Indian Journal of Agricultural Sciences **81** (7): 673–6, July 2011

Relative efficacy of certain bio-rational insecticides to citrus psylla (*Diaphorina citri*)*

C N RAO[1] and V J SHIVANKAR[2]

National Research Centre for Citrus, Amravati Road, Nagpur, Maharashtra 440 010

Received: 12 February 2010; Revised accepted: 10 May 2011

Key words: Bio-rational insecticides, Citrus psylla, Field efficacy, Relative toxicity

Citrus is one of the important fruit crops in India with the production of 86.08 lakh tonnes from 9.23 lakh ha with the productivity of 9.3 tonnes/ha at national level as compared to 25–30 tonnes/ha in advanced citrus-producing countries (NHB 2009). The productivity and quality of citrus is severely affected by several factors; insect pests being one of them. Among them, psylla *(Diaphorina citri* Kuwayama) is one of the major insect pests (Shivankar and Rao 2010) causing large-scale damage regularly to citrus cultivars grown across India. Both nymphs and adults of psylla suck the vital plant sap from the young shoots and cause heavy de-blossoming, thereby affects the fruit set seriously. Psylla is also known to transmit the greening disease, which accelerates 'citrus decline' syndrome (Bove 2006). It is active during spring and in dry spells during monsoon (Shivankar *et al.* 2001). High humidity associated with dry spells and moderate temperatures (25–30°C) are congenial for its rapid development. Citrus psylla epidemics were reported in central India in 1960–62, since then the pest has attained endemic status causing considerable loss to the crop (Shivankar and Rao 2010).

To contain citrus psylla, a host of researchers (Qureshi and Stansly 2008, Dahiya *et al*. 1994, Dadmal *et al*. 2002, Arora *et al*. 2005) reported the efficacy of several synthetic insecticides. However, safer and effective alternative to synthetic insecticides is the need of the hour. In this context, bio-rational insecticides play a key role in sustainable citriculture. Therefore, the present study was conducted to study the toxicity and efficacy of certain bio-rational insecticides against citrus psylla.

The seedlings of rough lemon *(Citrus jambhiri* Lush), Rangpur lime *(Citrus limonia* Osbeck), acid lime *(Citrus aurantifolia* Swingle) and curry leaf *(Murraya koenigii* L.) being maintained in the cage house were pruned at staggered intervals so that new flush is available for release and multiplication of pure culture of psylla round the year. Citrus leaves / twigs with psylla infestation were collected from the field and were released on the new flush of citrus and curry leaf seedlings.

The test bio-rational insecticides, viz spinosad 45 SC, abamectin 1.9 EC *(Actinomycetes* products), novaluron 10 EC (insect growth regulator), petroleum spray oil, neem *(Azadirachta indica* A.Juss.) oil, azadirachtin 10 000 PPM (plant products), *Bacillus thuringiensis* and *Verticillium lecanii* (microbial products) along with dimethoate 30 EC were procured from the market and diluted to different concentrations using the commercial grade compound with distilled water. In case of sweet flag *(Acorus calamus* L.) shade-dried rhizome was extracted in ethanol and stock solutions were prepared from the extracts. Neem soap and pongamia soap were procured from Indian Institute of Horticultural Research, Bangalore. Citrus twigs infested with second instar nymphs of psylla were considered for bioassay studies. Bio-assay study was carried out by following direct spray method during 2005–06. Selected citrus twigs with the psylla infestations were secured in a conical flask (25 ml capacity) with its cut end dipped in water. Each bio-rational insecticide was uniformly sprayed on citrus twigs with second instar nymphs of psylla using hand atomizer.

Mortality counts were taken 48 hr after treatment and moribund insects were considered as dead. The mortality data obtained were subjected to probit analysis (Finney 1971) to get LC_{50} values from which the relative toxicity values were calculated by taking LC_{50} values of dimethoate as unity.

