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Bio-Efficacy of different insecticides against Custard apple mealy bug, (*Maconellicocus hirsutus*)

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Custard apple or sugar apple (*Annona squamosa* L) is considered as the new super fruit of 21st century belonging to the family Annonaceae. It is one of the important minor fruit crops in India, commonly known as *sitaphal, sita palam, sharifa, sita pazham, sita phalmu, katal, ata* and sweet sop depending upon the region. Fruits can be called as a delicacy of dry region due to its very sweet delicate flesh and are rich in carbohydrate mainly in the form of sugar, protein, calcium, phosphorus and iron. It is grown throughout the plains of India except temperate region. The major custard apple growing states are Maharashtra, Gujarat, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Bihar, Assam, Rajasthan, Orissa and Tamil Nadu. Approximately 55,000 hectares are dedicated to custard apple cultivation (Anonymous, 2014). In Maharashtra, custard apple is grown in Pune, Beed, Aurangabad, Nanded, Dhule, Jalgaon, Nandurbar, Osmanabad, Latur, Ahmednagar, Solapur, Bhandara and Wardha districts. Balaghat hills of Marathwada are famous for natural occurrence of custard apple plantation. The fruit tolerates a variety of conditions from saline soils to droughts.

In custard apple cultivation, insect-pests remain as a major constrains in India. The 20 species of insect-pests has been reported on this crop (Butani, 1979), in which the mealy bug species viz., striped mealy bug, *Ferrisia virgata* (Cockerell), pink mealy bug, *Maconellicoccus hirstus* (Green), citrus mealy bug, *Planococcus citri* (Risso), passion vine mealy bug, *Planococcus pacificus* Cox and mango mealy bug, *Perissopneumon ferox* Newstead (Hemiptera: Pseudococcidae) are the major causing roots and significant fruit yield loss. Recently, the heavy infestation of mealy bug (*M. hirsutus*) was recorded on custard apple orchards during fruiting stage from October to November in different parts of Maharashtra. The heavy infestation was recorded up to 40-80% during November (Kapadia *et al.*, 2009). Both nymphs and adults are damageable, they fasten their mouth at fissure and furrow of rounded fleshy tubercles of the green fruits and suck the sap through piercing and sucking action. If the infestation occurs on developing stage, the fruit size becomes diminished, shrivelled and undergo premature dropping. These mealy bugs also infest at fruit stalks, leaves and terminal shoots causing, yellowing and drying symptoms. Bugs excretion contains honeydew which encourages the growth of sooty mold on leaves and fruits which attracts black ants to help in the spread of these mealy bugs. The sooty mould also reduces the photosynthetic efficiency of the plant (Maruthadurai and Karuppaiah, 2014). Once the mealy bug load is increased on fruits it is very difficult to manage the pest with conventional insecticides. Keeping this in view, the present investigation was undertaken to study the bio-efficacy of different newer insecticides along with conventional and botanical insecticide against mealy bug on custard apple.

A field experiment was conducted on custard apple (variety Dharur-6) orchard at Custard apple Research Station, Ambajogai, (VNMKV, Parbhani) Maharashtra during *Mrig Bahar* of 2014-15. The experiment was conducted in randomly block design with three replications. There were taken eleven treatments *viz.*, imidacloprid 70 WS @ 0.005 per cent, imidacloprid 17.8 SL @ 0.004 per cent, imidacloprid 30.5 SC @ 0.004 per cent, thiamethoxam 25 WG @ 0.005 per cent, acetamiprid 20 SP @ 0.002 per cent, clothianidin 50 WDG @ 0.01 per cent, diafenthiuron 50 WP @ 0.07 per cent, dimethoate 30 EC @ 0.04 per cent, fipronil 5 SC @ 0.02 per cent, azadirachtin 0.03 WSV @ 0.03 per cent and untreated control. Spraying was undertaken after developing heavy infestation of mealy bug population on custard apple fruits. The pre count of nymphs and adults of mealy bug noted on a day prior to application and post count at 1, 3, 5,7 and10 days after spraying. Efficacy of insecticides was judged on the basis of level of mealy bug incidence on randomly selected fruits. The generated data on survival of mealy bug population was transformed into values and subjected for statistical analysis according to Gomez and Gomez (1984).

