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Bio-efficacy of some newer insecticides and bio-pesticides against whitefly (*Bemisia tabaci* Gennadius) in Brinjal ecosystem

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Abstract

Efficacy of different treatments *viz.*, imidacloprid 17.8 SL, buprofezin 25 SC, fipronil 5 SC, spinosad 45 SC, emamectin benzoate 5 SG, *Bacillus thuringiensis*, and neem oil 1500 ppm was carried out to study the relative efficacy of some newer insecticides and biopesticides against whitefly (*Bemisia tabaci* Gennadius) in brinjal ecosystem. All the treatments were found significantly effective in reducing the population of whiteflies and thus increasing the yield as compared to control. Imidacloprid 17.8 SL @ 100ml/ha was found to be the most effective treatment in reducing the population of whitefly. The *B. thuringiensis* @ 1.0kg/ha was found less effective as compared to chemical treatments but it was significantly superior over control. The highest fruit yield (135.8 q/ha) was obtained in spinosad 45 SC but cost benefit ratio (1:11.50) was higher in imidacloprid 17.8 SL. Observations revealed that, there was no record of any phyto-toxicity symptoms on brinjal plants with dosages of Imidacloprid 17.8 SL, Spinosad 45 SC and neem oil. From the experiment, it was confirmed that Imidacloprid 17.8 SL is effective in the management of whitefly in brinjal without hindering natural enemy population and causing phyto-toxicity effect.

Keywords: Insecticides, biopesticides, neem oil, whitefly, bio-efficacy

1. Introduction

Agriculture is the most important sector of the Indian economy providing employment and livelihood to nearly 70% of the total population. A UN study on global population trends predicts that India will surpass China to become the most populous nation in the world by 2022. With a present size of 1.32 billion, India currently supports nearly 17.84% of the world population, with 2.4% land resources and 4 % of water resources (A report on Indian Agrochemical Industry July 2016). The rising population has led to increasing food demand. To meet the food & nutrition needs of a growing population requires a sustainable approach that puts thrust on increasing productivity against the background of lower yields and decreasing farm sizes. A vast majority of the population in India is engaged in agriculture and is therefore exposed to the pesticides used in agriculture. However, exposure to pesticides both occupationally and environmentally causes a range of human health problems. It has been observed that pesticide exposures are increasingly linked to immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer. At present per hectare use of pesticide in India is much lower as compared to other countries like China (13.06 kg/ha), Japan (11.85 kg/ha), Brazil (4.57 kg/ha) and other Latin American countries (FAOSTAT, 2017) [12].

The Brinjal (*Solanum melongena* L) is one of the most important solanaceous vegetable in South East Asian countries including India, Bangladesh, Sri Lanka, China and Japan etc. After China India is the second largest producer of brinjal cultivated in about 0.669 million hectares with a production of 12.40 million tonnes (Anonymous, 2017).

Pesticides can prevent large crop losses and will therefore continue to play a role in agriculture. However, the effects on humans and the environment of exposure to pesticides are a continuing concern. The use of pesticides to produce food, both to feed local populations and for export, should comply with good agricultural practices regardless of the economic status of a country. Farmers should limit the amount of pesticide used to the minimum necessary to protect their crops.

At present synthetic pyrethroids are regularly used for the control of shoot and fruit borer and their indiscriminate use, leading to whitefly, aphid and mite resurgence is well documented (Reddy and Srinivas, 2005) [24]. Brinjal being a vegetable crop, use of broad-spectrum insecticides will leave considerable toxic residues on the fruits. Beside this, sole dependence on several broad-spectrum insecticides for the control of these pests has led to insecticidal resistance (Harish *et al*., 2011) [14]. Even though, neonicotinoids are widely used for managing the homopteran insect pest, very little work on their side effects on natural enemy has been carried out (Cloyd and Bethke, 2011) [6]. In India, former sprayed on average of 20-30 times per crop season at about 26.7 liter/ ha of "cocktail" pesticides, such as chlorpyrifos, cypermethrin, monocrotophos and diamethoate resulting in the reduction of natural enemies and beneficial organisms (Chaudhary *et al*., 2013) [4]. The wide application of neonicotinoid systemic pesticides, their persistence in soil and water, and potential for uptake by crops and wild plants expose a wide range of species, which are important in providing valuable ecosystem services.

The whitefly, *B. tabaci* is a polyphagous pest inflicting a heavy yield loss to many crops (Singh *et al.*, 1994) [27]. It causes direct damage by sucking the phloem sap, and producing copious amount of honeydew. Besides this direct damage, it also inflicts an indirect damage by transmitting large number of viral diseases (Al-Deghairi, 2009) [1]. Brinjal is to have ayurvedic medicinal properties and is good for diabetic patients. It has also an excellent remedy for those suffering from liver complaints (Shukla and Naik 1993) [26].

