Doi: HTTPS://DOI.ORG/10.23910/2/2022.0466

Toxicity of Selected Insecticides against Cotton Mealybug (*Phenacoccus solenopsis* Tinsley) in Laboratory Bioassays

P. J. Padaliya, H. R. Desai, G. R. Bhanderi* and R. D. Patel

Main Cotton Research Station, Navsari Agricultural University, Surat (395 007), Gujarat, India

Corresponding Author

G. R. Bhanderi
e-mail: grbhanderi@nau.in

Article History

Article ID: IJEP0466
Received on 19th March, 2022
Received in revised form on 10th May, 2022
Accepted in final form on 23rd May, 2022

Abstract

Investigations on susceptibility of insecticides in cotton mealybug (*Phenacoccus solenopsis* Tinsley) was carried out at Main Cotton Research Station, Navsari Agricultural University, Surat during October 2020 to January 2021 through the IRAC leaf dip bio-assay technique. Mealybug population from the farmer's field of Bharuch district were collected and reared at Main Cotton Research Station, NAU, Surat under field cage cover. Leaf dip bio-assays were carried out for the seven insecticides *viz.,* imidacloprid 70 WG, acetamiprid 20 SP, thiamethoxam 25 WG, buprofezin 25 SC, lamda cyhalothrin 5 EC, spinosad 45 SC and profenophos 50 EC with eight concentrations including control with three repetitions. At recommended rate, profenophos 50 EC at 0.1% and acetamiprid 20 SP at 0.004% recorded 83.50 and 80.77% mortality of mealybug after 72 hours of exposure. Buprofezin 25 SC at 0.05% recorded 78.89 while imidacloprid 17.8 SL at 0.00445% exhibited 67.70 and thiamethoxam 25 WG at 0.01% found to show 65.91% mortality of mealybug under laboratory bioassay after 72 hours of exposure.

Keywords: Bioassay, concentration, exposure, mortality, susceptibility

1. Introduction

Cotton is an important cash crop in India, known as the King of fiber and commonly known as "White Gold". On a global basis, India ranks first in terms of area and second in terms of production. Cotton is cultivated primarily in three distinct geographic zones (North, Central, and South) in India. *Bt* cotton was first commercialized in India during 2002 and offered boons to the cotton farmers. The world produced 113.32 million bales of cotton from 32.20 million hectares of cultivated land with 766 kg ha^{-1} productivity while, based on Cotton Advisory Board figures, 37.1 million bales of cotton were produced on 12.95 million hectares of cultivated land in India and the production was 487 kg ha^{-1} and India's largest producer of cotton is Gujarat, with more than 9.1 million bales produced from 2.3 million hectares with 677 kg ha^{-1} of productivity for 2020-21 (Anonymous, 2021). Due to the dominance of *Bt* cotton in recent times in India, pest dynamics have changed more often with cropping systems and environmental changes. There are several pests that feed on cotton's leaves, including leaf hoppers, aphids, whiteflies, mealybug, and mealybug. The cotton ecosystem in the world is home to 1326 insect species (Hargreaves, 1948). According to Dhaliwal et al. (2004), 162 insect species have been shown to occur in cotton ecosystems in India, which together caused losses of Rs. 2,87,600 million yearly. In *Bt* cotton, sucking pests like aphid (*Aphis gossypii* Glover); leafhopper (*Amrasca biguttula biguttula* Ishida); mealybug (*Mealybug tabaci* Lindeman) and whitefly (*Bemisia tabaci* Gennadius) are of the major concern in Gujarat (Vennila, 2008). The insects caused a total of 39.50% of damage (Naqvi, 1975; Chaudhry, 1976). The yield loss for seed cotton was reported to be 8.45 q ha^{-1} by sucking pests, 16.55 q ha^{-1} by bollworms, and 17.35 q ha^{-1} by combined pests (Satpute et al., 1988). Without protective measures, sucking pests can cause up to half (40-50%) of the damage (Naqvi, 1976).