Study on field appraisal of these nine bio-rational insecticides along with neem soap and pongamia soap at determined doses against citrus psylla *(D. citri* Kuwayama) was conducted in a 10-year-old orchard of acid lime *(Citrus aurantifolia* cv. Pramalini) during *ambia* 2007, 2008 and 2009 at Experimental Farm of NRC for Citrus, Nagpur. The experiment was laid out in completely randomized block design and each treatment replicated three times. Each replication consisted of two trees. Observations were taken on population of psylla before and 3,7,11 and 15 days after the treatment. From the data, reduction in psylla population

*Short note

[1]Senior Scientist (Agricultural Entomology) (e mail:nandikesh @yahoo.com), [2]Director (e mail:citrus8_ngp@sancharnet.in)

Table 1 Toxicity of different insecticides against second instar nymphs of citrus psylla

Insecticide	Heterogenity X^2	Regression equation (y=)	LC_{50} ml/l	Fiducial limits	Relative toxicity
Spinosad 45 SC	2.75	1.28 + 2.18x	0.15	0.11–0.20	9.93
Abamectin 1.9 EC	1.99	0.82 + 2.89x	0.38	0.264–0.55	3.29
Novaluron 10 EC	0.61	0.81 + 2.79x	0.55	0.350–0.88	2.71
Petroleum spray oil	0.93	0.70 + 2.38x	5.90	2.58–13.6	0.25
Neem oil	4.02	1.41 + 0.38x	6.76	5.23 – 8.74	0.22
Azadirachtin 10 000 PPM	5.53	0.87 + 1.87x	3.65	2.54 – 5.25	0.41
Sweet flag	0.38	1.18 + 1.21x	1.63*	1.17–2.26	0.91
Bacillus thuringiensis	1.12	1.17 + 0.77x	4.14**	2.89 – 5.91	0.36
Verticillium lecanii	2.96	0.96 + 1.6x	3.39**	2.36 – 4.90	0.44
Dimethoate 30 EC	4.39	1.56 + 0.05x	1.49	1.19 – 1.87	1.00

* %, **g/l

was computed into percentages. The data were transformed to arc sine values and analyzed statistically.

The data on relative toxicity of different bio-rational insecticides to second instar nymphs of psylla revealed that based on the LC_{50} values, the order of toxicity of different bio-rational insecticides was spinosad > abamectin > novaluron > dimethoate > sweet flag > *Verticillium lecanii* > azadirachtin > *Bacillus thuringiensis* > petroleum spray oil > neem oil. Spinosad, abamectin and novaluron were more toxic (LC_{50}–0.15, 0.38 and 0.55 ml/l; relative toxicity – 9.93, 3.29 and 2.71, respectively) to the second instar nymphs of citrus psylla than dimethoate (Table 1).

Per cent reduction of psylla nymphs was significantly more in abamectin (52.9–60.5%) but was at par with novaluron (50.4–57%) and petroleum spray oil (50.5–58.3%) at three days after treatment (DAT) irrespective of year, except with novaluron (45.4%) in 2009. At 7 DAT per cent reduction in psylla nymphs was significantly more in abamectin (70.2–74.9%), novaluron (61.4–69.7%) and petroleum spray oil (62–71.5%) irrespective of year, but novaluron and petroleum spray oil were at par with spinosad (51.9%) in 2008. Similarly, abamectin (82.7–85%), and petroleum spray oil (78.1–83.1%) recorded significantly more per cent reduction of psylla nymphs at 11 DAT, irrespective of the year but petroleum spray oil was at par with novaluron (70.9–75.9%) in all the three years. At 15 DAT, per cent reduction of psylla nymphs was significantly more in abamectin (90.2–92.5%), irrespective of the year but was at par with novaluron (87.6–88.1%) and petroleum spray oil (89.8–90.4%) in 2007 and 2008. At 15 DAT, among other bio-rational insecticides, per cent reduction of psylla nymphs was significantly more in spinosad (65.5–72.3%), followed by dimethoate (56.1–62.4%). Pooled mean data also showed that abamectin, petroleum spray oil and novaluron were found effective with regard to per cent reduction in nymphal population of psylla (Table 2).

