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Bio-efficacy of newer insecticides and biopesticides against fruit fly, *Bactrocera cucurbitae* (Coquillett) on round gourd

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Abstract
The investigations on the "Bio-efficacy of newer insecticides and biopesticides against fruit fly, *Bactrocera cucurbitae* (Coquillett) on round gourd" were carried out at Horticultural farm of SKN college of agriculture, Jobner, Jaipur during Summer, 2016. Among the insecticides evaluated against fruit fly on round gourd, spinosad was found most effective. The next effective treatments were acephate + molasses followed by acephate and fipronil. The treatments of Neem Gold and NSE were found least effective. The maximum marketable yield of round gourd fruits was obtained in spinosad (105.14 q ha^{-1}) followed by acephate + molasses (102.57 q ha^{-1}) whereas; minimum (50.12 q ha^{-1}) was in NSE. The maximum net profit of Rs. 90956 ha^{-1} was obtained in treatment of acephate + molasses, whereas, minimum net profit of Rs. 13176 ha^{-1} was in NSE. The highest benefit cost ratio was computed in acephate (59.41), while the minimum was in Neem gold (5.54).

Keywords: Bio-efficacy, biopesticides, *Bactrocera cucurbitae*, round gourd etc.

1. Introduction

Round gourd or squash melon, *Citrullus vulgaris var. fistulosus* (Watt) commonly known as Tinda. Which is one of the most popular summer and rainy season vegetable crop, commercially cultivated in the Indo- Gangatic plains of North India, especially in Rajasthan, Punjab and Western Uttar Pradesh. In the warm and rainy months, the flies were more active as compared to that of dry and winter months (Laskar and Chatterjee, 2010) [9]. In Rajasthan cucurbits are extensively cultivated because of greater suitability of climate and soil. India is the second largest producer of vegetable in the world after china, accounting for about 10% of the world`s production. In India the area under the cultivation of vegetables during 2015-16 was 9775.38 thousand hectares, with an annual production of 166608.16 thousand ton and productivity of 17.04 ton per hectare (Anonymous, 2015-16) [2]. In Rajasthan the area under the cultivation of round gourd during 2015-16 was 6645 hectares, with an annual production of 14650 metric ton and productivity of 2.20 metric ton per hectare (Anonymous, 2016) [3].

There is a challenge to achieve the target of 182 million ton of vegetables production to fulfill the recommended requirement by 2020 and also their recommended requirement of 300 g per capita per day of vegetables for a balanced diet (ICMR) whereas, the present per capita intake of vegetables at 135 g / day is very low in comparison to recommended balanced diet. However, in past three decades, India has made a quantum jump in vegetable production in the world. Cucurbits are important crops grown throughout the country. Round gourd crop is also gaining importance in terms of foreign exchange earner on depicted from policies of central government promoting its export.

The continuous growing of round gourd crop in the region has made it susceptible to the attack of several insect pests like fruit fly, *Bactrocera cucurbitae* (Coquillett); red pumpkin beetle, *Aulacophora foveicollis* (Lues); hadda beetle, *Epilachna dodecastigma* (Wiebemal); Jassid, *Amrasca biguttula biguttula (*Ishid) and mites, *Tetraynchus cinnabarinus* (Boisduvol). Among these pests, the fruit fly, *Bactrocera cucuribitae* (Coquillett) (Diptera: Tephritidae), is the most serious constraints in round gourd cultivation in all the parts of the country. The pest is active throughout the year except in severe cold. The fruit fly species is considered a serious insect pest and is classified as an organism subject to quarantine restrictions (Bateman, 1972[5]; Shukla and Prasad, 1985) [14]. The fruit fly females puncture soft and tender fruits and lay eggs on the fruit in the cavity, 2-4 mm deep (Muthukrishnan *et al*. 2005) [11].

After hatching the maggots, bore into the ripening fruits, begin to rot and drop, thereby, reducing the yield and quality.

