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Bio-efficacy of new molecules and bio-rationals in the management of defoliator pests of sunflower

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Abstract
Studies on the field efficacy of new molecules and biorationals against on sunflower defoliator pests. Two need based foliar applications at 45 and 65 DAS were given. All the treatments rendered significant suppression of defoliators pests and percent foliage damage compared to untreated control. Among the chemical treatments minimum population and percent foliage damage recorded in chlorantraniliprole which was significantly superior in recording the lowest population and percent foliage damageand were found significantly superior over profenophos 50 EC treated plot. While in biorationals GCK extract (2%) which was significantly superior in recording the lowest population and percent foliage damage which was on par with NSKE (5%).Among chemical treatments highestnet profit was recorded in chlorantraniliprole (rynaxypyr 18.5 SC) and emamectin benzoate 5 SG. The results clearly indicated the superiority of newer insecticides and biorationals in controlling *Spilarctia obliqua* and *Thysanoplusia. orichalcea* of sunflower.

Keywords: Sunflower, new molecules, biorationals, defoliator pests, foliage damage

1. Introduction
Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops in the world and ranks third in area after soybean and groundnut. Cultivated sunflower belongs to the family Asteraceae (Compositae) a native of Southern USA and Mexico. It is a rich source of edible oil (40-52%) having anti-cholesterol properties due to the presence of polyunsaturated fatty acids (55-65% linoleic acid & 20-30% oleic acid) [1]. Presently in India sunflower is cultivated over an area of 0.75 mha with a production of 0.51 mt and productivity (692 kg/ ha^{-1}). The major sunflower growing states in the country are Karnataka, Maharashtra, Andhra Pradesh and Tamil Nadu. Among these, Karnataka is the leading state in the country, popularly known as “Sunflower state”. Presently in Karnataka sunflower is cultivated over an area is 0.39 mha with the production of 0.19 mt and productivity of 503 kg/ ha^{-1} [2].
Despite the rapid spread of other crop, disheartening trend to that, the productivity is going down in recent years. The potential of the crop is, far from being exploited and the yield levels of the country are the lowest in the world due to several biotic and a biotic stresses. Among the several biotic stresses for successful sunflower production, susceptibility to insect pests and diseases is one of the major constraints. Sunflower serves as a host for a wide array of insect species. Sunflower serves as a host for a wide array of insect species. As many as 251 insects and an acarine species use this crop as a food across the world. In each geographical region sunflower has its own distinctive insect pest’s fauna which is composed mainly of indigenous species [3]. Among them, nine are major pests and remaining as miner ones. Insect pests of sunflower are broadly classified as seedling pests, sucking pests, soil insects, defoliators and inflorescence pests [4]. The defoliating insects are definitely important pests of sunflower [5]. 25 species of defoliators have been documented to attack cultivated sunflower in India and in Karnataka the cabbage semilooper (*Thysanoplusia orichalcea* Fabricius), Bihar hairy caterpillar [*Spilarctia*(=*Spilosoma*) *obliqua* Walker], tobacco cutworm (*Spodoptera litura* Fab.) and the grasshoppers [*Attractomorpha crenulata* Fab. and *Cyrtacanthacrisranacea* (Stoll)], the weevils [*Myllocerus discolor* Fab., *M. dentifer* Fab., *M. viridanus* Fab. and *Ptochusovulum* Fab.] and the beetles [*Monolepta signata* Fab., *Aulocophorafoveicollis* Lucas] were found defoliating sunflower at different phenophases of crop growth [6], [7], [8]. The loss in seed yield per hectare due to defoliators in a rain-fed *kharif* crop was up to 58.06 percent [9] and year by year losses due to defoliator insect pests is increasing in rainfed tract of northern dry zone of Karnataka and so many new organic molecule have been introduced in the pest

management schedule of different crops. Under these circumstances, there is need to develop some information in the management of defoliator insect pests in Northern dry zone of Karnataka. Hence the present investigation was undertaken

