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Comparative Economics of Different Management Tactics by Novel Insecticides against Pest Complex on Capsicum (*Capsicum annuum* L.) under Protected Conditions

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ABSTRACT

Field experiment was conducted under shade net house at Hi-Tech Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura (Sri Karan Narendra Agriculture University, Jobner), Jaipur, Rajasthan to work out the economics and cost benefit ratio of different management strategies by three spraying of eleven bio-rationale and newer pesticides against Yellow Mite, *Polyphagotarsonemus latus* (Banks), thrips, *Scirtothrips dorsalis* Hood, aphids (*Aphis gossypii* Glover, *Myzus persicae* Sulzer), Whitefly, *Bemisia tabaci* (Gennadius) and Beat army worm, *Spodoptera exigua* (Hubner) during summer 2014 and 2015 on capsicum (*Capsicum annuum* L.). The result on the basis of pooled data indicated that maximum net profit of Rs 77185/ha was obtained in the treatment of fipronil 0.005% with the yield of 51.46 q/ha followed by emamectin benzoate 0.002% (Rs 67422/ha) with the yield of 49.77 q/ha. The minimum net profit of Rs 23840/ha was recorded in the treatment of NSKE 5% followed by azadirachtin 0.0003% (Rs 29876). The net profit ranging from Rs 53613/ha to Rs 60263/ha was computed in the treatment of acephate (Rs 53613/ha), spiromesifen (Rs 59971/ha), spinosad (Rs 58262/ha) and indoxacarb (Rs 60263/ha), whereas, Rs 39125/ha to 41476/ha was found in propargite and novaluron. The maximum incremental cost benefit ratio (1:20.23) was found in fipronil (0.005%) followed by 1:17.99 in the treatment of acephate (0.075%). The minimum ICBR (1:4.64) was recorded in the treatments of novaluron followed by spinosad (1:5.96). Study revealed that three spray of fipronil 5 SC @ 1 ml/l or emamectin benzoate 5 SG @ 0.4 g/l can be suggested to the farmers for the management of pest complex on capsicum under shade net house conditions during summer for off season production.

Keywords Capsicum, Comparative economics, Novel insecticide, Protected conditions, Shade net house, Incremental Cost Benefit Ratio (ICBR).

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INTRODUCTION

Capsicum is one of the most popular and highly remunerative vegetable crop grown in most parts of the world, viz., China, Spain, Mexico, Romania,

Yugoslavia, Bulgaria, USA, India, Europe, Central and South America are the major countries producing capsicum. In India, capsicum is extensively cultivated in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Himachal Pradesh and hilly areas of Uttar Pradesh. Capsicum, also known as sweet pepper, bell pepper, green pepper or shimla mirch is one of the popular vegetables grown throughout India. It differs from hot chilli in size, fruit shape, capsaicin content and usage. It is a cool season crop but it can be grown round the year using protected structures. A fresh, crisp green bell pepper is a tasty vegetable that can be a regular part of our healthy eating plan. This vegetable is low in calories and contains zero gram of fat and a good supplier of vitamins and minerals. Annual capsicum production in India in the year 2019-2020 amounted to 534 thousand metric tons from an area of 34 thousand hectares (Anonymous 2020-21). Capsicum is high value low volume crop cultivated natural and protected conditions in India (Nikki *et al.* 2017). Protected cultivation is the most intensive method of crop production and provides protection to crop plant from adverse environment condition (Sood *et al.* 2015). The protected environment also provide stable and congenial micro-climate which is favorable for the multiplication of insect pests which in turn become of the limiting factors for the successful crop production under protected environment. Often, the natural enemies that keep pests under control outside are not present under protected environment. For these reasons, pest situations often develop in the indoor environment more rapidly and with greater severity than outdoors. Mite, thrips, whitefly, fruit borer, beat army worm, aphid, leaf miner, gall midge and nematode are serious problems on vegetable crops under protected conditions. The productivity of capsicum is very low due to several limiting factors. Among them, insect pests cause severe losses. Capsicum is attacked by several insect and mite pests from seedling to fruiting stage. Many species of insect and mite pests reported in capsicum and cause severe problems. Gupta *et al.* (2016) reported various pests on capsicum as prominent pest infesting capsicum under shade net house in Rajasthan. Meena *et al.* (2013) reported the thrips as important pests infesting chilli in Rajasthan. Among different pests reported on capsicum there is information indicating significant crop losses due to key pests. No sincere attempt has been made in the past to evaluation of novel insecticides against pest complex on capsicum under shade net house in Rajasthan. Considering the economic importance of pest, the study was conducted to comparative economics of different management tactics by novel insecticides against pest complex on capsicum (*Capsicum annuum* L.) under protected conditions.