Presently, the management strategy of round gourd pests including fruit fly in semi-arid conditions of Rajasthan is entirely dependent on application of pesticides based. The role dependency on pesticides does control the pest, but causes ill effect to the environment, create problem of pest resistance, resurgences adversely affecting natural enemies and non target species. The use of persistent chemicals are hazardous to human and wild life, Therefore, the need is keenly felt for intensive investigation on possibilities of utilizing some safe insecticides and biopesticides and to find out resistant varieties against the major insect pests of round gourd. Therefore, the present investigation was proposed to overcome problems due to indiscriminate use of insecticides and to achieve economic and eco-friendly management of fruit fly on round gourd in semi-arid region of Rajasthan.

2. Materials and Methods

The details of the materials used and methodology adopted during the course of investigation are given as below. The experiment was laid out in a randomized block design in the plot size of 3 x 1.5 m^2 each plot was separated by irrigation channel. Seeds of Ujjawal variety of round gourd were sown by dibbling method in the field on 15th February during summer, 2016 with three replications of each treatment. All the recommended agronomical practices were followed from time to time to raise a healthy crop.

2.1 Preparation of Neem Seed Extract

Neem Seed Extract (NSE) was prepared by grinding known weight of neem seeds into fine powder. The resulting powder was soaked overnight in sufficient quantity of water. The described concentration of NSE (seed weight to volume of water mixture basis) was obtained by filtering the extract through fine muslin cloth with repeated washing in the next morning. The volume was made up by adding the required quantity of water to get 5% solution.

2.2 Treatments and their application

During the present studies, to evaluate the efficacy of different insecticides and biopesticides, nine treatments (NSE=Neem seed extract Freshly prepared, Neem Gold 0.15 EC, Flubendiamide 480 SC, Thiodicarb 75 WP, Spinosad 480 SC, Fipronil 5 SC, Acephate 75 SP, Malathion + Molasses 50 EC and Acephate + Molasses 75 SP) were used. All the treatments were applied as foliar spray. Foot sprayer was used for spraying the insecticides/biopesticides on the standing crops. The quantity of water used in each spray was at 500 litres per hectare. Two spray applications were made at an interval of 15 days starting from the initiation of fruit fly infestation in the experimental area at fruit set stage. Though, the observations of fruit fly infestation in the experimental area were started from flower bud initiation stage yet spraying was resorted when initial infestation of fruit fly was noticed after fruit set.

2.3 Method of observations

The observations on fruit fly infestation were recorded from the initiation of fruit set stage and subsequent three days interval after the spray. The infested (ovipositor punctures and feeding holes) and non infested fruits were taken at three days interval and per cent infestation of fruits was calculated both on number and weight basis.

3. Results and Discussion

Results presented in table 1 & 2 revealed that all treatments were found statistically superior over untreated control. The treatment spinosad 480 SC recorded the minimum infestation of 5.60 per cent mean fruit damage on number and 5.61 per cent on weight basis which was significantly superior over the rest treatments. The treatment acephate 75 SP + molasses recorded the mean fruit damage of 8.85 per cent on number and 9.33 per cent on weight basis were found next best treatment followed by treatment acephate 75 SP with the mean fruit damage of 9.53 per cent on number and 9.93 per cent on weight basis and fipronil 5 SC recorded the mean fruit damage of 10.47 per cent on number and 10.83 per cent on weight basis and found at par with each other. The treatments of flubendiamide 480 SC recorded the mean fruit damage of 12.42 per cent on number and 11.95 per cent on weight basis, thiodicarb 75 WP recorded the mean fruit damage of 14.82 per cent on number and 14.40 per cent on weight basis and malathion 50 EC + molasses recorded the mean fruit damage of 17.10 per cent on number and 17.21 per cent on weight basis and found moderatively effective treatments, however, the significant difference was observed between flubendiamide 480 SC and malathion 50 EC + molasses, whereas, these three treatments were significantly inferior to spinosad 480 SC, acephate 75 SP + molasses and acephate 75 SP. The Neem gold was found least effective with mean fruit damage of 19.72 per cent on number and 21.14 per cent on weight basis, followed by NSE (Neem Seed Extract) with mean fruit damage of 22.09 per cent on number and 21.71 per cent on weight basis and both were at par. However, Neem gold was also found at par with malathion + molasses. The maximum damage of fruit fly was found with the untreated check on round gourd with 26.09 per cent mean fruit damage on number and 25.55 per cent mean fruit damage on weight basis which was significantly inferior to all other treatments.

