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EVALUATION OF IPM MODULES AGAINST POMEGRANATE FRUIT BORER *DEUDORIX EPIJARBAS* (MOORE)

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ABSTRACT

Pomegranate fruit borer *Deudorix epijarbas* (Moore) is one of the serious pests of pomegranate. In Himachal Pradesh, the extent of loss varies between 50-90%. Various modules including insecticides and biopesticides were evaluated using 3 sprays at 21 days interval, initiating the first spray when 1-2 fruits in orchard showed signs of infestation. Among 19 modules, module M_{18} (cyantraniliprole-cyantraniliprole-cyantraniliprole (0.0075%)) resulted in maximum fruit yield (7.37kg/ ha) but its incremental benefit cost ratio (IBCR) value was low (3.42:1). To reduce problems due to repeated use of same insecticide, insecticides and biopesticides need to be used in rotation. Modules including first and second spray of biopesticides, were economically non-viable due to IBCR <1. Among biopesticides, only M_{14} (3 consecutive sprays of spinosad) showed encouraging results with infestation of 16.85% and IBCR of 5.75:1.

Key words: Pomegranate, *Deudorix epijarbas*, insecticides, cyantraniliprole, chlorantraniliprole, spinosad, emamectin benzoate, biopesticides, benefit cost ratio, spray, infestation, biopesrticides, rotation

Pomegranate is an important tree of the tropical and subtropical regions (Kulkarni and Aradhya, 2005) and is now cultivated in many countries (Holland et al., 2009). In Himachal Pradesh, the area under pomegranate cultivation is under area of 261 thousand ha with a production of 2315 thousand mt and productivity of 1.14 mt/ ha (NHB, 2020). Pomegranate fruit borer (*Deudorix epijarbas)* is one of the most serious pests (Butani, 1976; Prasad et al., 1987; Gupta and Dubey, 2005; Balikai et al., 2011, 2022). The extent of loss varies between 50-90% (Zaka-ur-Rab, 1980; Gupta and Dubey, 2005; Kumar and Gupta, 2018). Earlier the management measures for this pest included use of broad-spectrum pesticides. Concerns for health hazards, disruption of the natural ecosystem, increasing chances of pest resurgence and development of resistance in pests due to indiscriminate use of pesticides, stimulated the need of using eco-friendly pesticides. Further, the 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 fruit borer. Cyantraniliprole (10.26%) with OD @ 0.7- 0.9 ml/ l is included in the spray schedule of NRC on pomegranate fruit borer (Anonymous, 2017). Further, due to repeated use of same insecticide, the problem of pest resistance increases. In the present study various modules consisting of biopesticides and insecticides were evaluated for their efficacy against pomegranate fruit borer *D. epijarbas.*

MATERIALS AND METHODS

The efficacy studies were carried out in a 10 year old orchard (var. Kandhari) during 2019 (77.16^{0}N 30.85^{0}E 1241 masl). All the recommended "package of practices" were followed except the routine insecticides application. Insecticides namely, emamectin benzoate (0.002%), chlorantraniliprole (0.006%), cyantraniliprole (0.0075), flubendiamide (0.01%) and biopesticides viz., spinosad (0.002%), azadirachtin (0.02%) and *Bacillus thuringiensis* (0.1%) based formulations were evaluated in different modules comparing with the recommended quinalphos (0.05%). However, in control, only foliar application of water was given. The first spray was applied in mid- June at the initiation of borer infestation and second and third sprays were given after 21 days interval. The experiment was laid out in a randomized block design (RBD) where each treatment was replicated thrice and a tree represented a replicate (M_1: spinosad-emamectin benzoate-chlorantraniliprole; M_2: spinosad-emamectin benzoate- flubendamide; M_3: spinosad-emamectin benzoate- cyantraniliporole; M_4: azadiractin-spinosad-emamectin benzoate; M_5: azadiractin-spinosad-chlorantraniliprole; M_6: azadiractin-spinosad-flubendamide; M_7: azadiractin-spinosad-cyantraniliprole; M_8: Bt-azadiractin-spinosad;

