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Management of pomegranate fruit borer, *Deudorix epijarbas* (Moore) using new group insecticides and some biopesticides

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Abstract
In order to find an alternative to organophosphates, the present study was conducted to evaluate the efficacy of some insecticides belonging to new group of insecticides and some biopesticides for the management of the pomegranate fruit borer, *Deudorix epijarbas* (Moore). Among the new group insecticides, rynaxypyr (0.006%), spinosad (0.002%), emamectin benzoate (0.002%) and cyazypyr (0.0075%) with 16.11, 16.67, 17.78 and17.78 per cent infestation proved effective in managing the pest. The biopesticides namely *Azadirachtin*, *Bacillus thuringiensis* and *Beauveria bassiana* were less efficacious where the fruit infestation recorded was 27.78, 29.44 and 30.56 per cent, respectively. The highest benefit cost ratio (BCR) was recorded in spinosad (31.39:1) followed by cyazypyr (20.00:1) treatment. Overall, earlier used cypermethrin (0.01%) was most economical (BCR 74:1) followed by deltamethrin (0.0028%) with a BCR of 46.50:1. *Azadirachtin* among biopesticides was economically not viable due to BCR value less than one.

Keywords: *Deudorix epijarbas,* pomegranate, cyazypyr, rynaxypyr, spinosad, *azadirachtin*, emamectin benzoate, biopesticides

Introduction

Pomegranate (*Punica granatum* L.) is one of the important commercial fruit crop of the tropical and sub-tropical regions of the world. In India, pomegranate is grown on 2, 16, 000 ha area with a production of 26, 13, 000 MT [1]. Due to the high economic returns being obtained with pomegranate, the area under pomegranate cultivation in Himachal Pradesh has increased to 2482 hectares with a production of 1986 MT [2]. In India, pomegranate is attacked by more than 45 insects (Butani, 1979) of which pomegranate fruit borer, *Deudorix epijarbas* is the main pest infesting both cultivated and wild pomegranate [18, 7, 5, 12, 15]. It is a direct pest of regular occurrence, the caterpillars of which bore into developing fruit and feed on the seeds. The hole made by the larva invites secondary infection causing fruit to rot and drop. The extent of loss varies between 50-90 per cent [18, 6, 3, 11, 10]. The control of the pest is insecticide oriented most of them belonging to organophosphates and pyrethroids [16, 7, 15, 6]. Since multitude of problems like resistance, health hazards, environmental pollution etc. are associated with these insecticides some alternatives must be searched for to manage the pest in an eco-friendly way. Further, Central Insecticide Board and Registration committee is now stressing for the label claim and only very few insecticides are available in the approved usage list of insecticides against pomegranate borer. Therefore the present investigation was carried out to test some new insecticide molecules along with biopesticides and some non-chemical methods against pomegranate fruit borer, *D. epijarbas.*

Materials and Methods

The bioefficacy studies were carried out in a 5 year old well managed orchard of pomegranate (var. Kandhari) during 2015 in the pomegranate block of Model Farm at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan. The new group insecticides namely diflubendiamide, emamectin benzoate, spinosad, rynaxapyr, cartap hydrochloride, thiodiacarb, cyazypyr; biopesticides viz. *Bacillus thuringiensis* based, neem based and *Beauveria bassiana* based formulations were evaluated and were compared with pyrethroids namely cypermethrin and deltamethrin, and the recommended OP insecticide quinalphos. In control, however, foliar application of water was given.

The insecticides and biopesticides were sprayed on the marked trees with the help of a foot sprayer upto run off stage. The second and third spray was given after the 3 and 6 weeks of first spray, respectively. The experiment was laid out in a completely Randomised Block Design (RBD) where each treatment was replicated thrice and a tree represented a replicate. The observations on fruit infestation in different treatments were recorded before the application of the first spray and thereafter the data were recorded 7, 14 and 21 days after each spray application on randomly selected 20 fruits/ tree.

Results and Discussion

Bioefficacy studies

The mean data of each spray presented in Table 1 reveals that after first spray application, rynaxypyr (4.44%), flubendiamide (5.56%), emamectin benzoate (5.56%), spinosad (5.56%), cyazypyr (5.56%), cypermethrin (5.56%) and deltamethrin (5.56%) were at par and effective in managing the fruit borer infestation. However, rynaxypyr (4.44% infestation) was superior to cartap hydrochloride (7.22%), thiodicarb (6.67%), azadirachtin (7.22%), *B. bassiana* (6.67%) and quinalphos (7.78%). All the biopesticide treatments, were at par and better than control.

When fruit infestation was recorded after second spray application, the maximum infestation was recorded in control (49.44%), whereas, in the test treatments, the fruit infestation remained below 17.00 per cent. Ryanaxypyr proved most efficacious recording only 9.44 per cent infestation. Spinosad (11.11% infestation), emamectin benzoate (11.67% infestation), cypermethrin (11.67% infestation), cyazypyr (12.75% infestation) and deltamethrin (12.78% infestation) were at par. *Bt* among biopesticides performed better (16.67% infestation) and was at par with the recommended insecticide, quinalphos (15.00% infestation).

