.10	11.70	86.20	17.10	0.00
Feb 2021	5	33.20	12.29	82.29	14.43	0.00
	6	33.35	11.20	79.71	14.29	0.00
	7	34.45	12.18	78.44	13.14	0.00
	8	35.00	11.12	68.57	9.00	0.00

VITAE

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MASTER OF SCIENCE (AGRICULTURE)

IN
AGRICULTURAL ENTOMOLOGY
2021

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