M_9: Bt-azadiractin- emamectin benzoate; M_{10}: Bt-azadiractin-cyantraniliprole; M_{11}; Bt-azadiractin-flubendiamide: M_{12}: Bt-azadiractin- chlorantraniliprole; M_{13}: azadiractin-spinosad-quinalphos; M_{14}: spinosad-spinosad- spinosad; M_{15}: emamectin benzoate- emamectin benzoate- emamectin benzoate; M_{16}: flubendiamide-flubendiamide-flubendiamide; M_{17}: chlorantraniliprole-chlorantraniliprole- chlorantraniliprole; M_{18}: cyantraniliprole- cyantraniliprole- cyantraniliprole; M_{19}: quinalphos- quinalphos- quinalphos; M_{20}: control-control-control). Before the commencement of first foliar spray, observations on infestation in different trees marked for various modules was recorded and thereafter, the data were recorded 7, 14 and 21 days after each spray on randomly selected 20 fruits/ tree. The data were converted to % fruit infestation. The yield was recorded at the time of harvest and the avoidable loss was worked out as per Pradhan (1964). To know the effectiveness of modules in monetary terms, the incremental benefit cost ratio was worked out taking into account the cost of products (insecticides and biopesticides) keeping rest of the factors constant. The data were subjected to ANOVA using online software OPSTAT (Sheoran et al. 1998) and significantly different means were separated by least significant difference (LSD) at p= 0.05.

RESULTS AND DISCUSSION

Pretreatment infestation recorded in the present study before the commencement of first spray and it ranged from 0.00 to 3.11% and the differences were non- significant (Table 1). The means compared after first foliar spray, taking readings after 7, 14 and 21 days, M_1 (spinosad), M_{18} (cyantraniliprole) and M_3 (spinosad) proved effective being at par with infestation levels of 2.25, 2.38 and 2.71%, respectively. However, in the modules initiating with microbial pesticide namely *Bt* (5.40% (M_{11}) and 5.69% (M_{10})) and botanical (azadirachtin (5.41% (M_5) and 5.78% (M_7)) the, infestation levels were higher. In control, the infestation recorded was 20.24%, and all the modules were found superior over control. Similar results were observed by Dubey et al. (1993) who reported that the infestation of *D. epijarbas* initiated in the first fortnight of June on wild pomegranate but the economic damage started from first week of August onwards in the mid-hills of Himachal Pradesh. They also reported 60% damage by this pest. The data recorded after second spray (applied after 21 days of first spray) reveal that infestation ranged between 5.79 and 12.83% in different modules. When means of 7, 14 and 21 days were compared, M_{18} (cyantraniliprole-cyantraniliprole) was the most effective module with only 5.79% infestation followed by M_{17} (chlorantraniliprole-chlorantraniliprole) and M_1 (spinosad-emamectin benzoate) with infestation levels of 6.55 and 6.94%, respectively. However, maximum infestation was recorded in control (30.65%).

Similar results were reported by Kadam (2006) for pomegranate fruit borer control where three sprays of emamectin benzoate (0.0022%) 21 days interval proved most effective and superior with minimum damage, followed by emamectin benzoate (0.0016%) and deltamethrin (0.002%). In Karnataka, Vanitha (2017) carried out a study on the management of pomegranate fruit borer, *D. isocrates* and reported, rynaxypyr 18.5% SC as the most effective insecticide with minimum fruit damage of 2.07%, followed by cyazypyr 10.26% OD with 2.51% fruit damage. Here, rynaxypyr (chlorantraniliprole) and cyazypyr (cyantraniliprole) performed better with less infestation of 12.90 and 7.40%, respectively. After application of third spray maximum infestation (48.34%) was recorded in control after 21 days of spray. M_{18} (cyantraniliprole-cyantraniliprole-cyantraniliprole) and M_{16} (flubendiamide-flubendiamide-flubendiamide) proved equally effective with infestation of 7.40 to 9.12%, respectively. Cyantraniliprole (0.0075%) was found to be the most effective (7.40%) after three sprays at an interval of 21 days, which is in line with the recommendation of National Research Centre (ICAR) on pomegranate where cyantraniliprole (0.007%) has been included in the spray schedule (Anonymous, 2017). M_1 (spinosad-emamectin benzoate-chlorantraniiprole) and M_{17} (chlorantraniliprole-chlorantraniliprole-chlorantraniliprole) with infestation of 9.87 and 12.90%, respectively were also effective.