MATERIALS AND METHODS

The experiments were conducted for two consecutive years during summer 2014 and summer 2015 under shade net house at Hi-Tech Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura (Sri Karan Narendra Agriculture University, Jobner), Jaipur, Rajasthan. The experiment was laid out in a Randomized Block Design with 12 treatments and three replications including untreated check. Thirty days old seedling of capsicum variety, PSO 26 were transplanted in each treatments with plot size 3.5 × 1.0 m^2, keeping row to row and plant to plant distance of 0.50 m and 0.40 m respectively. Eleven bio-rationale and newer pesticides of different chemistry (Table 1) viz., spiromesifen 22.9 SC @ 1 ml/l, emamectin benzoate 5 SG @ 0.4 g/l, acephate 75 SP @ 1 g/l, indoxacarb 14.5 SC @ 0.8 ml/l, propargite 57 EC @ 2 ml/l, fipronil 5 SC @ 1 ml/l, novaluron 10 EC @ 1

Table 1. Formulations and concentrations of insecticides used.

Sl. No.	Common name	Trade name	Formulation	Dose/l of water	Concentration (%)
1	Spiromesifen	Oberon	22.9 SC	1 ml/l	0.0229
2	Emamectin benzoate	Missile	5 SG	0.4 g/l	0.002
3	Acephate	Anuphate	75 SP	1 g/l	0.075
4	Indoxacarb	Avant	14.5 SC	0.8 ml/l	0.0116
5	Propargite	Omite	57 EC	2 ml/l	0.114
6	Fipronil	Fipro	5 SC	1 ml/l	0.005
7	Novaluron	Rimon	10 EC	1 ml/l	0.01
8	Imidacloprid	Confidor	17.8 SL	0.33 ml/l	0.0058
9	Azadirachtin	Bioneem	0.15% EC	2 ml/l	0.0003
10	NSKE	Self-prepared	-	-	5
11	Spinosad	Spintor	45 SC	0.3 ml/l	0.0135
12	Untreated check	-	-	-	-

ml/l, imidacloprid 17.8 SL @ 0.33 ml/l, azadirachtin 0.15 EC @ 2 ml/l, NSKE 5% and spinosad 45 SC @ 0.3 ml/l were evaluated for the management of pest complex under protected conditions. Three consecutive sprays were applied at twenty day interval, starting from sufficient pest build up. Treatments were imposed by using pre calibrated Knapsack sprayer @ 500–600 liters sprays solution/ha depending on the stage of the crop. Care was taken to check the drift of insecticides by putting polythene sheet screen around each plot at the time of spraying. The various parameters used for workout the economics and cost benefit ratio of different management strategies and yield data recorded at the time of each harvest from each treatment separately and pooled than calculated on the basis of yield q/ha. The data have been subjected to statistical analysis and the economics of each treatment i.e. net return over control, expenditure of insecticide application and incremental cost benefit ratio were calculated as follows.

Gross monetary benefit : Gross monetary benefit was calculated by multiplying the additional yield over untreated control with prevailing local market of capsicum.

