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Bioefficacy of newer insecticides on aphids of pomegranate

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Abstract
The present investigation was undertaken regarding evolution of newer insecticides against aphids (*A. punicae*) on pomegranate at Department of Horticulture, VNMKV, Parbhani. The different newer insecticides were acephate, buprofezin, clothianidin, diafenthiuron, fipronil, flonicamid, spiromesifen and thiamethoxam were used. The pooled data of *Ambia* and *Hasta* bahar showed that the count of aphids in the insecticide treatments was significantly lower indicating that all evaluated insecticides were significantly effective against aphids. The best treatment to control pest population was the plants treated with clothianidin which found to be at par with thiamethoxam and flonicamid. The succeeding better treatment were fipronil > acephate > diafenthiuron > spiromesifen > buprofezin, respectively.

Keywords: *A. punicae*, bioefficacy, clothianidin, thiamethoxam and flonicamid

Introduction
Pomegranate cultivation is unique in its own way because of its drought tolerant hardy nature, low maintenance cost, steady and good yields, fine table and therapeutic values, better keeping quality and possibilities of throwing the plant into rest during period when irrigation potential is low, especially in the hot semi-arid and desert regions of India, Maharashtra, Uttar Pradesh, Andhra Pradesh, Gujarat, Karnataka and Tamil Nadu its cultivation has spread extensively. In Maharashtra area about 78.00 thousand ha and production 408.00 thousand tonne. In Maharashtra area under commercial production of pomegranate is steadly increasing mainly in Solapur, Nashik, Ahamednager, Pune, Sangali, Satara, Aurangabad, Jalna, and Parbhani districts (Anon, 2005) [2].

Through scanning of literature revealed a total of 91 insects, 6 mites and 1 snail pest feeding on pomegranate crop in India. The most obnoxious enemy is pomegranate butterfly, *Deudorix* (*Virachola*) *isocrates* (Fab.) which may destroy more than 50% of fruits. Overuse and improper use of insecticides has led to many serious problems like whiteflies (Pomegranate whitefly, *Siphoninus phillyreae* (Haliday); Spiralling whitefly, *Aleurodicus dispersus* Russell), mealybug (*Pseudococcus lilacinus* (Cockerell)) Thrips (*Rhipiphoro thrips cruentatus* Hood; *Scirtothrips dorsalis* Hood; *Anaphothrips oligochaetus* Karny), aphid (*Aphis punicae* (Passerini)) and mites, *Aceria granati* Can. & Massal; *Oligonychus punicae* (Hirst.). These sucking pests occur during the flowering and fruiting stage of the crop and thereby reduce the vigour of the plant in addition to excretion of honeydew on the leaves and development of sooty mould on leaves and fruits (Ananda N, Kotikal YK and Balikai, RA. 2009) [1]. The species of aphids (*Aphis punicae* Passerine.) infesting pomegranate is a polyphagous pest known to cause damage to several seasonal field crops, vegetables and fruit crops. Both nymphs and adults of aphids feed by sucking type of mouth parts. They lacerate the surface of developing fruiting parts and cause deformation showing corcky appearance on surface of fruits which ultimately deteriorate the quality, fetching the low price in domestic market and not accepted for export (Butani, 1979) [3].

Materials and Methods
Experimental details
The details of experiment are given below.
Experimental Design : Randomized Block Design
Replications : Three
Treatments : Ten
Spacing : 4 m x 4 m

Crop : Pomegranate
Variety : Bhagwa
Distance between two replications : 4m
Distance between two plots : 4m

Treatment details of insecticides for sucking pests

Tr. no.	Treatments	Dose (g.a.i./ha)
T_1	Acephate 75% WP	584 gm
T_2	Buprofezin 25% SC	250 ml
T_3	Clothianidin 50% WDP	20 gm
T_4	Diafenthiuron 50% WP	300 gm
T_5	Fipronil 5% SC	50 ml
T_6	Flonicamid 20% WP	50 gm
T_7	Spiromesifen 22.9% SC	96 ml
T_8	Thiamethoxam 70% WS	25 gm
T_9	Control	----

Methods of observations
Three observation plants were selected randomly from the net plot of each treatment in each replication. They were properly labeled. While thrips were observed on the fruits and the observation was observed at one day before and 1, 3, 7 and 14 days after application of insecticides.

Results and Discussion
The data presented in the (Table 1 and 2) shows the pooled population of aphids on pomegranate during *Ambia bahar* and *Hasta bahar* during the year 2014-15.

Pooled data of *Ambia bahar* 2014 and 2015
The data presented in the (Table 1) shows the population of aphids on pomegranate of *Ambia bahar* during the year 2014 and 2015. The aphid population was ranged from 10.42 to 12.42 which were found non significant statistically.