Bhut et al. (2013) reported that two sprays of chlorantraniliprole proved most effective followed by flubendiamide, novaluron, thiodicarb, endosulfan and malathion. Kambrekar et al. (2015) observed that emamectin benzoate 5 SG @ 0.25 g/ l ha gave highest reduction in the fruit damage followed by spinosad 45 SC 0.20 ml/l. Kumar and Gupta (2018) found rynaxypyr, spinosad, emamectin benzoate and cyazypyr effective; and quinalphos (infestation) and flubendiamide were moderately effective. In Karnataka, Vanitha (2017) reported the release of *Trichogramma chilonis* @ 2.5 lakh/ ha, spray of cyazypyr 10.26% OD (1.50ml/ l) and spinosad 45 SC (0.25ml/ l) in rotation. Khandare et al. (2021) during Ambe bahar in 2016 and 2017 studied the efficacy of insecticides against *Deudorix isocrates* (E)

Table 1. Infestation of *D. epijarbas* in modules and benefit cost analysis

Modules	Pre-count (%)	Av* mean fruit infestation (%) (after 1st spray)	Av* mean fruit infestation (%) (after 2nd spray)	Av* mean fruit infestation (%) (after 3rd spray)	Mean yield (kg/ tree)	Increase in yield over control (kg)	Avoid-able loss (%)	Cost of increased yield @ Rs 100/ kg	Cost of the test treatment (Rs)	Net monetary return (Rs)	Incremental Benefit Cost Ratio (IBCR)
M_1	0.00 (1.00)	2.25 (1.79)	6.94 (2.79)	9.87 (3.29)	4.28	2.72	63.55	272	44.84	227.16	5.07
M_2	1.67 (1.62)	3.29 (2.06)	7.80 (2.95)	14.76 (3.94)	3.53	1.97	55.81	197	57.72	139.28	2.41
M_3	0.00 (1.00)	2.71 (1.89)	8.21 (3.02)	15.29 (4.02)	3.74	2.18	58.29	218	76.68	141.32	1.84
M_4	1.85 (1.65)	4.63 (2.32)	8.98 (3.14)	18.40 (4.38)	2.76	1.20	43.48	120	532.91	-412.91	*
M_5	1.38 (1.49)	5.41 (2.48)	9.59 (3.24)	16.32 (4.13)	3.37	1.81	53.71	181	520.63	-339.63	*
M_6	2.64 (1.82)	5.07 (2.43)	9.32 (3.20)	18.62 (4.40)	3.15	1.59	50.48	159	533.51	-374.51	*
M_7	3.11 (1.92)	5.78 (2.57)	10.48 (3.37)	17.74 (4.31)	2.98	1.42	47.65	142	552.47	-410.47	*
M_8	1.67 (1.59)	4.32 (2.27)	11.19 (3.45)	20.60 (4.62)	2.53	0.97	38.34	97	516.77	-419.77	*
M_9	3.11 (1.98)	5.28 (2.48)	12.83 (3.69)	22.48 (4.83)	2.26	0.70	30.97	70	532.37	-462.37	*
M_{10}	3.11 (1.94)	5.69 (2.56)	11.59 (3.53)	19.55 (4.52)	2.12	0.56	26.42	56	551.93	-495.93	*
M_{11}	0.00 (1.00)	5.40 (2.51)	10.83 (3.41)	19.23 (4.49)	3.06	1.50	49.02	150	532.97	-382.97	*
M_{12}	0.00 (1.00)	4.74 (2.37)	11.08 (3.45)	19.38 (4.49)	2.88	1.32	45.83	132	520.09	-388.09	*
M_{13}	1.85 (1.64)	4.81 (2.38)	8.57 (3.08)	19.45 (4.49)	2.34	0.78	33.33	78	514.07	-436.07	*
M_{14}	1.38 (1.53)	3.01 (1.98)	7.80 (2.95)	16.85 (4.19)	3.31	1.75	52.87	175	25.92	149.08	5.75
M_{15}	1.85 (1.66)	3.48 (2.11)	8.78 (3.10)	19.27 (4.48)	3.12	1.56	50.00	156	72.72	83.28	1.15
M_{16}	1.67 (1.60)	3.31 (2.07)	8.34 (3.01)	9.12 (3.17)	4.07	2.51	61.67	251	74.52	176.48	2.37
M_{17}	1.85 (1.61)	3.33 (2.06)	6.55 (2.73)	12.90 (3.72)	5.16	3.60	69.77	360	35.88	324.12	9.03
M_{18}	1.38 (1.50)	2.38 (1.83)	5.79 (2.58)	7.40 (2.88)	7.37	5.81	78.83	581	131.4	449.6	3.42
M_{19}	2.64 (1.86)	4.54 (2.33)	9.78 (3.25)	18.41 (4.38)	3.58	2.02	56.42	202	16.20	185.8	11.47
M_{20}	1.67 (1.57)	20.24 (4.58)	30.65 (5.61)	48.34 (6.99)	1.56	-	-	-	-	-	-