2. Materials and methods

The field experiment conducted at Regional Agriculture Research Station (RARS), Vijayapur to know the bio-efficiency of new molecules and bio-rationals in the management of defoliator pests in sunflower crop during *Kharif* 2014.Observations were recorded on number of insect pests from 10 randomly selected plants from each treatment a day before, 1, 5, 10 and 15 days after each spray and percent foliage damage were recorded 15 days after each spray. Seed yield was recorded at harvest from each plot. The treatment details *viz.*, T_1- Emamectin benzoate5 SG @ 0.2g/l,T_2- Chlorantraniliprole (rynaxypyr 18.5 SC) @ 0.15ml/l,T_3- Flubendiamide 480 SC @ 0.075ml/l,T_4- Spinosad 45 SC @ 0.15ml/l,T_5- Profenophos 50 EC @ 2ml/l,T_6- *Prosopis juliflora* aqueous solution 1% @ 10ml/l, T_7 - NSKE 5%, T_8- *Beauveria bassiana* @ 5g/l,T_9- Pongamiaseed kernel extract 5%, T_{10}- Biodigester solution 5%, T_{11}- GCK (Garlic-Chilly-Kerosene) extract 2%and T_{12}- Un treated Control.

2.1 Observations recorded

1. Number of defoliator insect pests and percentage of leaf damage from 10 randomly selected plants.
   The incidence was estimated and the information gathered was scored as follows:
   L = Low (<10% infestation)
   M = Medium (11-25% infestation)
   H = High (>25 % infestation)
2. Seed yield (q/ha).
3. Cost economics of different treatments.

2.2 Statistical analysis

Yield data was computed to quintals per hectare. Percent foliage damage data was subjected to angular transformation before the analysis. Also the population count data was transformed to $\sqrt{X+1}$ values for analysis and yield data and the transformed data were analysed using ANOVA technique and subjected to DMRT (Duncan's Multiple Range Test).

2.3 Seed yield (q/ha)

The seed yield of sunflower per plot at the time of harvest was recorded and converted to q/ha and B: C ratio was worked out.

3. Result and Discussion

The results of experiments can be seen in table 1 to 4. The pretreatment the population density of *Spilarctia obliqua* and *Thysanoplusia orichalcea* larvae were uniformly distributed in both spray schedules and were stastically at par. After the application of chemicals and biorationals, all the treatments were effective in reducing the population density of defoliator pests. Among the chemical chlorantraniliprole (rynaxypyr 18.5 SC) (0.03 larvae/plant) which was significantly superior in recording the lowest *S. obliqua* population per plant and was on par with emamectin benzoate 5 SG and flubendiamide 480 SC (0.10 larvae/plant) and spinosad 45 SC (0.13 larvae/plant).Whereasbiorationals the significantly lowest *S. obliqua* population per plant was recorded in the treatment GCK extract 2% (0.83 larvae/plant) and was on par with NSKE 5% (0.90 larvae/plant) and*P. juliflora* aqueous solution 1% (0.93 larvae/plant) and found to be superior over untreated check3.67 l/plant (Table 1).

The lowest *T. orichalcea* population per plant was recorded among the chemicals treatments chlorantraniliprole (rynaxypyr 18.5 SC) (0.03 larvae/plant) which was significantly superior in recording the lowest *T. orichalcea* population per plant and was on par with emamectin benzoate 5 SG (0.07 larvae/plant) followed by flubendiamide 480 SC and spinosad 45 SC (0.10 larvae/plant) and (0.10 larvae/plant) respectively. While, in biorationals the significantly lowest *T. orichalcea* population per plant was recorded in the treatment GCK extract 2% (0.67 larvae/plant) and was on par with NSKE 5% (0.70 larvae/plant) and *P. juliflora* aqueous solution 1% (0.83 larvae/plant) and found to be superior over untreated check2.67 l/plant(Table 2).

The overall mean percent foliage damage of both sprays chlorantraniliprole (rynaxypyr 18.5 SC) treated plot was superior in recording the lowest foliage damage (11.33%) followed by emamectin benzoate 5 SG (12.00%), flubendiamide 480 SC (12.83%) and spinosad 45 SC (13.25 %). The profenophos 50 EC (21.33%) was inferior as compare to other chemicals treated plots. While, in biorationals the significantly lowest foliage damage was observed in the treatment GCK extract 2% (20.08%) showed lowest foliage damage followed by NSKE 5%(21.33 %) and*P. juliflora* aqueous solution 1% (22.00%) which was found to be superior over untreated check 46.67 percent (Table 3).