Our objective keeping in view the efficiently use of insecticides in brinjal in order to provide safer, eco-friendly and economical management of its major pests. As brinjal is a vegetable crop and harvesting of fruits is done at regular short intervals, safer and effective insecticides are needed for controlling the insect pest complex.

2. Materials and methods

A field experiment was carried out at Crop Research Center (CRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, in the year 2017; this center is situated 10 km far from the university. It lies between 29^0 17' N latitude and 77^0 42' E longitudes at an altitude of 237 meter above mean sea level. Meerut comes under the Western Plain Zone of Uttar Pradesh, sub region of upper Gangetic plain.

The experiment was laid out in a randomized block design (R.B.D.) with three replications (plot size 5X3 m^2). Brinjal variety BR 112 was sown on raised nursery bed with row to row distance of 10 cm. Thirty days old seedlings of brinjal were transplanted in each plot. The spacing between plant to plant and row to row was kept 60 cm. Light irrigation was provided after transplanting the seedlings.

Eight treatments including imidacloprid (Confidor 17.8 SL; Bayer crop science; Dose 100-ml/h), buprofezin (Applaud 25 SC; Rallis India Limited; Dose 800ml/h), fipronil (Regent 5 SC; Bayer crop science; Dose 750 ml/ha) spinosad (Conserve 45 SC; Nagarjun agrochem limited; Dose 160ml/h**),** emamectin benzoate (Proclaim 5 SG; Volex™ ; Dose 125ml/h) *B. thuringiensis*, Dose 1.0 kg/h and neem oil 1500 ppm; YK Laboratory; Dose 3 lit/h were taken in the presents experiment. Three sprays of each treatment were done, first at 30 days after transplanting and then second and third subsequently at 20 days' interval. The untreated control plot was sprayed with water only. The spray volume used for foliar application of insecticides was 600 liters/hectare (according to CIB & RC 2018). Insecticide drift to other plots was taken care of during spray. The quantity of insecticide required per liter of water was calculated by the following formula.

$$\text{Amount of formulation (L)} = \frac{\text{Concentration Required (\%) X Volume Required}}{\text{Concentration of toxicants in insecticidal formulation}} \text{ x } 100$$

Observations on the population of sucking pests were recorded on three leaves one each from top, middle and bottom canopy of the five plants selected randomly in each replication (Mathur *et al*., 2012) [18].

Fruit yield of all the treatments was recorded at weekly interval right from fruit formation till the harvest of crop. Cumulative yield of each picking was converted in to quintal per hectare for analysis and comparison of the data.

Increase in yield over control was worked out by deducting the yield recorded in control plot from the yield of the respective treated plots. The monetary value of increased yield was computed in rupees using local market price of brinjal. A comparison of cost involved in different treatments was also done on the basis of the maximum retail price printed on the smallest pack. Net return for each treatment was calculated by deducting the cost of treatment from the monetary value of increased yield. Cost benefit ratio, net return per rupees invested, was calculated by following formula-

$$\text{Benefit cost ratio} = \frac{\text{Net monetary return of additional yield (Rs ha}^{-1}\text{)}}{\text{Cost of the treatment (Rs ha}^{-1}\text{)}}$$

The data recorded during the course of investigation was subjected to statistical analysis by using analysis of variance technique (ANOVA) for randomized block design as suggested by Panse and Sukhatme (1978) [23]. Standard error of mean in each case and the critical differences only for significant cases were computed at 5% level of probability as under –

$$\text{SE (m)} \pm = \sqrt{\frac{\text{EMSS}}{\text{r}}}$$

Where,

SE (m) = Standard error of mean

EMSS = Error mean sum of square

r = Number of replications

The critical differences at 5 per cent level of probability was worked out to compare treatment means wherever, F was significant. Critical differences = SE (m) × √2 × t (at error degree of freedom)

3. Results and Discussion

3.1 Efficacy of different treatments against whitefly

Each treatment was applied three times during the cropping season. First spray was given at 30 days after transplanting and second and third subsequent sprays were applied at 20 days interval. The data on the number of whiteflies/leaf is presented in the following text.

The data (Table 1; Figure 1) revealed that all the treatments were significantly effective in reducing the population of whitefly compared to control. The initial whitefly population ranged from 7.33 to 8.67 whiteflies per leaf before the spray and did not differ significantly among all the treatments.