In recent decades, the exotic mealybug (*Phenacoccus solenopsis* Tinsley) has been considered a key pest in Gujarat and India (Nagrare et al., 2009; Kumar et al., 2010). The overall loss (based on 4-grade infested plants) was estimated to be 1.07% in 21 surveyed villages of Surat and Bharuch district with the prevalence of 8.55% natural parasitism of *Aenasius bambawalei* Hayat (Bhanderi et al., 2020). Limited data are available for assessing insecticide toxicity to mealybug species and describing application technology parameters that might influence efficacy of rescue treatments for controlling mealybug on cotton. Development of such data will help in the judicious selection of insecticides for effective mealybug management, monitoring of insecticidal resistance. Objectives of this study were to obtain data on relative toxicities of insecticides for control of mealybug species on

cotton through the IRAC leaf dip bio-assay technique.

2. Materials and Methods

2.1. Test insect

Cotton mealybug (*Phenacoccus solenopsis*) was chosen as the test insect for the experiment. The population of mealybug was collected from farmer's field of Bharuch district of Gujarat which was not treated with insecticides for more than fifteen days. For collecting the samples, infested cotton twigs/shoots with mealybug colonies at rational population pressure were plucked and collected in the special plastic bucket (height-26 cm, diameter-30 cm) having 40 mesh wire net fitted window at the whole central periphery to allow air circulation and the mouth of the bucket covered with muslin cloth and tied with rubber band. Such buckets were brought to the Main Cotton Research Station, Navsari Agricultural University, Surat for bioassays study. The collected mealybug samples were reared under field caged condition on hybrid, G.Cot.Hy.8 BG II for three generations at Research Farm, Main Cotton Research Station, Navsari Agricultural University, Surat. The established population after three generations was utilized for bioassay studies of seven commonly used insecticides.

2.2. *Test insecticides and preparation of insecticidal solution*

The commonly used seven insecticides *viz*., imidacloprid 70 WG, acetamiprid 20 SP, thiamethoxam 25 WG, buprofezin 25 SC, lamda cyhalothrin 5 EC, spinosad 45 SC and profenophos 50 EC were procured and used for bioassay against mealybug. The details of seven insecticides used are given in Table 1. Bioassay was carried out for each of the seven insecticides with eight concentrations in distilled water with three repetitions. The concentrations for each test insecticide rendering mortality between 20 to 80% mortality considered for bio-assays based on pilot scale testing. Insecticide solutions with graded concentration/doses especially in geometrical progression with three lower and three higher field recommended doses to get better responses along with no exposure were prepared by serial dilution technique in the glass jars with wide mouth (height-15 cm, diameter-13 cm) after washing thoroughly with distilled water just prior to experimentation and such jars with eight graded concentrations of single insecticide were properly labeled.

2.3. *Bio-assay for P. solenopsis to insecticides*

Samples of mealybug were collected from cotton grown under cage condition in field and exposed to graded concentrations of each test insecticide followingleaf dip method recommended by Insecticide Resistance Action Committee (IRAC No. 14). In order to treat substrate, upper leaves with long petioles were selected from 75 to 90-day old plants, and slanting cuts were made using sterilized knife. Immediately after the petioles were cut, they were wrapped with a cotton swab moistened with a ten percent sucrose solution and parafilm was applied. Such 175 leaves (with petiole) were selected and prepared for conducting tests. Three leaves were dipped for 30 seconds in insecticidal solutions of each concentration for each insecticide. A control was run which were dipped with distilled water. After dipping, each leaf was allowed to naturally shade dry for fifteen minutes under a fan before it was placed individually in Petri dishes (9 cm diameter). The established population of mealybug on G.Cot.Hy.8 BG II hybrid was brought to the laboratory by plucking infested leaves/ twigs in the plastic buckets from the intended plot. Uniform size 100 young nymphs of cotton mealybug were released per leaf of cotton with pointed camel hair brush in Petri dish. Such 24 petri dishes, each containing 100 mealy bugs were used for bioassay for eight different concentrations with three repetitions for single insecticide. A total of 168 sets comprising of seven insecticides were kept for observations. The mortality of mealybug was observed under laboratory at 24-hour interval up to 72 hours after exposure to different test concentrations. Counts of dead mealybug were made every 24 hours during observation in the petri dish. Those mealybugs, which were unable to move themselves within ten seconds on slight touch with camel hair brush or unable to turn on their back once disturbed, were considered dead. The suspected individuals were gently touched with a fine camel hair brush and their mortality recorded when in doubt. For each concentration, including control, the number of live and dead mealybug was counted at the end of 72 hours and the data so obtained were subjected to LDP analysis through Polo Leora software provided. The mortality data of each treatment were corrected with respect to control mortality as per Abbott's formula (1925) for mealybug bioassay.