The yield obtained from the different treatments was significantly higher compared to untreated control (5.56 q/ha). Among chemical treatments chlorantraniliprole (rynaxypyr 18.5 SC) @ 0.15 ml/l was recorded was significantly higher seed yield (17.26 q/ha) and was on par with emamectin benzoate 5 SG @ 0.2 g/l (16.67 q/ha) and flubendiamide 480 SC @0.075 ml/l (16.07 q/ha) followed by spinosad 45 SC @ 0.15 ml/l (15.67 q/ha). Whereas biorationals significantly higher yield was in NSKE 5% (12.10 q/ha) and was on par with GCK extract 2% (11.90 q/ha) and *P. juliflora* aqueous solution 1% @ 10 ml/l (11.71 q/ha) followed by *B. bassiana* @ 5 g/l (9.92 q/ha) and the lowest was recorded in biodigester solution (9.13 q/ha) followed by pongamia seed kernel extract 9.33 q/ha (Table 3).

Generally, chemicals were most superior to manage the insect pests, although biorationals showed moderate efficacy against pest population. All treatments effective in controlling both *S. obliqua* and *T. orichalcea* population and biorationals were best alternative next to the insecticides. Similar trend was noticed in all the observations. The results clearly indicated the superiority of newer insecticides in controlling *S. obliqua* and*T. orichalcea* of sunflower.

Present finding are corroborates with the worker. Emamectin benzoate is effective in managing both *S. litura* and *T. orichalcea* on soybean crop [10]. Repeated sprays of GCKE recorded least number of eggs (1.40 eggs/plant) followed by NSKE (5%) alternated with cow dung 10 percent (1.71 eggs/plant) and GCKE is significantly superior in reducing the fruit borer damage to the tune of 64.83 percent with higher fruit yield of 35.87 q/ha [11] and also reported the superiority of nimbecidine (0.5%) against *S. litura and T. orichalcea* after first and second spray and least percent pod damage (24.80 %) and seed damage (16.37%) with higher seed yield (21.71 q/ha) and B:C ratio (2.96). The next best treatments are NSKE (5%) and cristol 74 GL (1%) [12] and observed efficacy of NSKE (5%) and prosopan 40 EC (10 ml/lit) and found that, both the insecticides were significantly superior over the other treatments for suppression of defoliators of sunflower [13], evaluated the efficacy of new insecticide against okra fruit borer, *Helicoverpa armigera* (Hubner) and found that, rynaxypyr 20 SC @ 30 g a.i./ha and rynaxypyr 20 SC @ 20 g a.i. /ha were superior in recording less larval populations, lower fruit damage and higher fruit yield [14] and recorded lowest population of *H. armigera* in garlic chilli kerosene extract (GCKE) (0.11 larvae per plant) treated plot and superior over the untreated check [15] and chlorantraniliprole (0.006 %), spinosad (0.018 %) and emamectin benzoate (0.002 %) was noticed at the most effective in protecting the groundnut crop from the infestation of both *H. armigera* and *S. litura* pests [16], the number of *Helicoverpa* larvae per plant were lowest in plots treated with chlorantraniliprole 20 SC (0.43) [17].

4. Seed yield and cost economics

Among the chemical treatments chlorantraniliprole (rynaxypyr 18.5 SC) (17.26 q/ha) followed by emamectin benzoate 5 SG (16.67 q/ha), flubendiamide 480 SC (16.07 q/ha) and spinosad 45 SC (15.67 q/ha) recorded maximum yield and benefit: cost ratio. While, in biorationals seed yield recorded maximum in NSKE 5% (12.10 q/ha) followed by GCK extract 2% (11.90 q/ha) and *P. juliflora* aqueous solution 1% % (11.71 q/ha) recorded maximum seed yield and benefit: cost ratio lower yield and benefit: cost ratio was obtained from untreated control compared to rest of the treatments (Table 4).

All the chemical treatment recorded significantly superior seed yield and benefit: cost ratio over biorationals due to their minimum cost of production and maximum bio-efficacy against pest population.The present investigations are in close agreement with the reports, the superiority of nimbecidine (0.5%) which recorded maximum seed yield (21.71 q/ha) and B: C ratio (2.96) after first and second spray). The next best treatments were NSKE (5%) and cristol 74 GL (1%) [12], highest cost benefit ratio1:3.3 were observed in chlorantraniliprole (0.006%) treatment [16] and highest cost benefit ratio 1: 4.64 were observed in chlorantraniliprole 20 SC (0.43) treatment [17].