Statistically non-significant difference was noted in mealy bug population prior to spraying. Mealy bug population ranged from 32.33 to 46.78 nymphs and adults per fruit one day before spray. All insecticide treatments were significantly superior over untreated control in minimizing the incidence of mealy bug on 1, 3, 5, 7 and 10 day after spray treatment (DAS) (Table 1). At one day after spraying, significantly minimum population of custard apple mealy bug (6.37 nymphs and adults/fruit) was recorded with imidacloprid 70 WS @ 0.005 per cent followed by imidacloprid 30.5 SC @ 0.004 per cent (7.67 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (8.13 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (10.43 nymphs and adults /fruit) and thiamethoxam 25 WG @ 0.005 per cent (10.80 nymphs and

adults/fruit). All these treatments were statistically at par with each other. Acetamiprid 20 SP @ 0.002 per cent (14.03 nymphs and adults /fruit), dimethoate 30 EC @ 0.04 per cent (16.40 nymphs and adults /fruit), clothianidin 50 WDG @ 0.01 per cent (18.97 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (21.31 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (22.29 nymphs and adults/fruit) were found next effective treatments.

At three day after spraying, significantly lowest population of custard apple mealy bug (8.34 nymphs and adults/fruit) was recorded from the plants treated with imidacloprid 70 WS @ 0.005 per cent followed by imidacloprid 30.5 SC @ 0.004 per cent (9.64 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (10.11 nymphs and adults/fruit) and imidacloprid 17.8 SL @ 0.004 per cent (12.41 nymphs and adults/fruit). All these treatments were statistically at par with each other. Thiamethoxam 25 WG @ 0.005 per cent (12.77 nymphs and adults/fruit), acetamiprid 20 SP @ 0.002 per cent (16.01 nymphs and adults/fruit), dimethoate 30 EC @ 0.04 per cent (18.27 nymphs and adults /fruit), clothianidin 50 WDG @ 0.01 per cent (20.94 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (22.46 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (24.26 nymphs and adults/fruit) were found next effective treatments.

At five day after spraying, imidacloprid 70 WS @ 0.005 per cent evidenced significantly lowest population of custard apple mealy bug (10.37 nymphs and adults/fruit) which was followed by imidacloprid 30.5 SC @ 0.004 per cent (9.64 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (12.28 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (14.58 nymphs and adults/fruit) and thiamethoxam 25 WG @ 0.005 per cent (14.95 nymphs and adults/fruit). All these treatments were statistically at par with each other. The next effective treatments were dimethoate 30 EC @ 0.04 per cent (18.18 nymphs and adults/fruit), acetamiprid 20 SP @ 0.002 per cent (20.19 nymphs and adults /fruit), clothianidin 50 WDG @ 0.01 per cent (23.12 nymphs and adults /fruit), fipronil 5 SC @ 0.02 per cent (25.46 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (26.11 nymphs and adults/fruit).

At seven day after spraying, imidacloprid 70 WS @ 0.005 per cent achieved minimum population of custard apple mealy bug (12.62 nymphs and adults/fruit) and statistically at par with imidacloprid 30.5 SC @ 0.004 per cent (14.07 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (14.55 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (16.83 nymphs and adults/fruit) and thiamethoxam 25 WG @ 0.005 per cent (17.20 nymphs and adults/fruit). Acetamiprid 20 SP @ 0.002 per cent (20.29 nymphs and adults/fruit), dimethoate 30 EC @ 0.04 per cent (22.72 nymphs and adults/fruit), clothianidin 50 WDG @ 0.01 per cent (25.38 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (27.73 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (28.71 nymphs and adults/fruit) were found subsequently effective treatments.

At ten day after spraying, imidacloprid 70 WS @ 0.005 per cent exhibited most effective treatment in reducing population of custard apple mealy bug (15.26 nymphs and adults/fruit) which was followed by imidacloprid 30.5 SC @ 0.004 per cent (16.70 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (16.98 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (19.47 nymphs and adults/fruit) and thiamethoxam 25 WG @ 0.005 per cent (19.83 nymphs and adults/fruit). All these treatments were statistically at par with each other. Subsequently effective treatments in reducing population of custard apple mealy bug were dimethoate 30 EC @ 0.04 per cent (23.07 nymphs and adults/fruit), acetamiprid 20 SP @ 0.002 per cent (25.15 nymphs and adults/fruit), clothianidin 50 WDG @ 0.01 per cent (27.82 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (30.30 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (31.14 nymphs and adults/fruit). The descending order of effectiveness of different treatment was imidacloprid 70 WS > imidacloprid 30.5 SC > diafenthiuron 50 WP > imidacloprid 17.8 SL > thiamethoxam 25 WG > dimethoate 30 EC > acetamiprid 20 SP > clothianidin 50 WDG > fipronil 5 SC > azadirachtin 0.03 WSV when compared with control.