Corrected mortality (%): (X-Y)/(100-Y)×100

Where, X=% mortality in the treated sample

Y= % mortality in the control

3. Results and Discussion

The data presented in Table 2 revealed that there was significant difference in mortality of mealybug at different concentrations of different insecticides. The lowest to highest (0.0006125 to 0.0392%) concentration of imidacloprid 70 WG recorded 14.47 to 91.80% cumulative mortality of mealybug at 72 hours after exposure. The cumulative mortality of mealybug for imidacloprid 70 WG recorded at 72 hours after exposure was found highest (91.80%) in the highest concentration (0.0392%) followed by next higher concentrations. At recommended concentration, the mealybug population was the most susceptible to imidacloprid with 67.70% mortality. The lowest mortality (14.47%) of mealybug was found at lowest concentration (0.0006125%) of imidacloprid 70 WG. There was significant difference in mortality of mealybug in acetamiprid 20 SP at 72 hours after exposure. The lowest to highest (0.0005 to 0.032%) concentration of acetamiprid 20 SP recorded 16.62 to 99.43% mortality of mealybug at 72 hours after exposure. At recommended concentration of acetamiprid 20 SP, the mortality of mealybug was recorded

Table 1: Insecticides used against cotton mealybug for laboratory bio-assays

Sl. No.	Common name	Chemical name (IUPAC name)	Field dose (ha^{-1}) in 500 l water			Test concentrations (C1 to C8)	Manufacturer
			(g) a.i. ha^{-1}	Formulation (g or ml ha^{-1})	Field conc.		
1.	Imidacloprid 70 WG	N-{1-[(6-Chloro-3-pyridyl) methyl]-4,5 dihydroimidazol-2-yl}nitramide	24.5	35	0.0049	0.00, 0.0006125, .001225, 0.00245, 0.0049, 0.0098, 0.0196, 0.0392	Bayer Crop Science Ltd., Mumbai
2.	Acetamiprid 20 SP	N-[(6-chloro-3pyridyl)methyl]-N'-cyano-Nmethyl-acetamidine	20	100	0.0040	0.00, 0.0005, 0.001, 0.002, 0.004, 0.008, 0.016, 0.032	Rallis India Pvt. Ltd., Mumbai
3.	Thiamethoxam 25 WG	3-[(2-Chloro-1,3-thiazol-5yl) methyl]-5-methyl-N-nitro1,3,5-oxadiazinan-4-imine	50	200	0.0100	0.00, 0.00125, 0.0025, 0.005, 0.01, 0.02, 0.04, 0.08	Syngenta (India) Pvt. Ltd., Mumbai
4.	Profenofos 50 EC	4-bromo-2-chloro 1[ethoxy(propylsulfanyl)phos phoryl]oxybenzene	500	1000	0.1000	0.00, 0.0125, 0.025, 0.05, 0.1, 0.2, 0.4, 0.8	Excel Crop Care Ltd., Mumbai
5.	Buprofezin 25 SC	(2Z)-3-Isopropyl-2-[(2-methyl-2-propanyl)imino]-5-phenyl-1,3,5-thiadiazinam-4-one	250	1000	0.0500	0.00, 0.00625, 0.0125, 0.025, 0.05, 0.1, 0.2, 0.4	Rallis India Pvt. Ltd., Mumbai
6.	Lamda cyhalothrin 5 EC	(R)-α-cyano-3-phenoxybenzyl (1S)-cis-3-[(Z)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate and (S)-a-cyano-3-phenoxybenzyl (1R)-cis-3-[(Z)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate	25	500	0.0050	0.00, 0.000625, 0.00125, 0.0025, 0.005, 0.01, 0.02, 0.04	Syngenta (India) Pvt. Ltd., Mumbai
7.	Spinosad 45 SC	(1S,2R,5S,7R,9R,10S,14R,19S)-15-[(2R,5S,6R)-5-(dimethylamino)-6-methyloxan-2-yl]oxy-19-ethyl-14-methyl-7-[(2R,3R,4R,5S,6S)-3,4,5-trymethoxy-6-methyloxan-2-yl]oxy-20-oxatetracyclo[10.10.0.02,10.05,9]docosa-3,11-diene-13,21-dione	100	220	0.0198	0.00, 0.002475, 0.00495, 0.0099, 0.0198, 0.0396, 0.0792, 0.1584	Bayer Crop Science Ltd., Mumbai

