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***Short communication***

# Persistence of some nicotinoid insecticides against citrus leaf miner, *Phyllocnistis citrella* Stainton infesting rough lemon rootstock plants

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Amongst the various factors, pests played a significant role in limiting the diversification of citriculture. Out of 823 species of insects and mites on citrus in the world, about 250 species are found in India (Butani, 1), and only 27 species are active in Punjab (Sharma and Arora, 14). Among these species, serpentine leaf miner, *Phyllocnistis citrella* Stainton is the most serious pest, particularly on nursery and young plantation. Hot and dry climatic conditions have been reported to be favourable for the build up of its population (Sharma *et al.* 13) especially on plants raised in polythene bags. Several conventional and new insecticides (Sharma *et al.,* 17; Kumar and Sharma, 5) have been found effective both on nursery and full grown citrus trees, but only limited information on the efficacy of nicotinoid insecticides is available on the potted nursery plants (Sharma and Dhaliwal, 15). Keeping in view the importance of the pest under nursery conditions, the present studies were planned to elucidate the efficacy of nicotinoid insecticides against citrus leaf miner on rough lemon rootstock plants.

The present investigations were conducted at College Orchard, Department of Horticulture, Punjab Agricultural University, Ludhiana from 2006 to 2007 on rough lemon (*Citrus jambhiri* Lush) rootstock nursery plants. The nursery plants were raised in 400 gauge polythene bags (12"×7" size) containing potting mixture (2 parts of virgin fertile soil and one part of farm yard manure) as per university recommendation. To initiate the study, the freshly emerged leaves of six months old rough lemon seedlings were removed from 10 cm apical portion of each seedling, but the older leaves were retained for proper photosynthesis. The persistence of insecticides against citrus leaf miner was evaluated by two methods, *i.e.*, soil and foliar application. The application of insecticides was done in the month of March and continued upto July. The watering of seedling was done after 24 h in each treatment. Three nicotinoid insecticides, *viz.* imidacloprid 200 SL (6.0, 12.0 and 18.0 mg a.i./plant), acetamiprid 20 SP (6.0, 12.0 and 18.0 mg a.i./plant) and thiamethoxam 25 WG (7.5, 15.0 and 22.5 mg a.i./plant) were applied soon after the removal of the leaves. The required quantity of each insecticide was measured/weighed and dissolved in 250 ml of water. The solution so prepared was applied to 10 plants @ 25 ml/plant. There were three replicates of 10 plants each in every treatment. A set of untreated control was also kept. Foliar application of imidacloprid and acetamiprid (each 0.006 and 0.008% a.i.), and thiamethoxam (0.004, 0.006 and 0.008% a.i.) and fenvalerate 20 EC (0.02% a.i.) was made with the help of compression hand sprayer. The application of insecticides (both soil and foliar) was repeated as and when the leaf miner population reappeared on these treated plants.

The data for larval population of leaf miner was recorded daily upto 45 days after application from upper and lower side of the leaves taken from 10 cm apical portion of each seedling. Larvae were considered as dead when their colour changed to dark brown or black and/or did not respond to gentle pin prick or touch with camel hair brush. The data were also recorded for leaf miner infested and total leaves in each treatment. The height of the seedlings was measured from soil surface to seedling tip with the help of a scale/metre tap. Stem diameter of seedling was measured in all the treatments with vernier caliper at soil level and 20 cm above the soil level from last week of June to mid July every year and the seedling having more than 6 mm girth at 20 cm height were segregated for budding purpose. The number of total and healthy leaves per seedling in each treatment was also counted at the time of budding from the end of June to mid July. Per cent seedling attaining buddable stage was determined on the basis of stem thickness. The plants which attained a thickness of more than 6 mm at 20 cm height were considered ready for budding. The number of such plants was counted in each treatment to assess the impact of leaf miner attack. The data generated on various aspects in different experiments were statistically analyzed after appropriate transformations as per procedures given by Gomez and Gomez (3).

In imidacloprid at 6.0, 12.0 and 18.0 mg/plant, the larval infestation of *P. citrella* appeared 33, 36 and 41 days after treatment, respectively while in acetamiprid at the same level of doses, the larval population was observed after 30, 33 and 37 days. The larval population in case of thiamethoxam at 7.5,