*Mean 20 fruits; Figures in parentheses square root transformed values

C.D. p=0.05	C.D. p=0.05	C.D. p=0.05
Treatment (T): (0.10)	Treatment (T): (0.08)	Treatment (T): (0.09)
Days: -0.04	Days: -0.03	Days: -0.04
T×D: -0.17	T×D: -0.15	T×D: -0.16

and revealed that all the treatments were superior, with the least infestation being on spinosad 45SC @73 g a.i./ ha and chlorantraniliprole 18.5SC @30 g a.i./ ha. The treatments with flubendiamide 39.35SC @ 48 g a.i./ ha were also effective and at par with each other. Bharti et al. (2021) against *Deudorix isocrates* (F.) observed that after fourth spray, infestation of 8.19% with spinosad and 9.17% with flubendiamide were observed.

Average yield ranged between 2.12 and 7.37 kg/ tree in different modules (Table 1). However, in control, the yield recorded was only 1.56 kg/ tree. Maximum yield (7.37 kg/ tree) was recorded in module 18 (cyantraniliprole-cyantraniliprole-cyantraniliprole) which was 4.72 times higher than in control and 2.06 times higher than the yield recorded in the recommended insecticide i.e. 3 sprays of quinalphos. Vanitha (2017) recorded highest yield of 12.16 t/ ha with cyazypyr 10.26% OD @ 1.50 ml/ l followed by rynaxypyr 18.5% SC @ 0.30 ml. These findings are in line with present studies where, maximum yield (7.37 kg/ tree) was recorded in three exclusive sprays of cyantraniliprole, followed by that of chlorantraniliprole (5.16 kg/ tree). Avoidable loss values were recorded best in module M_{18} (cyantraniliprole-cyantraniliprole-cyantraniliprole) i.e. 78.83%. It was followed by M_{17} (chlorantraniliprole-chlorantranilprole-chlorantraniliprole) and M_1 (spinosad-emamectin benzoate-chlorantraniliprole) where avoidable loss values were 69.77 and 63.55%, respectively. In other modules negative values were obtained (Table 1). Kumar and Gupta (2010) reported maximum avoidable loss in quinalphos while biopesticides (Bt and azadirachtin) gave a loss of 54.54-58.33%. Avoidable loss of 56.42% was obtained in module based on three foliar application of quinalphos. The avoidable loss in treatments ranged between 70.55 to 73.03% in studies conducted by Bharti et al. (2021).