The results of field evaluation of bio-rational insecticides revealed that abamectin @ 0.38 ml/l water in *ambia* 2007 (92.5%), 2008 (91.3%) and 2009 (90.2%), followed by novaluron @ 0.55 ml/l (87.6–88.1%) and petroleum spray oil @ 5.9 ml/L (89.8–90.4%) in *ambia*, 2008 and 2009 were found effective for a period of 15 days with regard to% reduction in nymphal population of psylla. Similarly, Rogers (2008) reported the short-term control of psylla with the application of abamectin + oil.

Bio-assay studies showed that among the bio-rational insecticides, spinosad was most toxic to second instar nymphs of citrus psylla. However, field evaluation of bio-rational insecticides showed that abamectin followed by novaluron, petroleum spray oil and spinosad were most effective to citrus psylla nymphs. The low efficacy of spinosad to citrus psylla under field condition is probably due to the presence of other nymphal instars coupled with its interaction with prevailing weather conditions. Therefore, it is believed that bio-assay studies helps in short listing of insecticides to be tested for field evaluation.

Of all the bio-rational insecticides tested, abamectin followed by novaluron, petroleum spray oil and spinosad were most effective for citrus psylla nymphs. The high mortality of citrus psylla nymphs by residual effect of abamectin and spinosad could be due to more penetrable potential in to plant tissues and translaminar action. In case of petroleum spray oil the effect could be due to contact and suffocation/ asphyxiation of psylla nymphs, whereas in case of novaluron it could be due to contact and IGR activity. As repeated use of organophosporous insecticides over years have developed some resistance to citrus psylla (Arora *et al*. 2005) the bio-rational insecticides, viz abamectin, novaluron, petroleum spray oil and spinosad would be helpful in reducing the menace of citrus psylla, as these bio-rational insecticides with different mode of action would enhance the life of insecticide by reducing the chances of development of resistance. Therefore, the application of different bio-rational insecticides, viz abamectin, novaluron, petroleum spray oil and spinosad with different mode of action would be helpful in reducing psylla menace in citrus orchards. The identified

Table 2 Bio-efficacy of bio-rational insecticides against nymphal population of citrus psylla on acid lime cv. Pramalini during *ambia*, 2007, 2008 and 2009 under field conditions