The overall effectiveness of eco-friendly insecticides and biopesticides against fruit fly for mean data the descending order was : spinosad 480 SC > acephate 75 SP + molasses > acephate 75 SP > fipronil 5 SC > flubendiamide 480 SC > thiodicarb 75 WP > malathion 50 EC + molasses > Neem gold > NSE. The findings revealed that spinosad with mean fruit damage of 5.60 per cent on number and 5.61 per cent on weight basis was found most effective treatment against fruit fly on round gourd; it was significantly superior over all the treatments. The present investigation is in agreement with the findings of Bhowmik *et al*. (2014) who reported that most effective treatment was spinosad on bitter gourd in reducing the fruit infestation by melon fruit fly [6]. Similarly, Ho-Kun (2005) studied spinosad bait spray effectively controlled oriental fruit fly, *B. dorsalis* [7]. Similar finding was also made by Stark *et al*. (2004) who evaluated that toxicity of the spinosad and proved that spinosad was extremely toxic to fruit fly species [12]. The treatment of acephate 75 SP + molasses and acephate 75 SP alone were found next best treatment against fruit fly on round gourd. The present results are in agreement with finding of Bhowmik *et al*. (2014) [6] who reported that the acephate was the most effective insecticide in reducing the melon fruit fly infestation in bitter gourd. Similarly, Mehta *et al*. (2000) reported that the acephate was most effective against fruit fly in cucumber and got highest fruit yield [10]. The fipronil 5 SC was also found fourth effective treatment against fruit fly on round gourd. The present finding corroborated with that of Stark *et al*. (2009) who revealed that fipronil was equally effective

against *B. dorsalis* and B. *cucurbitae* [13]. The treatments of flubendiamide 480 SC, thiodicarb 75 WP and malathion 50 EC + molasses were found moderately effective against fruit fly on round gourd. The present findings are in conformity with Bhowmik *et al*. (2014) who reported that the chlorfenapyr and flubendiamide were found moderately effective insecticides against fruit fly [6]. The treatment of thiodicarb 75 WP was also found moderately effective against fruit fly on round gourd. Similar results were exhibited by Akhtaruzzaman *et al*. (2000) who reported that the application of molasses + malathion and water in the ratio of 1: 0. 1: 100 provided good control of melon fruit fly [1]. The treatments neem gold and NSE (Neem Seed Extract) were found least effective against fruit fly. The present investigation are in conformity with Kumar and Babu (1998) who found neemazal T/S (1 % azadirachtin) and neemazal F (5 % azadirachtin) less effective in controlling *B. cucurbitae* [4]. Similarly, Babu *et al*. (2002) reported that neem was found less effective in reducing the fruit fly infestation, *B. cucurbitae* population in the field condition [8].

Table 1: Bio-efficacy of newer insecticides and biopesticides against fruit fly based on number of fruits in Summer, 2016