80.77% at 72 hours after exposure. The higher 99.43% mortality of mealybug population was recorded at highest concentration (0.032%) of acetamiprid 20 SP and the lowest mortality (16.62%) at lowest concentration (0.0005%). The mortality of mealybug in thiamethoxam 25 WG varied from 14.77 to 94.89% from lowest to highest (0.00125 to 0.08%) concentrations at 72 hours after exposure. At recommended concentration of thiamethoxam 25 WG (0.01%), the mortality of mealybug was recorded 65.91% at 72 hours after exposure. The thiamethoxam 25 WG was found susceptible at recommended concentration. The 94.89% mortality of mealybug population was recorded at highest concentration (0.08%) of thiamethoxam 25 WG and the lowest mortality (14.77%) at lowest concentration (0.00125%).

There was significant difference in mortality of mealybug at 72 hours after exposure. The mortality of mealybug varied from 19.57 to 99.94% from lower to higher concentrations at 72 hours after exposure to profenophos 50 EC. The cumulative mortality of mealybug recorded at 72 hours after exposure to profenophos 50 EC was found highest (99.94%) to highest concentration (0.80%) followed by next higher concentrations.

At recommended concentration of profenophos 50 EC, the mortality of mealybug population was recorded 83.50% at 72 hours after exposure. The mealybug population was found susceptible against profenophos 50 EC at recommended concentration. 99.94% mortality of mealybug was recorded at highest concentration (0.80%) of profenophos 50 EC and lowest mortality (19.57%) at lowest concentration (0.0125%). The lowest to highest concentration of buprofezin 25 SC recorded 16.59 to 99.66% mortality at 72 hours after exposure. The mortality of mealybug was found highest (99.66%) in the highest concentration (0.40%) followed by next higher concentrations. At recommended concentration of buprofezin 25 SC being recorded as 78.89% at 72 hours exposure. The highest 99.66 % mortality of mealybug was recorded at highest concentration (0.40%) of buprofezin 25 SC and the lowest mortality (16.59%) at lowest concentration (0.0625%).

There was significant difference in mortality of mealybug in lamda cyhalothrin 5 EC at 72 hours after exposure. The lowest to highest (0.000625 to 0.04%) concentration of lamda cyhalothrin 5 EC recorded 13.64 to 86.02% mortality of mealybug at 72 hours after exposure. At recommended concentration of lamda cyhalothrin 5 EC, the mortality of mealybug was recorded 53.82% at 72 hours after exposure. The higher mortality (86.02%) of mealybug population was recorded at highest concentration (0.04%) of lamda cyhalothrin 5 EC and the lowest mortality (13.64%) at lowest concentration (0.000625%). The mortality of mealybug in spinosad 45 SC varied from 13.85 to 91.83% from lowest to highest (0.002475 to 0.1584%) concentrations at 72 hours after exposure. At recommended concentration of spinosad 45 SC (0.0198%), the mortality of mealybug was recorded 57.42% at 72 hours after exposure. The spinosad 45 SC was found susceptible at recommended concentration. 91.83% mortality of mealybug population was recorded at highest concentration (0.1584%) of spinosad 45 SC and lowest mortality (13.85%) at lowest concentration (0.002475%).