A. Performance after first spray
Pooled data after 1 DAS showed that the promising treatment was clothianidin (2.00 aphids/5 cm twig) followed by thiamethoxam (2.42 aphids/5 cm twig), flonicamid (2.58 aphids/ 5 cm twig) and fipronil (2.96 aphids/ 5 cm twigs) were found at par with each other.
At 3 and 7 DAS clothianidin proved best over all treatment which controlled (2.29 and 3.04 aphids / 5 cm twig) which was found at par with thiamethoxam and flonicamid which controlled (2.83 and 4.17 aphids / 5 cm twig) and (3.08 and 4.33 aphids / 5 cm twig).
The data recorded on 14 DAS showed that clothianidin was the superior treatment (4.75 aphids /5 cm twig) followed by thiamethoxam and flonicamid (6.00 and 6.21 aphids /5 cm twig). Whereas highest incidence was found on the untreated plant with buprofezin (7.42 aphids /5 cm twig). It indicated that those four insecticides were at par with each other and comparatively more effective than rest of the spray treatments.

B. Performance after second spray
The aphid population on untreated plants (control) showed increased from 12.88 to 13.50 aphids /5 cm twig during a span of 14 days. All insecticidal treatments were significantly superior over control in minimizing the pest incidence.
The data recorded at 1 and 3 DAS revealed that clothianidin treated plants showed lowest incidence (1.54 and 1.69 aphids /5 cm twig), followed by thiamethoxam (2.21 and 2.63 aphids /5 cm twig) and flonicamid (2.42 and 2.88 aphids /5 cm twig) which were statistically at par with each other and significantly superior over other test insecticides.
The observations recorded on 7 DAS showed that clothianidin was the superior treatment (2.58 aphids /5 cm twig). The next promising treatments were thiamethoxam and flonicamid recording (3.21 and 3.75 aphids /5 cm twig), respectively.
The data recorded on 14 DAS showed that clothianidin was the superior treatment (3.58 aphids /5 cm twig) followed by thiamethoxam and flonicamid (4.63 and 5.00 aphids /5 cm twig). Whereas highest incidence was found on the plant treated with buprofezin (6.33 aphids /5 cm twig). It indicated that those four insecticides were at par with each other and comparatively more effective than rest of the spray treatments.

C. Performance after third spray
According to the observations recorded on 1 and 3 DAS clothianidin was found to be the most superior treatments (0.67 and 0.96 aphids/5 cm twig). Next promising treatments were thiamethoxam (1.21 and 1.46 aphids/5 cm twig) and flonicamid (1.33 and 1.75 aphids/5 cm twig) those were found at par with each other.
The post treatment count of live population of aphids at 7 days after third spray clearly indicated the superiority of clothianidin 50 WDG @ 20 g a.i. ha^{-1} (1.33 aphids/5 cm twig), over other treatments followed by thiamethoxam 25 WG @ 25 g a.i. ha^{-1} (1.83 aphids/5 cm twig), flonicamid (2.08 aphids/5 cm twig) and fipronil (2.25 aphids/5 cm twig), respectively. These four treatments were statistically at par with each other and were significantly superior over rest of the treatments in minimizing aphid incidence.
The data recorded on 14 DAS showed that clothianidin was the superior treatment (2.17 aphids/5 cm twig) followed by thiamethoxam and flonicamid (3.04, 3.21 and 3.42 aphids/5 cm twig). Whereas highest incidence was found on the plant treated with buprofezin (4.50 aphids/5 cm twig). It indicates that those four insecticides were at par with each other and comparatively more effective than rest of the spray treatments.

Pooled data of *Hasta bahar* 2014 and 2015
A. Performance after first spray
The post treatment observations recorded on first day after spray (Table 2) indicated that all the insecticidal treatments were significantly superior over control in reducing aphid population. Among these treatments the plants treated with clothianidin 50 WDG @ 20 g a.i. ha^{-1} recorded lowest aphids population (1.92 aphids/5 cm twig) and was significantaly superior over other treatment. It was followed by thiamethoxam 25 WG @ 25 g a.i. ha^{-1} (2.75 aphids/5 cm twig) and flonicamid 20% WP @ 50 g a.i. ha^{-1} (3.00 aphids/5 cm twig) were found statisticaly at par with each other.
At 3 DAS, the results showed that the treatment of clothianidin was most effective in minimizing aphids population (2.08 aphids/5 cm twig) followed by thiamethoxam (3.08 aphids/5 cm twig) and flonicamid (3.21 aphids/5 cm twig). There was no statistical difference in their effectiveness against aphids.
On 7 DAS, the results showed that the treatment of clothianidin was most effective in minimizing aphids population (2.88 aphids/5 cm twig) followed by thiamethoxam (4.13 aphids/5 cm twig) and flonicamid (4.29 aphids/5 cm twig). There was no statistical difference in their effectiveness against aphids.
The aphid population on control plants showed a gradual increase from (12.46 aphids/5 cm twig) to (15.58 aphids/5 cm twig) over a period of 14 days. The results obtained at 14 DAS showed that clothianidin (4.38 aphids/5 cm twig)