Table 1: Bio-efficiency of new molecules and bio-rationals against *Spilarctia obliqua* on sunflower.

Sl. No	Treatments	Dosage	After 1st spray (45 DAS*) Population density of *S. obliqua* (larvae/plant)					After 2nd spray (65 DAS*) Population density of *S. obliqua* (larvae/plant)				
			1DBS	1DAS	5DAS	10DAS	15DAS	1DBS	1DAS	5DAS	10DAS	15DAS
1.	Emamectin benzoate 5 SG	0.2 g/l	2.97 (1.98)	1.93 (1.71)^{ab}	0.27 (1.13)^{ef}	0.50 (1.22)^{de}	1.03 (1.42)^{d}	2.07 (1.75)	1.60 (1.61)^{cd}	0.10 (1.05)^{d}	0.10 (1.05)^{e}	0.20 (1.10)^{d}
2.	Chlorantraniliprole (rynaxypyr 18.5 SC)	0.15 ml/l	2.93 (1.98)	1.90 (1.70)^{ab}	0.03 (1.02)^{f}	0.47 (1.20)^{e}	1.00 (1.41)^{d}	2.03 (1.74)	1.47 (1.57)^{cd}	0.03 (1.02)^{d}	0.03 (1.02)^{e}	0.17 (1.07)^{d}
3.	Flubendiamide 480 SC	0.075 ml/l	2.77 (1.93)	1.93 (1.71)^{ab}	0.40 (1.18)^{def}	0.53 (1.24)^{cde}	1.20 (1.48)^{cd}	2.13 (1.77)	1.67 (1.63)^{cd}	0.10 (1.05)^{d}	0.13 (1.06)^{e}	0.23 (1.11)^{d}
4.	Spinosad 45 SC	0.15 ml/l	2.63 (1.91)	1.97 (1.72)^{ab}	0.43 (1.20)^{cdef}	0.57 (1.25)^{cde}	1.33 (1.53)^{cd}	2.17 (1.78)	1.70 (1.64)^{cd}	0.13 (1.06)^{d}	0.17 (1.08)^{e}	0.23 (1.11)^{d}
5.	Profenophos 50 EC	2 ml/l	2.57 (1.89)	1.13 (1.46)^{c}	0.93 (1.39)^{bcd}	1.10 (1.45)^{bcd}	1.97 (1.72)^{bc}	2.57 (1.89)	1.37 (1.53)^{d}	1.03 (1.42)^{c}	1.17 (1.47)^{cd}	1.30 (1.52)^{c}
6.	*Prosopis juliflora* aqueous solution	10 ml/l	2.53 (1.87)	1.80 (1.67)^{abc}	0.93 (1.39)^{bcd}	1.17 (1.47)^{bc}	1.90 (1.70)^{bcd}	2.77 (1.92)	1.83 (1.68)^{bcd}	0.93 (1.38)^{c}	0.97 (1.39)^{d}	1.53 (1.59)^{bc}
7.	NSKE	5 %	2.77 (1.92)	1.77 (1.65)^{abc}	0.87 (1.37)^{bcd}	0.93 (1.39)^{bcde}	1.90 (1.70)^{bcd}	2.47 (1.86)	1.67 (1.63)^{bc}	0.90 (1.38)^{c}	0.97 (1.39)^{d}	1.50 (1.58)^{bc}
8.	*Beauveria bassiana*	5 g/l	2.63 (1.90)	2.33 (1.82)^{ab}	1.03 (1.43)^{bc}	1.23 (1.49)^{b}	2.07 (1.73)^{bc}	2.40 (1.84)	2.20 (1.78)^{bc}	1.83 (1.67)^{b}	1.87 (1.68)^{bc}	1.93 (1.70)^{bc}
9.	Pongamia seed kernel extract	5 %	2.50 (1.87)	2.30 (1.81)^{ab}	1.27 (1.50)^{b}	1.30 (1.52)^{b}	2.07 (1.73)^{bc}	2.77 (1.94)	2.50 (1.87)^{b}	2.00 (1.73)^{b}	2.17 (1.78)^{b}	2.17 (1.77)^{bc}
10.	Biodigester solution	5 %	2.93 (1.97)	2.33 (1.83)^{ab}	1.50 (1.55)^{b}	1.57 (1.58)^{b}	2.33 (1.83)^{b}	2.63 (1.91)	2.50 (1.87)^{b}	2.13 (1.76)^{b}	2.33 (1.81)^{b}	2.33 (1.83)^{b}
11.	GCK (Garlic-Chilly-Kerosene) extract	2 %	2.90 (1.97)	1.67 (1.63)^{bc}	0.77 (1.33)^{bcde}	0.87 (1.37)^{bcde}	1.87 (1.69)^{bcd}	2.50 (1.87)	1.47 (1.57)^{cd}	0.83 (1.35)^{c}	0.93 (1.39)^{d}	1.47 (1.56)^{c}
12.	Untreated Control	-	2.50 (1.87)	2.50 (1.87)^{a}	2.67 (1.91)^{a}	3.07 (2.02)^{a}	3.57 (2.13)^{a}	3.63 (2.13)	3.63 (2.14)^{a}	3.67 (2.16)^{a}	3.73 (2.18)^{a}	3.93 (2.22)^{a}
S.Em±			0.10	0.07	0.07	0.07	0.08	0.08	0.07	0.07	0.08	0.08
CD @ 5%			NS	0.21	0.21	0.21	0.24	NS	0.21	0.22	0.24	0.23
CV (%)			8.56	7.07	8.99	8.51	8.54	7.72	7.19	9.03	9.90	9.02