Treatments	Conc. (%)/Dosage	Percent infestation of fruits at different picking (Three days interval)									
		Date of Observation									
		20.03.2016	23.03.2016	26.03.2016	29.03.2016	01.04.2016	04.04.2016	07.04.2016	10.04.2016	13.04.2016	Mean
NSE (Neem seed extract)	5.0%	18.56	16.72	20.13	23.76	26.19	22.54	20.68	23.58	26.63	22.09
		(25.52)	(24.14)	(26.66)	(28.49)	(30.78)	(28.34)	(27.05)	(29.05)	(31.07)	(28.09)
Neem gold 0.15 EC	0.2 ml/l	15.38	13.68	18.46	21.52	23.48	18.05	20.70	22.19	24.00	19.72
		(23.09)	(21.71)	(25.45)	(27.64)	(28.98)	(25.14)	(27.06)	(28.10)	(29.33)	(26.28)
Flubendiamide 480 SC	2 ml/l	12.14	10.38	13.23	12.43	14.24	11.74	8.96	13.37	15.26	12.42
		(20.39)	(18.79)	(21.33)	(20.64)	(22.17)	(20.04)	(17.42)	(21.45)	(22.99)	(20.58)
Thiodicarb 75 WP	2 ml/l	14.29	11.12	13.19	16.34	16.82	12.46	13.97	16.32	18.86	14.82
		(22.21)	(19.48)	(21.30)	(23.84)	(24.21)	(20.67)	(21.95)	(23.83)	(25.74)	(22.58)
Spinosad 480 SC	0.4 ml/l	5.18	3.69	5.20	6.24	7.05	6.73	4.20	5.51	6.56	5.60
		(13.16)	(11.07)	(13.18)	(14.47)	(15.40)	(15.04)	(11.83)	(13.58)	(14.84)	(13.62)
Fipronil 5 SC	2 ml/l	10.70	9.55	9.82	10.46	12.31	9.86	8.34	10.70	12.48	10.47
		(19.09)	(18.00)	(18.26)	(18.87)	(20.54)	(18.30)	(16.79)	(19.09)	(20.69)	(18.85)
Acephate 75 SP	0.05%	9.21	8.18	8.86	10.23	11.58	9.84	8.58	9.10	10.18	9.53
		(17.67)	(16.62)	(17.32)	(18.65)	(19.89)	(18.28)	(17.03)	(17.56)	(18.61)	(17.96)
Malathion 50 EC + Molasses	0.05%+2%	11.22	13.18	15.34	19.14	21.23	18.05	16.19	18.23	21.32	17.10
		(19.57)	(21.29)	(23.06)	(25.94)	(27.44)	(25.14)	(23.73)	(25.28)	(27.50)	(24.33)
Acephate 75 SP +Molasses	0.05%+2%	8.42	7.12	7.98	9.76	11.34	8.82	7.52	8.88	9.78	8.85
		(16.87)	(15.48)	(16.41)	(18.20)	(19.68)	(17.28)	(15.92)	(17.34)	(18.22)	(17.27)
Control (Untreated)	-	17.32	19.67	22.42	28.34	34.12	36.42	31.62	24.15	20.78	26.09
		(24.59)	(26.33)	(28.26)	(32.16)	(35.74)	(37.12)	(34.22)	(29.43)	(27.12)	(30.55)
SEm±		0.71	0.65	0.76	0.92	1.03	0.89	0.84	0.88	0.96	0.84
CD at 0.5%		2.06	1.87	2.21	2.65	2.99	2.58	2.44	2.54	2.79	2.44

Mean of three replications
Figures in parentheses are angular transformed values
Date of sowing = 15.02.2016, 1st spray = 17.03.2016, 2nd spray 01.04.2016

Table 2: Bio-efficacy of newer insecticides and biopesticides against fruit fly based on weight of fruits in Summer, 2016