Cost of treatments : The cost of treatments involved to the purchase of insecticides, bio-agents, accordingly treatment used as per market rate on cost /kg or/ liter. Labor charges have calculated at prevailing rate of Rs 166 per day in 2014 and Rs 189/day in 2015. The total labor was calculated on the basis of labor requirement on hectare basis for spraying. One labor was considered sufficient for spraying over one acre crop. Thus total labor cost required for spraying was worked out = (1 Labor* 2.5). The hire charges for conventional sprayer were considered Rs 40 and 50 per day in 2014 and 2015, respectively. Thus application charges of pesticides were calculated on 515 and 598 per spray/ha in 2014 and 2015, respectively. Market rate of pesticides accordingly treatment, labor and higher charges of application equipment were summed up to work out the total cost for application of each treatment against the pest.

Net monetary return : This was calculated by subtracting the total additional cost required for treatment (as worked out under B) from the monetary benefit (as worked out under A) above for each treatment separately.

The incremental cost benefit ratio (ICBR) was calculated dividing the net monetary return (c) by the total additional cost due to treatment as worked out (B).

RESULTS AND DISCUSSION

Eleven bio-rationale and newer pesticides, viz., spiromesifen, propargite, fipronil, emamectin benzoate, acephate, indoxacarb, novaluron, imidacloprid, spinosad, azadirachtin and NSKE were evaluated against the pest complex on capsicum under shade net house conditions. During 2014 the data presented in the Table 2, indicated that the maximum net profit of Rs 80910/ha with yield 57.86 q/ha was computed in the treatment of fipronil 0.005%, followed by emamectin benzoate 0.002% (Rs 67427/ha) with yield 55.24 q/ha. The minimum net profit of Rs 23285/ ha was recorded in the treatment of NSKE 5% with yield 43.33 q/ha followed by azadirachtin 0.0003% (Rs 28441/ha) with yield 44.52 q/ha. The maximum incremental cost benefit ratio (ICBR) 1:21.93 was found in fipronil (0.005%) followed by 1:18.90 in the treatment of acephate (0.075%). The minimum ICBR (1:4.59) was recorded in the treatments of novaluron followed by propargite (1:5.44).

During 2015 the data presented in the Table 3, indicated that the maximum net profit of Rs 73421/ ha was computed in the treatment of fipronil 0.005% with yield 45.05 q/ha, followed by emamectin ben-

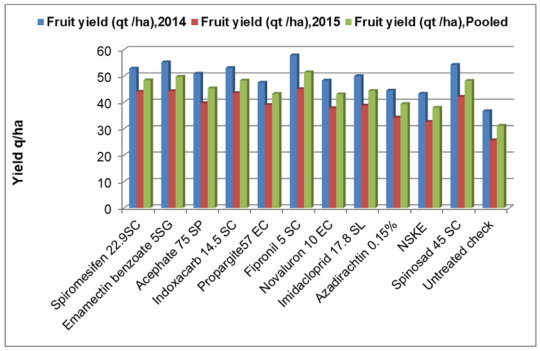

Fig. 1. Effect of different pesticidal treatments on yield.

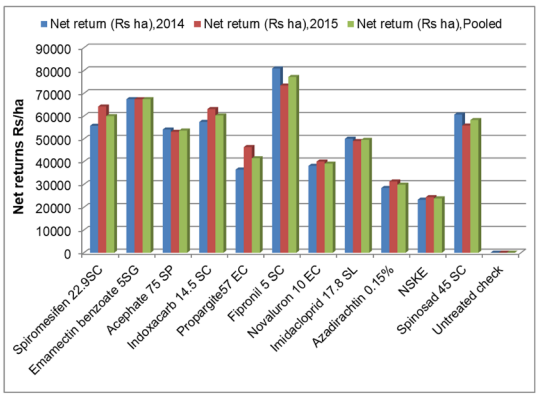

Fig. 2. Effect of different pesticidal treatments on net return.