DBS- Day before spray. DAS*- Days after sowing. DAS- Days after spray. Figures in the parentheses are $\sqrt{(x+1)}$ transformed values.

Table 2: Bio-efficiency of new molecules and bio-rationals against *Thysanoplusia orichalcea* on sunflower.

Sl. No	Treatments	Dosage	After 1st spray (45 DAS*) Population density of *T. orichalcea* (larvae/plant)					After 2nd spray (65 DAS*) Population density of *T. orichalcea* (larvae/plant)				
			1DBS	1DAS	5DAS	10DAS	15DAS	1DBS	1DAS	5DAS	10DAS	15DAS
1.	Emamectin benzoate 5 SG	0.2 g/l	2.33 (1.82)	1.47 (1.56)^{abc}	0.10 (1.05)^{d}	0.10 (1.05)^{c}	0.27 (1.12)^{c}	0.93 (1.39)	0.73 (1.32)^{c}	0.07 (1.03)^{c}	0.10 (1.05)^{d}	0.13 (1.06)^{c}
2.	Chlorantraniliprole (rynaxypyr 18.5 SC)	0.15 ml/l	2.23 (1.80)	1.43 (1.56)^{abc}	0.07 (1.03)^{d}	0.07 (1.03)^{c}	0.10 (1.05)^{c}	0.87 (1.36)	0.67 (1.29)^{c}	0.03 (1.02)^{c}	0.03 (1.02)^{d}	0.03 (1.02)^{c}
3.	Flubendiamide 480 SC	0.075 ml/l	2.17 (1.78)	1.50 (1.57)^{abc}	0.27 (1.12)^{d}	0.30 (1.14)^{c}	0.37 (1.17)^{c}	1.00 (1.41)	0.83 (1.35)^{c}	0.10 (1.05)^{c}	0.13 (1.06)^{d}	0.17 (1.08)^{c}
4.	Spinosad 45 SC	0.15 ml/l	2.00 (1.73)	1.50 (1.57)^{abc}	0.30 (1.14)^{d}	0.33 (1.15)^{c}	0.37 (1.17)^{c}	1.00 (1.41)	0.70 (1.30)^{c}	0.10 (1.05)^{c}	0.13 (1.06)^{d}	0.17 (1.08)^{c}
5.	Profenophos 50 EC	2 ml/l	2.27 (1.81)	0.87 (1.35)^{c}	1.00 (1.41)^{c}	1.17 (1.47)^{b}	1.33 (1.52)^{b}	1.50 (1.56)	0.63 (1.28)^{c}	0.63 (1.28)^{b}	0.90 (1.37)^{c}	1.00 (1.41)^{b}
6.	*Prosopis juliflora* aqueous solution	10 ml/l	2.10 (1.75)	1.30 (1.52)^{bc}	1.10 (1.45)^{bc}	1.27 (1.50)^{b}	1.33 (1.52)^{b}	1.67 (1.61)	1.23 (1.48)^{bc}	0.83 (1.35)^{b}	0.83 (1.35)^{c}	0.87 (1.37)^{b}