Treatments	Conc. (%)/Dosage	Percent infestation of fruits at different picking (Three days interval)									
		Date of Observation									
		20.03.2016	23.03.2016	26.03.2016	29.03.2016	01.04.2016	04.04.2016	07.04.2016	10.04.2016	13.04.2016	Mean
NSE (Neem seed extract)	5.0%	18.56	16.72	20.13	23.76	26.19	19.63	21.19	23.58	26.63	21.71
		(25.52)	(24.14)	(26.66)	(28.49)	(30.78)	(26.30)	(27.41)	(29.05)	(31.07)	(27.71)
Neem gold 0.15 EC	0.2 ml/l	17.38	15.43	19.46	22.52	25.82	19.39	20.72	23.42	26.12	21.14
		(24.64)	(23.13)	(26.18)	(28.33)	(30.54)	(26.13)	(27.08)	(28.94)	(30.74)	(27.30)
Flubendiamide 480 SC	2 ml/l	11.69	9.79	12.54	11.67	13.82	11.36	9.52	12.46	14.67	11.95
		(19.99)	(18.23)	(20.74)	(19.98)	(21.82)	(19.70)	(17.97)	(20.67)	(22.52)	(20.18)
Thiodicarb 75 WP	2 ml/l	13.82	10.54	13.87	16.73	15.43	12.10	13.11	16.54	17.46	14.40
		(21.82)	(18.94)	(21.87)	(24.14)	(23.13)	(20.36)	(21.23)	(24.00)	(24.70)	(22.24)
Spinosad 480 SC	0.4 ml/l	5.22	5.28	6.37	5.24	7.12	5.12	4.18	5.82	6.10	5.61
		(13.21)	(13.28)	(14.62)	(13.23)	(15.48)	(13.08)	(11.80)	(13.96)	(14.30)	(13.66)
Fipronil 5 SC	2 ml/l	11.18	9.86	10.19	10.88	12.83	10.34	8.59	10.94	12.68	10.83
		(19.53)	(18.30)	(18.62)	(19.26)	(20.99)	(18.76)	(17.04)	(19.31)	(20.86)	(19.19)
Acephate 75 SP	0.05%	10.20	9.18	8.76	10.18	11.97	9.56	8.22	10.12	11.16	9.93
		(18.63)	(17.64)	(17.22)	(18.61)	(20.24)	(18.01)	(16.66)	(18.55)	(19.52)	(18.34)
Malathion 50 EC + Molasses	0.05%+2%	12.18	12.87	16.49	18.39	21.67	18.88	16.46	18.22	19.74	17.21
		(20.43)	(21.02)	(23.96)	(25.39)	(27.74)	(25.75)	(23.94)	(25.27)	(26.38)	(24.43)

Acephate 75 SP +Molasses	0.05%+2%	9.18	7.34	8.05	10.78	12.56	8.92	7.98	9.24	9.94	9.33
		(17.64)	(15.72)	(16.48)	(19.17)	(20.76)	(17.38)	(16.41)	(17.70)	(18.38)	(17.74)
Control (Untreated)	-	17.85	21.34	23.23	26.72	32.18	35.19	30.79	22.47	20.18	25.55
		(24.99)	(27.51)	(28.81)	(31.13)	(34.56)	(36.39)	(33.70)	(28.30)	(26.69)	(30.23)
SEm±		0.71	0.65	0.78	0.91	1.00	0.88	0.82	0.87	0.91	0.84
CD at 0.5%		2.05	1.87	2.26	2.64	2.88	2.56	2.37	2.51	2.62	2.42

Mean of three replications
Figures in parentheses are angular transformed values
Date of sowing = 15.02.2016, 1st spray = 17.03.2016, 2nd spray 01.04.2016

3.1 Impact of insecticides and biopesticides on the yield of round gourd

All the treatments significantly increased the marketable yield of round gourd fruits over untreated check (control) during Summer, 2016. The data presented in table 3 indicated that maximum yield was recorded in spinosad 480 SC with 105.14 q ha^{-1} followed by acephate 75 SP + molasses with 102.57 q ha^{-1} which were at par and significantly superior to other treatments. The fruit yield recorded in acephate 75 SP was 98.12 q ha^{-1} followed by fipronil 5 SC, where the fruit yield was 85.46 q ha^{-1} and found next best treatments. The minimum fruit yield of 50.12 q ha^{-1} was recorded in NSE followed by Neem gold with 68.95 q ha^{-1} and malathion 50 EC + molasses with 72.37 q ha^{-1}. The yield 40.58 q ha^{-1} was recorded in untreated check. During present study the highest round gourd yield was found in spinosad 480 SC with 105.14 q ha^{-1} followed by acephate 75 SP + molasses with 102.57 q ha^{-1} and acephate 75 SP with 98.12 q ha^{-1}. The present investigation is in agreement with the findings of Bhowmik *et al*. (2014) who recorded that the higher yield of bitter gourd was found in spinosad followed by acephate [6]. The minimum fruit yield was recorded in the treatment NSE with 50.12 q ha^{-1} followed by Neem gold with 68.95 q ha^{-1}.