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15.0 and 22.5 mg/plant, appeared after 32, 35 and 45 days compared to 4 days in untreated control (Table 1). Soil application of imidacloprid also provided control of *P. citrella* for 120 days (Salas *et al.* 10; Conti *et al.* 2) whereas two foliar sprays controlled the pest for only 18 days, which is at variation to present findings. Due to the greater effectiveness of imidacloprid against *P. citrella,* Nucifora *et al.* (7) proposed to apply it to soil for complete protection for 80 days @ 0.2 ml/plant and for six months @ 0.4 ml/plant. The longer persistence in these findings at divergence to the present studies might be due to agro-climatic conditions, application method, dose, age of plants and varietal differences. Soil application of imidacloprid under field conditions was found to provide longer persistence than foliar application (Sharma *et al.,* 12). Sharma and Dhaliwal (15) also reported that soil application of imidacloprid, acetamiprid and thiamethoxam in the polythene bags remained effective against leaf miner for 35-42 days which is in conformity to the present findings. The persistence of foliar application in terms of reappearance of *P. citrella* larval population on fresh leaves indicated that thiamethoxam (0.008%) was significantly more persistent (30 days) followed by imidacloprid and acetamiprid (each 0.008%) which persisted for 28 days (Table 2). The results of soil and foliar applications of these insecticides indicated that soil applied insecticides at the highest dose remained effective for longer duration against *P. citrella* compared to foliar application (Tables 1-2). Nucifora *et al.* (8) found imidacloprid @ 0.15-0.20 ml/plant effective against *P. citrella* for about 80 days after application, whereas 0.45-0.60 ml/plant of imidacloprid was effective for whole of the vegetative period. The present studies also suggested that soil application of imidacloprid and acetamiprid (each 18.0 mg/plant), and thiamethoxam (22.5 mg/plant) would reduce the frequency of application.

The longer effective period of insecticides is very useful for the control of *P. citrella* as it often damages the fresh leaves and number of sprays (*i.e.*, frequency of sprays) would certainly be reduced with the application of more persistent new insecticides under nursery conditions. Thus imidacloprid, thiamethoxam and acetamiprid at their highest respective dose of soil and foliar applications in the present findings would be useful in mitigating the pest population under nursery conditions. Jerraya *et al.* (4) showed that acetamiprid had greater residual effect than imidacloprid. However, the present findings suggested that acetamiprid had least effective period compared to either imidacloprid or thiamethoxam, which could be due to agro-climatic conditions at different locations. Leocata (6) found that imidacloprid gave the best control of *P. citrella* on nursery plants, but caused phytotoxicity and the best dose for not causing excessive phytotoxicity was 0.5 ml a.i./plant, as also observed in the present findings but without any phytotoxicity on citrus nursery plants. Two foliar application of thiamethoxam at an interval of 10 days on spring flush suggested that thiamethoxam should be applied at 2.0 g a.i./100 litres of water for the control *P. citrella* (Raga *et al.* 9). Salas and Goane (11) reported that application of 0.35 g a.i. imidacloprid/plant and 0.25 g a.i. thiamethoxam/plant controlled citrus leaf miner up to 100 days after planting and their higher rates extend the control for 10-20 days. The foliar

**Table 1.** Effect of soil applied insecticides on the morphological characteristics of nursery plants as a result of *P. citrella* control.

| Insecticide | Dose (a.i. mg/plant) | Time of effectivity after days of application* | No. of healthy leaves/plant* | Height of plants (cm)* | !Per cent plants buddable in July** |
|---|---|---|---|---|---|
| Imidacloprid | 6.0 | 33 (5.74)$^{bc}$ | 44.7 (6.68)$^{a}$ | 61.7 (7.85)$^{b}$ | 57 (49.02)$^{b}$ |
| | 12.0 | 36 (6.00)$^{abc}$ | 46.8 (6.84)$^{a}$ | 66.3 (8.14)$^{a}$ | 60 (50.77)$^{b}$ |
| | 18.0 | 41 (6.40)$^{ab}$ | 43.9 (6.62)$^{a}$ | 65.4 (8.08)$^{ab}$ | 63 (52.84)$^{a}$ |
| Acetamiprid | 6.0 | 30 (5.47)$^{c}$ | 46.6 (6.82)$^{a}$ | 68.6 (8.28)$^{a}$ | 57 (49.02)$^{b}$ |
| | 12.0 | 33 (5.74)$^{bc}$ | 44.8 (6.69)$^{a}$ | 67.5 (8.21)$^{a}$ | 57 (49.02)$^{b}$ |
| | 18.0 | 37 (6.08)$^{a}$ | 44.4 (6.66)$^{a}$ | 69.6 (8.34)$^{a}$ | 63 (52.54)$^{a}$ |
| Thiamethoxam | 7.5 | 32 (5.65)$^{c}$ | 43.6 (6.60)$^{a}$ | 65.7 (8.10)$^{ab}$ | 54 (47.29)$^{c}$ |
| | 15.0 | 35 (5.91)$^{ab}$ | 46.8 (6.84)$^{a}$ | 64.7 (8.04)$^{ab}$ | 54 (49.29)$^{b}$ |
| | 22.5 | 45 (6.70)$^{a}$ | 46.3 (6.80)$^{a}$ | 66.9 (8.17)$^{a}$ | 57 (49.02)$^{b}$ |
| Control | | 4 (2.00)**$^{d}$ | 0 (0)$^{b}$ | 44.8 (6.69)$^{c}$ | 3 (9.97)$^{d}$ |

*The figures in parentheses are square root; **The figures in parentheses are arc sine percentage.