7.	NSKE	5 %	2.07 (1.75)	1.27 (1.50)^{bc}	1.10 (1.45)^{bc}	1.27 (1.50)^{b}	1.30 (1.51)^{b}	1.67 (1.61)	1.17 (1.47)^{bc}	0.70 (1.30)^{b}	0.77 (1.33)^{c}	0.80 (1.34)^{b}
8.	*Beauveria bassiana*	5 g/l	2.17 (1.78)	1.87 (1.69)^{ab}	1.57 (1.60)^{b}	1.60 (1.61)^{ab}	1.63 (1.62)^{ab}	1.80 (1.67)	1.67 (1.63)^{ab}	1.00 (1.41)^{b}	1.33 (1.52)^{bc}	1.50 (1.57)^{b}
9.	Pongamia seed kernel extract	5 %	2.10 (1.75)	1.97 (1.72)^{ab}	1.53 (1.59)^{b}	1.83 (1.66)^{ab}	2.07 (1.75)^{ab}	2.37 (1.83)	2.00 (1.72)^{a}	1.93 (1.70)^{a}	2.17 (1.76)^{ab}	2.43 (1.84)^{a}
10.	Biodigester solution	5 %	2.07 (1.75)	1.97 (1.72)^{ab}	1.53 (1.58)^{b}	1.73 (1.65)^{ab}	2.00 (1.72)^{ab}	2.33 (1.82)	2.17 (1.78)^{a}	2.00 (1.72)^{a}	2.13 (1.75)^{ab}	2.40 (1.83)^{a}
11.	GCK (Garlic-Chilly-Kerosene) extract	2 %	2.20 (1.79)	1.20 (1.48)^{bc}	1.00 (1.41)^{c}	1.23 (1.49)^{b}	1.27 (1.50)^{b}	1.60 (1.58)	1.00 (1.41)^{bc}	0.67 (1.29)^{b}	0.70 (1.30)^{c}	0.77 (1.33)^{b}
12.	Untreated Control	-	2.17 (1.78)	2.17 (1.78)^{a}	2.27 (1.80)^{a}	2.33 (1.82)^{a}	2.40 (1.84)^{a}	2.43 (1.85)	2.47 (1.86)^{a}	2.67 (1.91)^{a}	2.77 (1.94)^{a}	2.87 (1.96)^{a}
S.Em±			0.08	0.08	0.05	0.08	0.09	0.12	0.07	0.07	0.08	0.08
CD @ 5%			NS	0.22	0.14	0.25	0.25	NS	0.22	0.21	0.24	0.24
CV (%)			7.68	8.35	6.12	10.26	10.28	12.79	8.59	9.36	10.14	10.09

DBS- Day before spray. DAS*- Days after sowing. DAS- Days after spray. Figures in the parentheses are $\sqrt{(x+1)}$ transformed values.

Table 3: Effect of new molecules and biorationals on percent foliage damage and seed yield of sunflower.