recorded lowest aphid population and was at par with thiamethoxam (6.25 aphids/5 cm twig) and flonicamid (6.50 aphids/5 cm twig).

The aphid population on control plants showed a gradual increase from (12.46 aphids/5 cm twig) to (15.58 aphids/5 cm twig) over a period of 14 days. The results obtained at 14 DAS showed that clothianidin (4.38 aphids/5 cm twig) recorded lowest aphid population and was at par with thiamethoxam (6.25 aphids/5 cm twig) and flonicamid (6.50 aphids/5 cm twig) were found at par with clothianidin. The other treatments fipronil, acephate, diafenthiuron, spiromesifen and buprofezin showed live count of 6.71, 6.92, 7.08, 7.38 and 7.75 aphids/5 cm twig, respectively. However, all the insecticides lost their efficacy in controlling the aphids at 14 DAS after first spray as lowest count was more than 5.00 aphids/5 cm twig amongst the treated plants.

B. Performance after second spray

The data (Table 2) revealed that all the insecticides under investigation were observed to be significantly superior over control in reducing the population of aphids on pomegranate at all the days of observations after second spray.

At 1 day and 3 days after second spray significantly minimum number of aphids (1.67 and 1.96 aphids/5 cm twig) were recorded from the treated plants with clothianidin followed by thiomethoxam (2.33 and 2.79 aphids/5 cm twig), flonicamid (2.54 and 3.04 aphids/5 cm twig) and fipronil (2.75 and 3.29 aphids/5 cm twig). However, thiomethoxam, flonicamid and fipronil were at par with each other after 1 DAS and after 3 DAS clothianidin, thiomethoxam and flonicamid found at par stastically.

The significantly lowest population of aphids was recorded from the plots sprayed with clothianidin (2.38 and 3.63 aphids/5 cm twig) at 7 and 14 days after second spray over rest of the insecticides excepting thiomethoxam (3.25 and 4.92 aphids/5 cm twig) and flonicamid (3.50 and 5.13 aphids/5 cm twig). However, these insecticides were at par with each other.

C. Performance after third spray

According to the observations recorded on 1 and 3 DAS clothianidin was found to be the most superior treatments (0.79 and 1.04 aphids/5 cm twig). Next promising treatments were thiamethoxam (1.13 and 1.50 aphids/5 cm twig) and flonicamid (1.38 and 1.79 aphids/5 cm twig) those were found at par with each other.

The post treatment count of live population of aphids at 7 days after third spray clearly indicated the superiority of clothianidin 50 WDG @ 20 g a.i. ha^{-1} (1.50 aphids/5 cm twig), over other treatments followed by thiamethoxam 25 WG @ 25 g a.i. ha^{-1} (2.13 aphids/5 cm twig) and flonicamid (2.33 aphids/5 cm twig), respectively. These three treatments were statistically at par with each other and were significantly superior over rest of the treatments in minimizing aphid incidence.

The data recorded on 14 DAS showed that clothianidin was the superior treatment (2.38 aphids/5 cm twig) followed by thiamethoxam and flonicamid (3.13 and 3.42 aphids/5 cm twig). Whereas highest incidence was found on the plant treated with buprofezin (4.71 aphids/5 cm twig). It indicates that those four insecticides were at par with each other and comparatively more effective than rest of the spray treatments.

The reports of earlier researchers on chemical control of pomegranate aphids (*Apis punicae*) infesting many field crops are discussed here. Gore *et al.* (2010) [4] observed that the lowest incidence of aphids/ 5 cm shoot length was recorded with thiamethoxam and it was significantly superior over all other treatments. The next treatments in order of their merit were acetamiprid, imidacloprid, dimethoate, acephate, fipronil and diafenthiuron. All these treatments significantly differed from each other. The highest aphid incidence was recorded in untreated control. The study revealed that thiamethoxam 25 WG @ 0.2 g/l recorded highest reduction in population followed by imidacloprid 70 WG @ 0.3g/l (Kambrekar *et al.* 2013) [6]. Jadhav (2015) [5] observed that the treatments comprised of clothianidin 50 WDG @ 20 g a.i. ha^{-1} (4.49 aphids/twig), thiamethoxam 25 WG @ 25 g a.i. ha^{-1} (4.75 aphids/twig), imidacloprid 17.8 SL @ 25 g a.i. ha^{-1} (5.28 aphids/twig) and fipronil 5 SC @ 50 g a.i. ha^{-1} (6.15 aphids/twig) were the most effective treatments at 14 DAS followed by and were at par with each other.