The results on susceptibility of cotton mealybug to various insecticides *viz.,* imidacloprid, acetamiprid, thiamethoxam, buprofezin, lamda cyhalothrin, spinosad and profenophos in the present investigation is in accordance with El-Zahi and Farag (2017) who found the toxicity in the descending order based on LC_{50} (mg a.i. l^{-1}) value as thiamethoxam 25 WG (23.6)>methomyl 90 SP (34.3)>acetamiprid 20 SP (39.0)>imidacloprid 30.5 EC (43.5)>chlorpyrifos 48 EC (73.4)>deltamethrin 2.5 EC (94.8)>lufenuron 5 EC (556.1) using leaf dip method and deltamethrin 2.5 EC (39.6)>20 SP (56.5)>thiamethoxam 25 WG (59.3)>imidacloprid 30.5 EC (66.4)>methomyl 90 SP (112.8)>chlorpyrifos

Table 2: Susceptibility of cotton mealybug population to different insecticides

Sl. No.	Per cent corrected cumulative mortality of mealybug after treatments					
	Imidacloprid 70 WG		Acetamiprid 20 SP		Thiamethoxam 25 WG	
	Conc. (%)	72 HAT	Conc. (%)	72 HAT	Conc. (%)	72 HAT
1.	0.03920000	73.38 (91.80)	0.0320	85.88 (99.43)	0.080000	76.91 (94.89)
2.	0.01960000	64.93 (82.07)	0.0160	74.86 (93.20)	0.040000	65.94 (83.41)
3.	0.00980000	59.98 (75.01)	0.0080	67.68 (85.59)	0.020000	59.72 (74.60)
4.	0.00490000	55.35 (67.70)	0.0040	63.97 (80.77)	0.010000	54.26 (65.91)
5.	0.00245000	46.02 (51.81)	0.0020	47.80 (54.91)	0.005000	46.55 (52.73)
6.	0.00122500	33.50 (30.49)	0.0010	36.42 (35.27)	0.002500	35.81 (34.26)
7.	0.00061250	22.35 (14.47)	0.0005	24.05 (16.62)	0.001250	22.59 (14.77)
Mean		50.79 (59.05)	-	57.24 (66.54)	-	51.68 (60.08)
SEm±		0.36	-	0.52	-	0.27
CD (p=0.05)		1.12	-	1.60	-	0.83
CV %		1.24	-	1.57	-	0.91

Table 2: Continue...

Sl. No.	Per cent corrected cumulative mortality of mealybug after treatments							
	Profenophos 50 EC		Buprofezin 25 SC		Lamda cyhalothrin 5 EC		Spinosad 45 SC	
	Conc. (%)	72 HAT	Conc. (%)	72 HAT	Conc. (%)	72 HAT	Conc. (%)	72 HAT
1.	0.8000	89.18	0.4000	86.62	0.040000	68.03	0.158400	73.38
		(99.94)		(99.66)		(86.02)		(91.83)
2.	0.4000	77.16	0.2000	78.54	0.020000	58.93	0.079200	64.21
		(95.04)		(96.04)		(73.40)		(81.10)
3.	0.2000	69.77	0.1000	71.20	0.010000	53.05	0.039600	56.36
		(88.07)		(89.64)		(63.90)		(69.35)
4.	0.1000	66.01	0.0500	62.62	0.005000	47.17	0.019800	49.25
		(83.50)		(78.89)		(53.82)		(57.42)
5.	0.0500	49.50	0.0250	47.13	0.002500	34.97	0.009900	36.90
		(57.85)		(53.75)		(32.88)		(36.08)
6.	0.0250	38.87	0.0125	33.21	0.001250	27.85	0.004950	30.52
		(39.40)		(30.03)		(21.84)		(25.82)
7.	0.0125	26.25	0.0625	24.03	0.000625	21.66	0.002475	21.84
		(19.57)		(16.59)		(13.64)		(13.85)
Mean	-	59.53	-	57.62		44.52		47.50
	-	(69.05)	-	(66.37)		(49.36)		(53.64)
SEm±	-	0.42	-	0.32		0.19		0.25
CD (*p*=0.05)	-	1.30	-	0.98		0.59		0.76
CV %	-	1.22	-	0.96		0.75		0.90