Bio-rational insecticide	Per cent reduction of psylla nymphs												
	3 DAT			7 DAT			11 DAT			15 DAT			Pooled
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	mean
Spinosad 45 SC @ 0.15 ml/l	45.2 (42.25)^{b}	40.2 (39.35)^{b}	41.1 (39.82)^{c}	53.2 (46.83)^{b}	51.9 (46.09)^{bc}	50.2 (45.11)^{b}	67.4 (55.18)^{c}	62.4 (52.18)^{c}	61.8 (51.83)^{c}	72.3 (58.24)^{b}	70.0 (56.79)^{b}	65.5 (44.66)^{e}	56.7 (48.13)
Abamectin 1.9 EC @ 0.38 ml/l	60.5 (51.06)^{a}	55.8 (48.33)^{a}	52.9 (46.66)^{a}	74.9 (59.93)^{a}	70.2 (56.91)^{a}	71.5 (57.73)^{a}	85.0 (67.21)^{a}	82.7 (65.42)^{a}	83.4 (65.96)^{a}	92.5 (74.11)^{a}	91.3 (72.84)^{a}	90.2 (71.76)^{a}	75.9 (61.49)
Novaluron 10 EC @ 0.55 ml/l	57.0 (49.02)^{a}	50.4 (45.23)^{a}	45.4 (42.36)^{b}	69.7 (56.60)^{a}	61.4 (51.59)^{ab}	63.0 (52.53)^{a}	75.9 (60.60)^{b}	75.2 (60.13)^{b}	70.9 (57.35)^{bc}	88.1 (69.82)^{a}	87.6 (69.38)^{a}	74.0 (59.34)^{b}	68.2 (56.16)
Petrolium spray oil @ 5.9 ml/l	58.3 (49.78)^{a}	53.2 (46.83)^{a}	50.5 (45.29)^{a}	71.5 (57.73)^{a}	62.0 (51.94)^{ab}	69.9 (56.23)^{a}	83.1 (65.73)^{ab}	78.8 (62.58)^{ab}	78.1 (62.10)^{ab}	90.4 (71.95)^{a}	89.8 (71.37)^{a}	76.8 (61.21)^{b}	71.8 (58.56)
Neem oil @ 6.76 ml/l	20.9 (27.20)^{d}	22.0 (27.97)^{cd}	20.1 (26.64)^{gf}	38.7 (38.47)^{cd}	39.5 (38.94)^{d}	38.3 (38.23)^{cd}	37.6 (37.82)^{e}	37.3 (37.64)^{d}	36.6 (37.23)^{d}	35.8 (36.75)^{cd}	33.1 (35.12)^{cd}	32.7 (34.88)^{d}	32.7 (34.73)
Azadirachtin 10 000 PPM @ 3.65 ml/l	21.2 (27.42)^{d}	23.3 (28.86)^{cd}	21.7 (27.76)^{fe}	39.8 (39.11)^{cd}	40.6 (39.58)^{d}	41.4 (40.05)^{bc}	36.8 (37.35)^{e}	35.7 (36.69)^{d}	34.4 (35.91)^{de}	34.1 (35.73)^{d}	32.7 (34.88)^{cd}	31.9 (34.39)^{d}	32.7 (34.81)
Sweet flag @ 1.63%	16.7 (24.12)^{de}	17.5 (24.73)^{de}	16.6 (24.04)^{h}	26.2 (30.79)^{e}	28.2 (32.08)^{e}	29.7 (33.02)^{de}	22.3 (28.18)^{f}	20.4 (26.84)^{e}	23.8 (29.20)^{ef}	19.0 (25.84)^{e}	18.4 (25.40)^{ef}	20.5 (26.92)^{e}	21.6 (27.59)
Neem soap @ 5 g/l	24.5 (29.67)^{cd}	25.2 (30.13)^{c}	24.3 (29.53)^{e}	37.2 (37.58)^{cd}	38.7 (38.47)^{d}	38.0 (38.06)^{cd}	40.7 (39.64)^{e}	37.2 (37.58)^{d}	36.3 (37.05)^{d}	43.4 (41.21)^{c}	36.9 (37.41)^{d}	34.5 (35.97)^{d}	34.7 (36.02)
Pongamia soap @ 5 g/l	22.3 (28.18)^{d}	24.7 (29.80)^{c}	23.8 (24.50)^{hg}	35.1 (36.33)^{d}	40.9 (39.76)^{cd}	37.2 (37.58)^{cd}	39.0 (38.65)^{e}	38.5 (38.35)^{d}	35.7 (36.69)^{d}	42.9 (40.92)^{c}	37.6 (37.82)^{c}	33.2 (35.18)^{d}	34.2 (35.31)
Bacillus thuringiensis @ 4.14 g/l	8.3 (16.74)^{f}	9.2 (17.66)^{f}	8.1 (16.54)^{i}	11.4 (19.73)^{f}	12.5 (20.70)^{f}	11.4 (19.73)^{f}	13.7 (21.72)^{g}	14.3 (22.22)^{e}	13.9 (21.89)^{g}	18.9 (25.77)^{e}	24.0 (29.33)^{de}	21.0 (27.28)^{e}	13.8 (21.60)
Verticillium lecani @ 3.39 g/l	12.5 (20.70)^{ef}	14.9 (22.71)^{e}	15.4 (23.11)^{h}	15.6 (23.26)^{f}	16.2 (23.73)^{f}	20.6 (26.99)^{e}	19.5 (26.21)^{fg}	20.2 (26.71)^{e}	22.4 (28.25)^{fg}	22.6 (28.38)^{e}	19.2 (25.99)^{ef}	18.8 (25.70)^{e}	18.1 (25.14)
Dimethoate 30 EC @ 0.05%	30.1 (33.27)^{c}	29.5 (32.90)^{c}	26.0 (30.66)^{d}	43.3 (41.15)^{c}	45.1 (38.35)^{de}	39.1 (38.70)^{cd}	56.2 (48.56)^{d}	57.8 (49.49)^{c}	45.6 (42.48)^{d}	62.4 (52.18)^{b}	61.5 (51.65)^{b}	56.1 (48.50)^{c}	46.0 (42.32)
Control	4.5 (12.25)^{g}	3.4 (10.63)^{f}	2.9 (9.81)^{j}	6.5 (14.77)^{g}	6.1 (14.3)^{g}	3.5 (10.78)^{g}	7.1 (15.45)^{h}	7.5 (15.89)^{f}	4.6 (12.39)^{h}	9.5 (17.95)^{f}	9.8 (18.24)^{f}	4.9 (12.79)^{f}	5.8 (13.77)
SED±	2.100	2.389	1.202	1.962	3.076	2.980	2.533	2.515	3.517	2.430	3.944	3.309	
CD (*P*=0.005)	4.26	4.93	2.48	3.98	6.35	6.15	5.14	5.19	7.26	4.93	8.14	6.83	