Table 1: Bioefficacy of newer insecticides against aphids infesting pomegranate Pooled (*Ambia bahar*-2014 & 2015)

Treatments	Dose g.a.i./ha	Average no. of aphids/ 5 cm twig											
		Pre-count	1st spray				2nd spray				3rd spray			
			1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS
Acephate	584 gm	10.42 (3.30)	3.38 (1.96)	3.67 (2.01)	4.83 (2.31)	6.71 (2.68)	2.92 (1.85)	3.25 (1.93)	4.33 (2.20)	5.66 (2.47)	1.71 (1.48)	2.08 (1.59)	2.50 (1.73)	3.63 (2.03)
Buprofezin	250 ml	11.00 (3.39)	3.83 (2.08)	4.33 (2.19)	5.54 (2.46)	7.42 (2.81)	3.58 (2.02)	3.92 (2.10)	5.13 (2.36)	6.33 (2.61)	2.38 (1.69)	2.75 (1.79)	3.17 (1.91)	4.50 (2.23)
Clothianidin	20 gm	11.17 (3.42)	2.00 (1.58)	2.29 (1.64)	3.04 (1.87)	4.75 (2.28)	1.54 (1.41)	1.69 (1.47)	2.58 (1.75)	3.58 (1.99)	0.67 (1.08)	0.96 (1.18)	1.33 (1.33)	2.17 (1.60)
Diafenthiuron	300 gm	11.46 (3.46)	3.54 (2.00)	3.79 (2.06)	5.04 (2.35)	6.96 (2.73)	3.08 (1.89)	3.54 (2.01)	4.67 (2.27)	6.00 (2.55)	1.88 (1.53)	2.25 (1.65)	2.83 (1.82)	3.96 (2.11)
Fipronil	50 ml	10.79 (3.36)	2.96 (1.86)	3.42 (1.97)	4.58 (2.25)	6.42 (2.63)	2.75 (1.80)	3.08 (1.89)	4.08 (2.14)	5.33 (2.41)	1.50 (1.40)	1.96 (1.56)	2.25 (1.66)	3.42 (1.97)
Flonicamid	50 mg	11.63 (3.48)	2.58 (1.75)	3.08 (1.88)	4.33 (2.20)	6.21 (2.59)	2.42 (1.70)	2.88 (1.84)	3.75 (2.06)	5.00 (2.34)	1.33 (1.34)	1.75 (1.50)	2.08 (1.61)	3.21 (1.92)
Spiromesifen	96 ml	11.00 (3.39)	3.67 (2.04)	4.08 (2.12)	5.33 (2.41)	7.21 (2.78)	3.29 (1.94)	3.75 (2.06)	4.83 (2.31)	6.13 (2.57)	2.21 (1.64)	2.50 (1.73)	3.04 (1.88)	4.21 (2.17)
Thiamethoxam	25 gm	11.58 (3.47)	2.42 (1.70)	2.83 (1.81)	4.17 (2.16)	6.00 (2.51)	2.21 (1.64)	2.63 (1.76)	3.21 (1.92)	4.63 (2.25)	1.21 (1.29)	1.46 (1.38)	1.83 (1.52)	3.04 (1.88)
Control	-	12.42 (3.59)	12.58 (3.61)	12.83 (3.65)	13.33 (3.72)	14.83 (3.92)	12.88 (3.66)	12.21 (3.59)	13.17 (3.69)	13.50 (3.73)	12.58 (3.62)	12.46 (3.59)	12.71 (3.63)	12.88 (3.65)
S.E.+	-	0.05	0.09	0.10	0.11	0.12	0.10	0.12	0.11	0.12	0.09	0.11	0.10	0.11
C.D. at 5%	-	N.S.	0.30	0.31	0.34	0.39	0.31	0.38	0.34	0.39	0.30	0.36	0.33	0.34

***** Figures in parentheses are √x+0.5 transfer values *DAS: Days after spray * NS: Non significant

Table 2: Bioefficacy of newer insecticides against aphids infesting pomegranate Pooled (*Hasta bahar*-2014 & 2015)