!girth of plants > 6 mm at 20 cm above ground level.

Figures with same letters are statistically non-significant (p = 0.05) after DMRT.

**Table 2.** Effect of foliar applied insecticides on the morphological characteristics of nursery plants as a result of *P. citrella* control.

| Insecticide | Dose (% a.i.) | Time of effectivity after days of application* | No. of healthy leaves/plant* | Plants height (cm)* | !Per cent buddable plants in July ** |
|---|---|---|---|---|---|
| Imidacloprid | 0.006 | 18 (4.24)$^{b}$ | 38.7 (6.22)$^{bc}$ | 56.7 (7.52)$^{ab}$ | 27.0 (31.31)$^{d}$ |
| | 0.008 | 28 (5.29)$^{a}$ | 44.6 (6.67)$^{a}$ | 61.1 (7.81)$^{a}$ | 48.0 (43.85)$^{ab}$ |
| Acetamiprid | 0.006 | 16 (4.00)$^{b}$ | 26.4 (5.13)$^{d}$ | 50.3 (7.09)$^{b}$ | 36.0 (36.87)$^{c}$ |
| | 0.008 | 28 (5.29)$^{a}$ | 35.8 (5.98)$^{c}$ | 54.7 (7.39)$^{ab}$ | 45.0 (42.13)$^{b}$ |
| Thiamethoxam | 0.004 | 13 (3.60)$^{b}$ | 27.6 (5.25)$^{d}$ | 51.1 (7.14)$^{b}$ | 27.0 (31.31)$^{d}$ |
| | 0.006 | 18 (4.24)$^{b}$ | 39.7 (6.30)$^{bc}$ | 54.8 (7.40)$^{ab}$ | 42.0 (40.40)$^{bc}$ |
| | 0.008 | 30 (5.47)$^{a}$ | 45.1 (6.71)$^{a}$ | 55.9 (7.47)$^{ab}$ | 54.0 (47.29)$^{a}$ |
| Control | | 11 (3.31)$^{c}$ | 2.1 (1.44)$^{e}$ | 39.6 (6.29)$^{c}$ | 0 (0)$^{e}$ |
| | | 4(2.00)**$^{d}$ | 2.1 (1.44)$^{c}$ | 39.6 (6.29)$^{c}$ | 0(0)$^{b}$ |

*The figures in parentheses are square root.

**The figures in parentheses are Arc Sine percentage.

!girth of plants > 6 mm at 20 cm above ground level.

Figures with same letters are statistically non-significant (p = 0.05) after DMRT.

application of imidacloprid and thiamethoxam (each 0.008%) in the present studies remained effective > 20 days and is contrary to the above findings due to the fact that dose of these insecticides was very high. Sharma *et al.* (16) found that imidacloprid at 0.008 per cent took slightly more initial time to produce its toxic effect but remained effective for about 15 days which was in deviation to the present findings as the height of seedlings was not measured and the insecticides were applied in the under field conditions. Sharma and Dhaliwal (15) also reported that imidacloprid, thiamethoxam and acetamiprid each @ 0.008 per cent were highly effective against *P. citrella.*

The effectiveness of insecticides against *P. citrella* had a significant impact on the morphological characteristics of rough lemon nursery plants. The soil application of all the insecticides, namely imidacloprid, acetamiprid and thiamethoxam at all the tested concentrations had 43.6-46.8 leaves/plant (Table 1). The height of treated plants ranging from 61.7-69.6 cm was significantly more compared to untreated plants (44.8 cm), which clearly indicated that leaf miner infestation significantly reduced the plant growth. The results further showed that all these insecticidal treatments had significant impact on the production of buddable seedlings (54-63% having > 6 mm girth at 20 cm height of seedlings) of rough lemon compared to untreated control (only 3%) due to the fact that treated plants had more healthy leaves compared to untreated plants and thus more photosynthesis occurred in healthy leaves which, in turn, influence the plant growth. The foliar application of imidacloprid, acetamiprid and thiamethoxam (each 0.008%) resulted in 44.6, 35.8 and 45.1 healthy leaves per plant (Table 2), respectively in comparison to untreated control (2.1 leaves). The results indicated that insecticidal treatment had a significant impact on height of seedlings by controlling *P. citrella* as its feeding on freshly emerged leaves caused a stunting effect of 11.5 to 21.5 cm. The effective control of *P. citrella* resulting in more number of healthy leaves and more height of seedlings had a direct influence on the girth of seedlings. To corroborate these findings, Sharma and Dhaliwal (15) reported that soil application of imidacloprid, thiamethoxam and acetamiprid had about 53.6, 74.5 and 28.5 per cent increase in height of seedlings, girth at buddable height and number of leaves, respectively. The studies concluded that soil applied insecticides were more persistent against citrus leaf miner compared to foliar application but soil application could be applicable at smaller scale due to being laborious in practice.

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