Sl. No	Treatments	Dosage	% foliage damage due to defoliator insect pests: After 1st spray (45 DAS*) After (15 DAS)	% foliage damage due to defoliator insect pests: After 2nd spray (65 DAS*) After (15 DAS)	Mean	Yield q/ha
1	Emamectin benzoate 5 SG	0.2 g/l	10.00 (18.43)^{de}	14.00 (21.66)^{c}	12.00	16.67^{a}
2	Chlorantraniliprole (rynaxypyr 18.5 SC)	0.15 ml/l	9.33 (17.63)^{e}	13.33 (21.14)^{c}	11.33	17.26^{a}
3	Flubendiamide 480 SC	0.075 ml/l	11.33 (19.61)^{cde}	14.33 (21.93)^{c}	12.83	16.07^{a}
4	Spinosad 45 SC	0.15 ml/l	11.67 (19.89)^{cde}	14.83 (22.48)^{c}	13.25	15.67^{ab}
5	Profenophos 50 EC	2 ml/l	17.50 (24.61)^{bcd}	25.17 (30.04)^{bc}	21.33	12.10^{bc}
6	*Prosopis juliflora* aqueous solution	10 ml/l	18.67 (25.54)^{bc}	25.33 (30.15)^{bc}	22.00	11.71^{bc}
7	NSKE	5 %	18.50 (25.41)^{bc}	24.17 (29.36)^{bc}	21.33	12.10^{bc}
8	*Beauveria bassiana*	5 g/l	20.67 (27.03)^{b}	28.33 (32.14)^{b}	24.50	9.92^{c}
9	Pongamia seed kernel extract	5 %	22.50 (28.29)^{b}	31.00 (33.81)^{b}	26.75	9.33^{cd}
10	Biodigester solution	5 %	23.50 (28.96)^{b}	34.33 (35.87)^{b}	28.92	9.13^{cd}
11	GCK (Garlic-Chilly-Kerosene) extract	2 %	18.00 (24.75)^{bc}	23.67 (29.08)^{bc}	20.08	11.90^{bc}
12	Untreated Control	-	36.67 (37.14)^{a}	56.67 (49.22)^{a}	46.67	5.56^{d}
S.Em±			2.00	2.93	-	1.29
CD @ 5%			5.86	8.59	-	3.78
CV (%)			13.98	17.05	-	18.16

DAS- Days after spraying. DAS*- Days after sowing. Figures in the parentheses are angular transformed values.

Table 4: Effect of insecticides on the seed yield and cost economics of sunflowers.

Sl. No	Treatments	Dosage %/ml/g/ha	Yield (q/ha)	Gross income (Rs/ha)	*Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B C ratio
1	Emamectin benzoate 5 SG	100 g	16.67	55000	18333	36667	1:3.00
2	Chlorantraniliprole (Rynaxypyr 20 SC)	75 ml	17.26	56964	18983	37981	1:3.00
3	Flubendiamide 480 SC	37.5 ml	16.07	53036	18158	34878	1:2.92
4	Spinosad 45 SC	75 ml	15.67	51726	18158	33568	1:2.85
5	Profenophos 50 EC	1000 ml	12.10	39940	18193	21748	1:2.20
6	*Prosopis juliflora* aqueous solution	5000 ml	11.71	38631	17883	20748	1:2.16
7	NSKE	25000 ml	12.10	39940	17933	22008	1:2.23
8	*Beauveria bassiana*	2500 g	9.92	32738	18133	14605	1:1.81
9	Pongamia Seed Kernel Extract	25000 ml	9.33	30774	17933	12841	1:1.72
10	Biodigester solution	2500 ml	9.13	30119	18233	11886	1:1.65
11	GCK (Garlic-Chilly-Kerosene) extract	10000 ml	11.90	39286	18133	21153	1:2.17
12	Untreated Control	-	5.56	18333	17633	700	1:1.04

Market price: Sunflower seeds = Rs. 3,300/q
*Cost of cultivation (17633) + cost of treatments

5. Conclusions

In the management of defoliator insect pests of sunflower, chlorantraniliprole (rynaxypyr 18.5 SC) @ 0.15 ml/l and emamectin benzoate 5 SG @0.2 g/l were found effective in managing both *S. obliqua* and *T. orichalcea* and was on par with flubendiamide 480 SC @ 0.075 ml/l and spinosad 45 SC @ 0.15 ml/l andrecorded least larval population and percent foliage damage. While the, biorationals GCK extract 2% showed better efficacy and was recorded least larval population and percent foliage damage which was on par with NSKE 5% and *P. juliflora* aqueous solution 1% @ 10 ml/l and was significantly superior over the other botanicals. Among the different treatments tested for defoliator insect pests management in sunflower. The chlorantraniliprole (rynaxypyr 18.5 SC) @ 0.15 ml/l and emamectin benzoate 5 SG @0.2 g/l was recorded the maximum benefit: cost ratio with higher seed yield. While, in biorationals highest benefit: cost ratio was obtained from the NSKE 5% followed by GCK extract 2% and was superior over untreated control.

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