Treatments	Dose g.a.i./ha	Average no. of aphids/ 5 cm twig											
		Pre-count	1st spray				2nd spray				3rd spray			
			1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS	1 DAS	3 DAS	7 DAS	14 DAS
Acephate	584 gm	13.13 (3.68)	3.42 (1.97)	3.83 (2.08)	4.88 (2.32)	6.92 (2.72)	3.00 (1.86)	3.63 (2.02)	4.00 (2.12)	5.67 (2.48)	1.83 (1.52)	2.25 (1.65)	3.04 (1.88)	3.92 (2.10)
Buprofezin	250 ml	13.45 (3.72)	4.00 (2.12)	4.67 (2.27)	5.58 (2.46)	7.54 (2.83)	3.79 (2.06)	4.33 (2.20)	4.75 (2.29)	6.29 (2.60)	2.50 (1.72)	2.96 (1.85)	3.71 (2.05)	4.71 (2.28)
Clothianidin	20 gm	12.76 (3.62)	1.92 (1.54)	2.08 (1.60)	2.88 (1.81)	4.38 (2.19)	1.67 (1.46)	1.96 (1.54)	2.38 (1.67)	3.63 (2.02)	0.79 (1.13)	1.04 (1.23)	1.50 (1.39)	2.38 (1.66)
Diafenthiuron	300 gm	11.96 (3.52)	3.63 (2.03)	4.08 (2.14)	5.13 (2.37)	7.08 (2.75)	3.21 (1.92)	3.88 (2.09)	4.33 (2.19)	5.83 (2.52)	2.00 (1.58)	2.50 (1.73)	3.17 (1.91)	4.17 (2.16)
Fipronil	50 ml	12.42 (3.58)	3.21 (1.92)	3.58 (2.02)	4.67 (2.27)	6.71 (2.68)	2.75 (1.80)	3.29 (1.92)	3.71 (2.05)	5.38 (2.42)	1.58 (1.43)	2.04 (1.58)	2.63 (1.76)	3.67 (2.03)
Flonicamid	50 mg	11.75 (3.49)	3.00 (1.87)	3.21 (1.92)	4.29 (2.19)	6.50 (2.64)	2.54 (1.74)	3.04 (1.87)	3.50 (2.00)	5.13 (2.37)	1.38 (1.37)	1.79 (1.51)	2.33 (1.68)	3.42 (1.98)
Spiromesifen	96 ml	11.92 (3.52)	3.88 (2.09)	4.50 (2.23)	5.42 (2.43)	7.38 (2.80)	3.58 (2.01)	4.04 (2.12)	4.54 (2.24)	6.08 (2.56)	2.29 (1.67)	2.79 (1.80)	3.38 (1.96)	4.42 (2.22)
Thiamethoxam	25 gm	13.42 (3.72)	2.75 (1.80)	3.08 (1.89)	4.13 (2.15)	6.25 (2.60)	2.33 (1.68)	2.79 (1.81)	3.25 (1.93)	4.92 (2.33)	1.13 (1.26)	1.50 (1.40)	2.13 (1.60)	3.13 (1.90)
Control	-	12.33 (3.58)	12.46 (3.26)	13.08 (3.69)	14.08 (3.82)	15.58 (4.01)	14.71 (3.90)	14.88 (3.92)	15.04 (3.94)	14.00 (3.80)	12.79 (3.64)	13.04 (3.68)	13.75 (3.77)	13.50 (3.74)
S.E.±	-	0.10	0.11	0.13	0.13	0.15	0.11	0.11	0.11	0.12	0.09	0.09	0.10	0.10
C.D. at 5%	-	N.S.	0.35	0.40	0.41	0.48	0.34	0.34	0.34	0.38	0.29	0.30	0.32	0.33

***** Figures in parentheses are √x+0.5 transfer values *DAS: Days after spray * NS: Non significant

Discussion

The pooled data on the incidence of aphids (Avg. no. of aphids/ 5 cm twig) of two seasons revealed that the count of aphids before initiation of spray treatments was in the range of 10.42 to 12.42 and 10.42 to 11.63 aphids on twig. The untreated control plants showed an increasing aphid population during a span of 14 days. The count of aphids in the insecticide treatments was significantly lower indicating that all evaluated insecticides were significantly effective against aphids. The best treatment to control pest population was the plants treated with clothianidin 20 g a.i.ha^{-1}, thiamethoxam 25 g a.i.ha-1 and flonicamid 50 g a.i.ha^{-1} which found to be at par with clothianidin. The next better treatment were fipronil > acephate > diafenthiuron > spiromesifen > buprofezin, respectively.

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