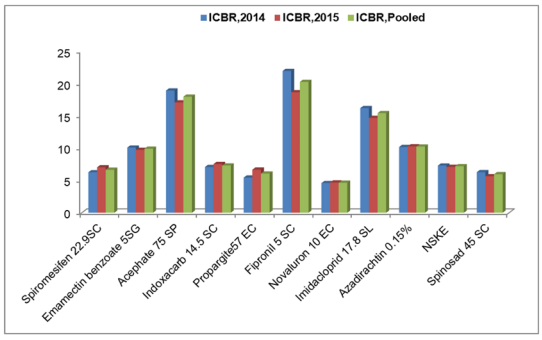

Fig. 3. Effect of different pesticidal treatments on ICBR.

Table 2. Comparative economics of different bio-rationales and newer pesticides against insect pest complex of capsicum during 2014. Selling price of capsicum= Rs 4000 per quintal.

Sl. No.	Treatments	Concentration (%)	Mean yield of healthy fruit (q/ha)	Increased yield over control (q/ha)	Value of increased yield (Rs/ha)	Expenditure in insecticidal treatment (Rs/ha)	Net profit (Rs/ha)	Incremental benefit cost ratio (IBCR)
1	Spiromesifen 22.9 SC	0.0229	52.86	16.15	64600	8904	55696	6.26
2	Emamectin benzoate 5SG	0.002	55.24	18.53	74120	6693	67427	10.07
3	Acephate 75 SP	0.075	50.95	14.24	56960	2862	54098	18.90
4	Indoxacarb14.5 SC	0.0116	53.1	16.39	65560	8132	57428	7.06
5	Propargite 57 EC	0.114	47.52	10.81	43240	6719	36521	5.44
6	Fipronil 5 SC	0.005	57.86	21.15	84600	3690	80910	21.93
7	Novaluron 10 EC	0.01	48.33	11.62	46480	8310	38170	4.59
8	Imidacloprid 17.8 SL	0.0058	50	13.29	53160	3094	50066	16.18
9	Azadirachtin 0.15%	0.0003	44.52	7.81	31240	2799	28441	10.16
10	NSKE(self-prepared)	5	43.33	6.62	26480	3195	23285	7.29
11	Spinosad 45 SC	0.0135	54.29	17.58	70320	9653	60667	6.28
12	Untreated check	-	36.71	-	-	-	-	-

Table 3. Comparative economics of different bio-rationales and newer pesticides against insect pest complex of capsicum during 2015. Selling price of capsicum= Rs 4000 per quintal.

Sl. No.	Treatments	Concentration (%)	Mean yield of healthy fruit (q/ha)	Increased yield over control (q/ha)	Cost of increased yield (Rs/ha)	Expenditure in insecticidal treatment (Rs/ha)	Net profit (Rs/ha)	Incremental benefit cost ratio (IBCR)
1	Spiromesifen 22.9 SC	0.0229	44.05	18.34	73360	9153	64207	7.01
2	Emamectin benzoate 5 SG	0.002	44.29	18.58	74320	6942	67378	9.71
3	Acephate 75 SP	0.075	39.76	14.05	56200	3111	53089	17.06
4	Indoxacarb14.5 SC	0.0116	43.57	17.86	71440	8381	63059	7.52
5	Propargite 57 EC	0.114	39.05	13.34	53360	6968	46392	6.66
6	Fipronil 5 SC	0.005	45.05	19.34	77360	3939	73421	18.64
7	Novaluron 10 EC	0.01	37.86	12.15	48600	8559	40041	4.68
8	Imidacloprid 17.8 SL	0.0058	38.81	13.1	52400	3343	49057	14.67
9	Azadirachtin 0.15%	0.0003	34.29	8.58	34320	3048	31272	10.26
10	NSKE(self-prepared)	5	32.67	6.96	27840	3444	24396	7.08
11	Spinosad 45 SC	0.0135	42.14	16.43	65720	9902	55818	5.64
12	Untreated check	-	25.71	-	-	-	-	-

Table 4. Comparative economics of different bio-rationales and newer pesticides against insect pest complex of capsicum (pooled of 2014 and 2015). Selling price of capsicum= Rs 4000 per quintal.