Note: Figures in parentheses are original values, those outside are arc sine transformed values; HAT: Hours after treatment

48 EC (295.9)>lufenuron 5 EC (556.1) using insect-spray method. Seni and Naik (2017) found lamda cyhalothrin 4.9 CS as the most toxic insecticide against *P. solenopsis* reared on chrysanthemum leaves having the lowest LD_{50} (16.03 ppm) followed by chlorpyriphos 20 EC (27.56 ppm), ethiprole+imidacloprid 80 WG (44.82 ppm), imidacloprid 30.5 SC (80.68 ppm), thiacloprid 240 SC (87.13 ppm), pymetrozine 50 WP (181.45 ppm), acephate 95 SG (359.61 ppm) and fipronil 5 SC (705.59 ppm) 24 h after the exposure.

4. Conclusion

Profenophos 50 EC was highly effective in reducing mealybug population followed by acetamiprid 20 SP and buprofezin 5 EC whereas mealybug population was less susceptible to lamda cyhalothrin 5 EC and spinosad 45 SC and developed resistance against these insecticides.

5. References

Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18, 265−267.

Anonymous, 2021. ICAR-AICRP (Cotton) Annual Report (2020-21). ICAR - All India Coordinated Research Project on Cotton, Coimbatore, Tamil Nadu. pp. A1−A4.

Bhanderi, G.R., Patel, R.D., Desai, H.R., Patel, R.K., 2020. Assessment of yield losses due to mealybug (*Phenacoccus solenopsis* Tinsley) infestation in the cotton farmers' field of south Gujarat. Journal of Entomology and Zoology Studies 8(2), 73−79.

Chaudhry, G.Q., 1976. Pest control in cotton production, Proc. Cotton production seminar organized by ESSO Fertilizer Co. Ltd. Pakistan, pp. 114−118.

Dhaliwal, G.S., Arora, R., Dhawan, A.K., 2004. Crop losses due to insect pests in Indian Agriculture, an update. Indian Journal of Ecology 31(1), 1−7.

El-Zahi, S.E., Farag, A.I., 2017. Population dynamic of *Phenacoccus solenopsis* Tinsley on cotton plants and its susceptibility to some insecticides in relation to the exposure method. Alexandria science exchange journal 38(2), 231−237.

Hargreaves, H., 1948. List of recorded cotton insects of the world. Common Wealth Institute of Entomology, London, 50p.

Kumar, V., Maisuria, I. M., Patel, C. J., Desai, H.R., Sheth, D.B., 2010. Eco-friendly management of Mealybug in cotton. Booklet, Printed under Rashtriya Krishi Vikas Yojna, Main Cotton Research Station, NAU, Surat, pp.30.

Nagrare, V. S., Kranthi, S., Biradar, V.K., Zade, N.N., Sangode, V., Kakde, G., Kranthi, K.R., 2009. Widespread infestation of the exotic mealybug species, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), on cotton in India. Bulletin of entomological Research 99(5), 537.

Naqvi, K.M., 1975. Crop protection to boost up cotton production. Paper read at Cotton Seminar on April 13-14th, 1975 at Layllpur.

Naqvi, K.M., 1976. Crop protection to boost up the cotton production. Seminar organized by ESSO, Fert. Co. Ltd. Pakistan.

Satpute, U.S., Sarnaik, D.N., Bhalerao, P.D., 1988. Assessment of avoidable field losses in cotton yield due to sucking pests and bollworms. Journal of Plant Protection 16, 37−39.

Seni, A., Naik, B.S., 2017. Bio-efficacy of some insecticides against cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). International Journal of Environment, Agriculture and Biotechnology 2(6), 3089−3091.

Vennila, S., 2008. Pest management for cotton ecosystem. Current Science 94, 1351−1352.