The increase in yield over control was maximum (5.81 kg/ tree) in M_{18} (cyantraniliprole-cyantraniliprole-cyantraniliprole), followed by M_{17} (chlorantraniliprole-chlorantraniliprole-chlorantraniliprole), M_1 (spinosad-emamectin benzoate-chlorantraniliprole), M_{16} (flubendiamide-flubendiamide-flubendiamide) and M_3 (spinosad-emamectin benzoate-cyantraniliprole) with values of 3.60, 2.72, 2.51 and 2.18 kg/ tree, respectively. The recommended insecticide quinalphos (M_{19}), registered 2.02 kg/ tree increase over control. The increase in yield over control ranged from 0.56 to 1.81 kg/tree in modules M_4- M_{13} consisting of biopesticides and insecticides in rotation. When cost of yield and treatments were taken into consideration to calculate the IBCR, maximum value i.e. 11.47:1 was recorded in the recommended insecticide quinalphos (M_{19}) although, its monetary return was low (Rs. 185.8/ tree). IBCR of M_{17} (chlorantraniliprole-chlorantraniliprole-chlorantraniliprole) was 9.03:1, followed by M_{14} (spinosad-spinosad-spinosad) and M_1 (spinosad-emamectin benzoate-chlorantraniliprole) with BC ratio of 5.75:1 and 5.07:1, respectively. The most effective module i.e. M_{18} (cyantraniliprole-cyantraniliprole-cyantraniliprole), which showed highest net monetary return of Rs. 449.6/ tree, resulted in BC ratio of 3.42:1 (Table 1). Modules including biopesticides and insecticides used in rotation did not give encouraging results as in all the modules (M_4-M_{13}), the net monetary return was negative, hence these modules were non-viable.

Kambrekar et al. (2015) observed highest reduction in fruit damage in Karnataka with emamectin benzoate 5 SG @0.25g/ l and spinosad 45 SC. Net returns of Rs 8,35,650/ ha and Rs 8,11,240/ha were obtained in emamectin benzoate and spinosad treatments, respectively, with the maximum IBCR value of 10.65:1 and 10.61:1. In the present study emamectin benzoate and spinosad spray were found not effective as their net returns and IBCR values were very less i.e. Rs. 83.28/ tree; 1.15:1 and Rs. 149.08/ tree and 5.75:1, respectively, which is contrasting to the above findings. Vanitha (2017) while working on seasonal incidence and management of *D. isocrates,* reported highest net returns of Rs. 7,41,100/ ha with cyazypyr followed by rynaxypyr (Rs. 6,38,865/ha) and emamectin benzoate (Rs. 5,62,563/ ha). In terms of incremental benefit cost ratio, again, cyazypyr proved best followed by rynaxypyr. In the present study cyantraniliprole resulted in net monetary returns of Rs. 449.6/ tree, followed by chlorantraniliprole (Rs. 324.12/ tree returns). The IBCR values obtained in cyantraniliprole spray treatment was only 3.42:1 due to its high input cost, with chlorantraniliprole (9.03:1), it was appreciable. Kumar and Gupta (2018) concluded that spinosad, quinalphos and cyazypyr proved effective with IBCR values of 31.91:1, 30.48:1 and 20.00:1, respectively.

Thus, spray of cyantraniliprole (3 consecutive sprays at 21 days interval) proved effective but if we compare its incremental benefit cost ratio, it is quite less (3.42:1), which is due to high input cost of insecticide. On the other hand, chlorantraniliprole spray gave better incremental benefit cost ratio (9.03:1) and effective control of infestation. Recommended insecticide, quinalphos (0.05%) also performed well due to its low cost and high efficiency. To avoid repetitive use of same insecticides, it is revealed from the present study that, the module 1 (spinosad-emamectin benzoate-chlorantraniliprole) thus was better.

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AUTHOR CONTRIBUTION STATEMENT

NC and DG conceived and designed research. NC conducted experimental field trials. DG provided with necessary facility to conduct trial. NC and DG analysed data. NC wrote the manuscript. DG read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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