Table 3: Impact of different insecticides and biopesticides on marketable yield of round gourd in Summer, 2016

S. No.	Treatments	Conc.(%)/Dosage	Marketable yield of round gourd fruits# (q/ha)
1	NSE (Neem seed extract)	5.0%	50.12
2	Neem Gold 0.15 EC	0.2 ml/l	68.95
3	Flubendiamide 480 SC	2 ml/l	80.67
4	Thiodicarb 75 WP	2 ml/l	77.27
5	Spinosad 480 SC	0.4 ml/l	105.14
6	Fipronil 5 SC	2 ml/l	85.46
7	Acephate 75 SP	0.05%	98.12
8	Malathion 50 EC + Molasses	0.05%+2%	72.37
9	Acephate 75 SP S+ Molasses	0.05%+2%	102.57
10	Control (Untreated)	-	40.58
	SEm±		1.82
	CD (P=0.05%)		5.27

Mean of three replication, NSE = neem seed extract

Table 4: Comparative economics of insecticidal treatment on round gourd in Summer, 2016

S. No.	Treatments	Conc.(%)/ Dosage	Yield (q/ha)	Increase in yield (q/ha)	Gross return (Rs./ha)*	Expenditure**	Net return	B:C ratio
1	NSE (Neem seed extract)	5.0%	50.12	9.54	14310	1134	13176	11.61
2	Neem Gold 0.15 EC	0.2 ml/l	68.95	28.37	42555	6506	36049	5.54
3	Flubendiamide 480 SC	2 ml/l	80.67	40.09	60135	4056	56079	13.82
4	Thiodicarb 75 WP	2 ml/l	77.27	36.69	55035	7436	47599	6.40
5	Spinosad 480 SC	0.4 ml/l	105.14	64.56	96840	7156	89684	12.53
6	Fipronil 5 SC	2 ml/l	85.46	44.88	67320	3126	64198	20.53
7	Acephate 75 SP	0.05%	98.12	57.54	86310	1428.66	84881.64	59.41
8	Malathion 50 EC + Molasses	0.05%+2%	72.37	31.79	47685	1606	46079	28.69
9	Acephate 75 SP + Molasses	0.05%+2%	102.57	61.99	92985	2028.66	90956.34	44.83
10	Control (Untreated)	-	40.58	-	-	-	-	-

*Cost of round gourd fruit at current season was Rs. 15 per kg ** It includes cost of insecticides and labour charges

3.2 Economics of different eco-friendly insecticides and biopesticides

The maximum net return of Rs. 90956.34 ha^{-1} was found in acephate 75 SP + molasses, followed by Rs. 89684 ha^{-1} in spinosad 480 SC and Rs. 84881.64 ha^{-1} in acephate 75 SP. The minimum net profit was recorded in NSE Rs.13176 ha^{-1}, followed by Rs. 36049 ha^{-1} in Neem gold and Rs. 47599 ha^{-1} in thiodicarb 75 WP. The highest benefit cost ratio was found in acephate 75 SP with 59.41 followed by acephate 75 SP + molasses with 44.83 and malathion + molasses, 28.69. Whereas, in spinosad 480 SC 12.53 benefit cost ratio was found. Minimum benefit cost ratio was obtained in Neem gold with 5.54. The main aim of providing protection to crop against insect pests by means of various insecticides and biopesticides is to increase the production at economical level by reducing the pest damage. Therefore, before recommending any effective insecticides and biopesticides to protect the crop from injurious pest, *B. cucurbitae*, the per cent increase in yield over control and net monetary return obtained by these operations are to be taken into consideration. The maximum net profit was found in acephate 75 SP + molasses with Rs. 90956.34 ha^{-1} and benefit cost

ratio of, 44.83. The minimum net profit of Rs. 13176 ha^{-1} was recorded in NSE and benefit cost ratio of 11.61. The maximum benefit cost ratio of, 59.41 and net return Rs. 84881.64 ha^{-1} were recorded with the treatment acephate 75 SP, while the treatment spinosad 480 SC observed the benefit cost ratio of, 12.53 and net return of Rs.89684.

4. Conclusion

From the present study, it can be concluded that Spinosad followed by acephate + molasses, acephate and fipronil proved most effective insecticides against fruit fly infestation on round gourd crop. The highest benefit cost ratio was obtained in the treatment of acephate followed by acephate + molasses and malathion + molasses.

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6. References

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