DAT, Days after treatment
Figures in parentheses are arcsine-transformed values
Values followed by same letter in a column are not significantly different (*P*=0.05)

bio-rational insecticides may be incorporated into IPM module for the sustainable management of citrus psylla.

SUMMARY

Toxicity of bio-rational insecticides, viz spinosad, abamectin, novaluron, sweet flag *(Acorus calamus* L.), petroleum spray oil, neem *(Azadirachta indica* A.Juss.) oil, azadirachtin, *Bacillus thuringiensis*, *Verticillium lecanii* and dimethoate (as standard) was evaluated against the second instar nymphs of citrus psylla *(Diaphorina citri* Kuwayama) at NRCC, Nagpur during 2006. Based on LC_{50} values, spinosad, abamectin and novaluron were 9.93, 3.29 and 2.71 times more toxic to psylla nymphs than dimethoate. Further, field appraisal of these bio-rational insecticides along with neem soap and pongamia *(Pongamia glabra* Vent.) soap against citrus psylla in 10-year-old acid lime *(Citrus aurantifolia* Swingle) cv. Pramalini conducted during *ambia* 2007–09 showed that abamectin @ 0.38 ml/L (90.2–92.5% reduction), followed by petroleum spray oil @ 5.9 ml/l (89.8–90.4% reduction), novaluron @ 0.55 ml/l (87.6–88.1% reduction) and spinosad @ 0.15 ml/l (65.5–72.3% reduction) were found effective against citrus psylla for a period of 15 days.

REFERENCES

Arora P K, Battu R S and Singh B. 2005. Bioefficacy of some insecticides against citrus psylla vis à vis determination of quinalphos residues in Kinnow mandarian fruits. *Pest Management in Horticultural Ecosystem* **11**: 33–8.

Bove J M. 2006. Huanglongbing:a destructive,newly emerging century-old disease of citrus. *Journal of Plant Pathology* **88**: 7–37.

Dadmal S M, Pawar N P, Kale K B and Shivankar S K. 2002. Efficacy of plant products and some insecticides agaist citrus psylla, *Diaphorina citri* Kuwayama. *Insect Environment* **8**: 94–5.

Dahiya K K, Lakra R K, Dahiya A S and Singh S P. 1994. Bioefficacy of some insecticides against citrus psylla, *Diaphorina citri* Kuw. (Homoptera: Psyllidae) *Crop Research Hisar* **8**: 137–40.

Finney W J. 1971. *Probit Analysis*, 3rd edn. Cambridge University Press, London

N H B. 2009. Indian Horticulture Data Base. *Agricultural Research Data Book*, ICAR, New Delhi.

Qureshi J A and Stansly P A. 2008. Rate, placement and timing of aldicarb applications to control Asian Citrus Psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) in oranges. *Pest Management Sciences* **64**: 1159–69.

Rogers, M E. 2008. List of Insecticides and miticides recommended for use in the Florida citrus Pest Management Guide and their effects on citrus pests and their natural enemies. www.crec.ifas.ufl.edu

Shivankar VJ and Rao CN. 2010. Psyllids and their management. *Pest Management in Horticultural Ecosystems* **16** (1) : 1–4.

Shivankar,V J., Rao C N and Shyam Singh. 2001. Incidence of citrus psylla, *Diaphorina citri* Kuwayama (Homoptera: Psyllidae) and its bioagents in central India. *Pest Management in Horticultural Ecosystem* **8** (1) : 43–5.