Sl. No.	Treatments	Concentration (%)	Mean yield of healthy fruit (q/ha)	Increased yield over control (q/ha)	Cost of increased yield (Rs/ha)	Expenditure in insecticidal treatment (Rs/ha)	Net profit (Rs/ha)	Incremental benefit cost ratio (IBCR)
1	Spiromesifen 22.9 SC	0.0229	48.46	17.25	69000	9029	59971	6.64
2	Emamectin benzoate 5SG	0.002	49.77	18.56	74240	6818	67422	9.89
3	Acephate 75 SP	0.075	45.36	14.15	56600	2987	53613	17.95
4	Indoxacarb 14.5 SC	0.0116	48.34	17.13	68520	8257	60263	7.30
5	Propargite 57 EC	0.114	43.29	12.08	48320	6844	41476	6.06
6	Fipronil 5 SC	0.005	51.46	20.25	81000	3815	77185	20.23
7	Novaluron 10 EC	0.01	43.10	11.89	47560	8435	39125	4.64
8	Imidacloprid 17.8 SL	0.0058	44.41	13.20	52800	3219	49581	15.40
9	Azadirachtin 0.15%	0.0003	39.41	8.20	32800	2924	29876	10.22
10	NSKE (self-prepared)	5	38.00	6.79	27160	3320	23840	7.18
11	Spinosad 45 SC	0.0135	48.22	17.01	68040	9778	58262	5.96
12	Untreated check	-	31.21	-	-	-	-	-

zoate 0.002% (Rs 67378 /ha) with yield 43.57 q/h. The minimum net profit of Rs 24396/ha was recorded in the treatment of NSKE 5% with yield 32.67 q/ha followed by azadirachtin 0.0003% (Rs 31272/ha) with yield 34.29 q/ha. The maximum incremental cost benefit ratio (1:18.64) was found in fipronil (0.005%) followed by 1:17.06 in the treatment of acephate (0.075%). The minimum ICBR (1:4.68) was recorded in the treatments of novaluron followed by spinosad (1:5.64).

On the basis of pooled data Table 4 and Figs. 1–3 indicate that the maximum net profit of Rs 77185/ha with yield 51.46 q/ha was obtained in the plots treated with fipronil at 0.005% followed by emamectin benzoate at 0.002% (Rs 67421/ha) with yield 49.77 q/ha. The minimum net profit of Rs 23840/ha was obtained in the plots treated with NSKE 5% with yield 38.00 q/ha followed by azadirachtin at 0.0003% (Rs 29876/ha) with yield 39.41 q/ha. The net profit ranging from Rs 53613 to 60263/ha was computed in the treatment of acephate at 0.075% (Rs 53613/ha), spiromesifen at 0.0229% (Rs 59971/ha), spinosad at 0.0135% (Rs 58262/ha) and indoxacarb at 0.0116% (Rs 60263/ha), respectively whereas, Rs 39125 to 41476/ha was found in propargite 0.114% and novaluron 0.01%. Kaur and Singh (2013) also reported that acephate and imidacloprid treated plot get better yield.

The maximum incremental cost benefit ratio (1:20.23) was found in fipronil at 0.005% followed by at 1:17.99 in the treatment of acephate 0.075%. The minimum ICBR (1:4.64) was recorded in the treatments of novaluron at 0.01% followed by spinosad at 0.0135% (1:5.96). The present results are in agreement with that of Roopa and Kumar (2014) who reported maximum benefit cost ratio with spinosad followed by fipronil against fruit borer of capsicum. In conformity with present finding, Halder *et al.* (2015) also reported that fipronil and spiromesifen treated plots get better yield and indicating superior of these newer molecules over the conventional ones. However, the maximum cost benefit ratio was recorded in dimethoate followed by dicofols which were old insecticides. Studies conducted by Maity *et al.* (2015) support the present findings who reported that highest ICBR was found with the treatment of fipronil. Nagaraju and Kumar (2022) support the present findings who reported that highest ICBR was found with the treatment of fipronil.

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