Similar results were obtained when the data were recorded after the third spray application, where the maximum fruit infestation was recorded in control (76.11%). Among all the test treatments tested, rynaxypyr (16.11% infestation), spinosad (16.67%), emamectin benzoate (17.78%), cyazypyr (17.78%) and deltamethrin (18.33%) were at par and found effective in managing fruit infestation. The other treatments namely flubendiamide (25.00%), cartap hydrochloride (21.11%), thiodiacarb (22.78%) and quinalphos (20.56%) proved moderately efficacious. Among the biopesticides, azadirachtin (27.78%) proved better over the other two biopesticides, namely *Bt* (29.44%) and *B. bassiana* (30.56%). All the test treatments were found superior to control.

In the present study rynaxapyr, spinosad, cyazypyr and emamectin benzoate proved efficacious in management of *D. epijarbas.* Similar to the present study, among the various new group of insecticides used for the management of *D. isocrates*, emamectin benzoate and spinosad with the minimum fruit infestation and maximum yield were the most effective treatments [9, 8].

Cypermethrin, deltamethrin and quinalphos were found effective in managing pomegranate fruit borer infestation. Corroborating the present findings, in work carried out on the management of *D. epijarbas*, cypermethrin was reported to be effective in suppressing the pomegranate fruit borer infestation [7-6]. Kumar (2010) reported cypermethrin (0.01%), deltamethrin (0.0028%) and quinalphos (0.05%) to be effective in managing pomegranate fruit borer, which is in accordance with the results obtained in the present study [11].

Table 1: Bioefficacy of insecticides and biopesticides against pomegranate fruit borer, *Deudorix epijarbas*

Treatment	Conc. (%) /quantity	Average fruit infestation (%) before spray	Mean fruit infestation (%) after		
			First spray	Second spray	Third spray
FlubendiamideT_1	0.01	1.67 (1.48)	5.56 (2.51)	14.44 (22.30)	25.00 (29.95)
Emamectin benzoateT_2	0.002	3.33 (1.97)	5.56 (2.51)	11.67 (19.74)	17.78 (24.88)
SpinosadT_3	0.002	0.00 (1.00)	5.56 (2.51)	11.11 (19.37)	16.67 (24.05)
RynaxypyrT_4	0.006	1.67 (1.48)	4.44 (2.29)	9.44 (17.70)	16.11 (23.61)
Cartap HydrochlorideT_5	0.10	3.33 (1.97)	7.22 (2.83)	14.44 (22.26)	21.11 (27.32)
ThiodicarbT_6	0.15	3.33 (1.97)	6.67 (2.74)	15.56 (23.18)	22.78 (28.45)
CyazypyrT_7	0.0075	0.00 (1.00)	5.56 (2.51)	12.78 (20.86)	17.78 (24.88)
Halt (*Bt* based)T_8	2g/L	0.00 (1.00)	6.11 (2.64)	14.44 (22.22)	29.44 (32.66)
AzadirachtinT_9	0.02	1.67 (1.48)	7.22 (2.82)	16.67 (24.05)	27.78 (31.70)
Daman (*B. bassiana*)T_{10}	10g/L	0.00 (1.00)	6.67 (2.73)	15.56 (23.12)	30.56 (33.40)
CypermethrinT_{11}	0.01	1.67 (1.48)	5.56 (2.51)	11.67 (19.90)	18.89 (25.70)
QuinalphosT_{12}	0.05	3.33 (1.77)	7.78 (2.91)	15.00 (22.74)	20.56 (26.91)
DeltamethrinT_{13}	0.0028	1.67 (1.48)	5.56 (2.52)	12.78 (20.80)	18.33 (25.28)
Control T_{14}	Water	0.00 (1.00)	16.67 (4.05)	49.44 (44.66)	76.11 (60.94)

Figures in parentheses are square root transformed values

Table 2: Avoidable loss in yield due to application of insecticides and biopesticides against pomegranate fruit borer, *Deudorix epijarbas*

Treatment	Mean Yield (kg/tree)	Increased in yield over control (kg)	Avoidable loss (%)
FlubendiamideT_1	9.75	5.75	58.97
Emamectin benzoateT_2	14.25	10.25	71.93
SpinosadT_3	15.50	11.50	74.19
RynaxypyrT_4	16.25	12.25	75.38
Cartap HydrochlorideT_5	12.00	8.00	66.67
ThiodicarbT_6	10.25	6.25	60.98
CyazypyrT_7	14.50	10.50	72.41
Halt (*Bt* based) T_8	7.50	3.50	46.67
AzadirachtinT_9	9.25	5.25	56.76
Daman(*B. bassiana*)T_{10}	8.00	4.00	50.00
CypermethrinT_{11}	13.00	9.00	69.23

QuinalphosT_{12}	12.50	8.50	68.00
DeltamethrinT_{13}	13.50	9.50	70.37
ControlT_{14}	4.00	-	-

Avoidable loss

Among the new group insecticide molecules evaluated in the present study (Table 2), the highest marketable yield and maximum losses were avoided with T4 (rynaxypyr) treatment, followed by T3 (spinosad), T7 (cyazypyr) and T2 (emamectin benzoate) treatments with avoidable loss values of 75.38, 74.19, 72.41 and 71.93 per cent, respectively. Similarly, Saha *et al.* (2014) reported that the maximum yield (347 q/ha) and net profit (1, 56, 707) was obtained with rynaxypyr (0.006%), when used against *L. orbonalis* [14].