The present investigation revealed that imidacloprid 70 WS @ 0.005 per cent, imidacloprid 30.5 SC @ 0.004 per cent, diafenthiuron 50 WP @ 0.07 per cent, imidacloprid 17.8 SL @ 0.004 per cent and thiamethoxam 25 WG @ 0.005 per cent were significantly superior in reducing population of custard apple mealy bug. The present findings are in conformity with the findings of Kulkarni and Patil (2013) who reported that imidacloprid @ 0.005 per cent (4.79 nymphs and adults/fruit) and diafenthiuron @ 0.02 per cent (4.88 nymphs and adults/fruit) found effective insecticides in minimizing population of custard apple mealy bug. Tanwar *et al.* (2010) reported imidacloprid 17.8 SL (0.6 ml/l), thiamethoxam 25 WG (0.6 g/l) and dimethoate 30 EC (2 ml/l) better insecticides for reducing papaya mealy bug. Whereas, Tanwar *et al.* (2007) recommended imidacloprid 200 SL @ 1 ml/l for reducing *M. hirsutus* population. Similarly, Biradar *et al.* (2006) reported that diafenthiuron 50 SC @ 800 and 1600, and at 600, 800 and 1600 g per ha resulted in the lowest mealy bug colonies 10 days after sprayings during first and second spray treatments, respectively. In the present investigation, the conventional insecticide viz., dimethoate 30 EC @ 0.04 per cent proved equally effective in minimizing mealy bug population. However, botanical insecticide viz., azadirachtin 0.03 WSV @ 0.03 per cent evidenced least effective as compared to chemical insecticides. These results found supports from the investigation of Kulkarni and Patil (2013) who reported NSKE 5 per cent as a least effective treatment in managing custard apple mealy bug. Whereas, Sawant *et al.* (2007) recommended foliar spray of azadirachtin 1 per cent @ 2ml per litre or 5 per cent @ 1 ml per litre for the effective management of *M. hirsutus*. Anonymous (2014) reported that azadirachtin 10000 ppm @ 3ml per litre documented effective against custard apple mealy bug. The present study clearly

Table 1. Effect of different insecticides on the population of custard apple mealy bug

Treatments	Dose (%)	Mean population of mealy bug per fruit					
		1 day before Spraying	Days after spraying				
			1	3	5	7	10
Imidacloprid 70 WS	@ 0.005	44.33 (6.67)*	6.37 (2.60)	8.34 (2.96)	10.37 (3.28)	12.62 (3.62)	15.26 (3.97)
Imidacloprid 17.8 SL	@ 0.004	38.00 (6.16)	10.43 (3.31)	12.41 (3.58)	14.58 (3.89)	16.83 (4.20)	19.47 (4.47)
Imidacloprid 30.5 SC	@ 0.004	40.67 (6.41)	7.67 (2.86)	9.64 (3.19)	11.82 (3.50)	14.07 (3.81)	16.70 (4.15)
Thiamethoxam 25 WG	@ 0.005	32.33 (5.72)	10.80 (3.33)	12.77 (3.64)	14.95 (3.90)	17.20 (4.19)	19.83 (4.50)
Acetamiprid 20 SP	@ 0.002	34.44 (5.88)	14.03 (3.79)	16.01 (4.04)	20.19 (4.55)	20.29 (4.56)	25.15 (5.05)
Clothianidin 50 WDG	@ 0.01	41.78 (6.47)	18.97 (4.39)	20.94 (4.61)	23.12 (4.84)	25.38 (5.08)	27.82 (5.31)
Diafenthiuron 50 WP	@ 0.07	35.44 (5.94)	8.13 (2.89)	10.11 (3.21)	12.28 (3.55)	14.55 (3.85)	16.98 (4.16)
Dimethoate 30 EC	@ 0.04	39.44 (6.29)	16.40 (4.10)	18.27 (4.31)	18.18 (4.30)	22.72 (4.80)	23.07 (4.84)
Fipronil 5 SC	@ 0.02	46.78 (6.84)	21.31 (4.65)	22.46 (4.78)	25.46 (5.09)	27.73 (5.30)	30.30 (5.54)
Azadiractin 0.03 WSV	@ 0.03	35.78 (6.00)	22.29 (4.75)	24.26 (4.97)	26.11 (5.16)	28.71 (5.38)	31.14 (5.61)
Untreated Control	-	35.22 (5.96)	34.72 (5.91)	36.70 (6.07)	38.87 (6.26)	41.14 (6.43)	43.57 (6.63)
S.E.±		4.92	0.26	0.22	0.22	0.22	0.21
C.D. at 5%		NS	0.79	0.66	0.65	0.67	0.63

*Figures in parentheses are square root transformed values ($\sqrt{x+0.5}$)
N.S.: Non-significant

indicates that newer insecticides proved effective tool in minimizing the population of custard apple mealy bug on fruits under the circumstances of heavy infestation. It also illustrates that population of custard apple mealy bug should be kept under control from the beginning of infestation for avoiding population reaching to beyond control.

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