In the present study a loss of 68.00 per cent can be avoided by using the recommended insecticide, quinalphos. Pyretheroids namely deltamethrin and cypermethrin recorded higher yields which resulted into an avoidable loss values of 69.23 and 70.37 per cent, respectively, whereas, Kumar (2010), reported the avoidable loss values of (60-65%) in cypermethrin, deltamethrin and quinalphos treatments used against *D. epijarbas.* In general, lowest values of avoidable loss ranging between 46.67 to 56.76 per cent were recorded in the biopesticide treatments (T8-T10) [11].

Table 3: Benefit cost ratio of insecticides and biopesticides application against pomegranate fruit borer, *Deudorix epijarbas*

Treatment	Mean yield (kg/tree)	Increased in yield over control (kg)	Cost of increased yield @ Rs 100/kg	Cost of the test treatment (Rs)	Net monetary return (Rs)	Benefit Cost Ratio (BCR)
T_1	9.75	5.75	575	145.35	429.65	2.96:1
T_2	14.25	10.25	1025	120.00	905.00	7.54:1
T_3	15.50	11.50	1150	35.50	1114.50	31.39:1
T_4	16.25	12.25	1225	169.20	1055.80	6.24:1
T_5	12.00	8.00	800	73.20	726.80	9.93:1
T_6	10.25	6.25	625	187.20	437.80	2.34:1
T_7	14.50	10.50	1050	50.00	1000.00	20.00:1
T_8	7.50	3.50	350	69.12	280.88	4.06:1
T_9	9.25	5.25	525	750.00	-225.00	*
T_{10}	8.00	4.00	400	120.00	280.00	2.33:1
T_{11}	13.00	9.00	900	12.00	888.00	74.00:1
T_{12}	12.50	8.50	850	27.00	823.00	30.48:1
T_{13}	13.50	9.50	950	20.00	930.00	46.50:1
T_{14}	4.00	-	-	-	-	-

Benefit cost ratio

When cost of increased yield and cost of treatments were taken into consideration to calculate the BCR (Table 3), maximum value i.e. 74.00:1 was recorded in cypermethrin treatment followed by deltamethrin (46.50:1) due to their less cost in comparison to new group insecticide. Kakar *et al.* (1987) reported similar results where, cypermethrin (150 g a.i/ ha), fenvelarate (50 g a.i./ ha) and deltamethrin (7.5g a.i./ ha) were found effective in managing *D. epijarbas* population and the maximum BCR was obtained with cypermethrin [7]. In a similar study, Kumar and Gupta (2018) reported the maximum BCR of 29.60:1, when cypermethrin was used in a six spray schedule against pomegranate fruit borer [10]. Similar results were obtained when different insecticides were evaluated against *Leucinodes orbonalis* on brinjal, where the maximum BCR (32.62: 1) was obtained from cypermethrin (0.01%) treatment [13].

Spinosad (31.39:1) and quinalphos (30.48:1) were found equally viable from economic angle. Among the new group of insecticides, spinosad (31.39:1) was the best followed by cyazypyr (20:1). Similar results were reported by Kambrekar *et al.* (2015) where, emamectin benzoate 5SG @ 0.25g/l and spinosad 45 SC 0.2 ml/l were the most economical treatment, among the new insecticides molecules evaluated [8].

The most effective rynaxypyr treatment resulted in BC ratio of 6.24:1 which was very low in comparison to number of other treatments. Due to the high cost, these treatments resulted in low BCR. Among the biopesticides, *Azadirachtin* treatment resulted in negative value i.e. (<1) whereas in *Bt* and *B. bassiana* the corresponding values were 4.06:1 and 2.33:1 were obtained. Kumar (2010) reported similar results where, the BCR computed for the biopesticides was negative and the BCR for *Bt* was (3.87: 1) [11], whereas, Singh and Singh (2000) reported both neem and *Bt* to be economically non-viable as the BCR computed for both the treatments was negative [17].

Conclusions

Among the new group of insecticides, rynaxypyr, spinosad, emamectin benzoate and cyazypyr were found effective in checking the pomegranate borer, *D.epijarbas* infestation. The pyrethroids namely cypermethrin and deltamethrin were equally efficacious. Biopesticides, in the earlier stage were found effective, as the infestation even in control was less. Overall the biopesticides did not prove much effective. From economic point of view, rynaxypyr, the most effective insecticide in managing the pest, was not much remunerative, due to its high cost. Spinosad was better on the economic front also. Cypermethrin was the best option as for as economics of the treatments is concerned followed by deltamethrin due to high benefit cost ratio mainly due to less cost of these pesticides but are not under CIB Pesticide Usage list. The recommended insecticide quinalphos was more or less equal to spinosad as far as BC ratio is concerned.

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