The minimum whitefly population (2.40 whiteflies/ leaf) was recorded in the plot treated with imidacloprid 17.8 SL @ 100 ml/ha and it was significantly superior to rest of the treatments, 7 days after first spray. The next in order of effectiveness of treatment was fipronil 5 SC @ 750 ml/ha (3.46 whiteflies/leaf), buprofezin 25 SC @ 800 ml/ha (3.93 whiteflies/leaf), spinosad 45 SC @ 160 ml/ha (4.46 whiteflies/leaf), emamectin benzoate 5 SG @ 125 g/ha (5.00 whiteflies/leaf), neem oil 1500 ppm @ 3 lit/ha (5.60 whiteflies/leaf) and *B. thuringiensis* @ 1.0 kg/ha (6.00 whiteflies/leaf). Maximum whitefly population (8.00 whiteflies/leaf) was recorded in control plot.

Observation recorded on 14th day after first application, showed increase pattern of whitefly in all the treatments but still all the treatments maintained their efficacy and significance over control. Most effective treatment found was imidacloprid 17.8 SL @ 100 ml/ha with minimum whitefly population (2.8 whiteflies/leaf) followed by fipronil 5 SC @ 750 ml/ha (3.46 whiteflies/leaf). The next effective treatment was buprofezin 25 SC @ 800 ml/ha (4.10 whiteflies/leaf) followed by spinosad 45 SC @ 160 ml/ha (4.8 whiteflies/leaf), emamectin benzoate 5 SG @ 125 g/ha (5.33 whiteflies/leaf) and neem oil 1500 ppm @ 3.0 lit/ha (5.93 whiteflies/leaf). *B. thuringiensis* @ 1.0 kg/ha (6.67 whiteflies/leaf) was the least effective. However, maximum whitefly population (8.40 whiteflies/leaf) was recorded in control plot.

Observation recorded on 7th day of second application revealed that imidacloprid 17.8 SL @ 100 ml/ha again proved most effective treatment with minimum population (2.20 whiteflies/leaf). The next effective treatment was fipronil 5 SC @ 750 ml/ha (2.73 whiteflies/leaf) followed by buprofezin 25 SC @ 800 ml/ha (3.60 whiteflies/leaf), spinosad 45 SC @ 160 ml/ha (3.86 whiteflies/leaf), emamectin benzoate 5 SG @ 125g/ha (4.5 whiteflies/leaf) and neem oil 1500 ppm @ 3.0 lit/ha (5.16 whiteflis/leaf). *B. thuringiensis* @ 1.0 kg/ha (5.67 whiteflies/leaf) was the least effective but it was significantly superior over control. However, maximum whitefly population (7.33 whiteflies/leaf) was recorded in control plot.

Data recorded on 14th day after second application showed that all the treatments were found effective over control (Table 1; Figure 1). Imidacloprid 17.8 SL @ 100 ml/ha maintained its efficacy and recorded lowest whitefly population (2.67 whiteflies/leaf). The next effective treatment was fipronil 5 SC @ 750 ml/ha (3.33 whiteflies/leaf) followed by buprofezin 25 SC @ 750 ml/ha (3.67 whiteflies/leaf), spinosad 45 SC @ 160 ml/ha (4.00 whiteflies/leaf) and emamectin benzoate 5 SG @ 125 g/ha (4.60 whiteflies/leaf). The rest treatment neem oil 1500 ppm @ 3.0 lit/ha (5.33 whitefly/leaf) and *B. thuringiensis* 1.0 kg/ha (5.80 whiteflies/leaf) were least effective. Maximum whitefly population (7.67 whiteflies/leaf) was recorded in control plot.

The data revealed that 7th day after third spray; all the treatments were found significantly superior over control have been presented in Table 1. At this stage, minimum whitefly population (1.33 whiteflies/leaf) was recorded in imidacloprid 17.8 SL @ 100 ml/ha treated plots and it was at par with fipronil 5 SC @ 750 ml/ha (1.67 whiteflies/leaf) followed by buprofezin 25 SC @ 800 ml/ha (2.00 whiteflies/leaf) and spinosad 45 SC @ 160 ml/ha (2.33 whiteflies/leaf). The population of 3.00, 3.67 and 4.33 whiteflies/leaf was recorded with emamectin benzoate 5 SG @ 125 g/ha, neem oil 1500 ppm @ 3.0 lit/ha and *B. thuringiensis* @ 1.0 kg/ha, respectively. The maximum population (6.00 whiteflies/leaf) was recorded in control plot.

Data recorded on 14th day after third spray, all the treatments were found significantly superior over control. The lowest population (1.00 whiteflies/leaf) was recorded in imidacloprid 17.8 SL @ 100 ml/ha and it was significantly superior over rest of treatments. The next effective treatment was fipronil 5 SC 750 ml/ha (1.67 whiteflies/leaf) followed by buprofezin 25 SC @ 800 ml/ha (2.00 whiteflies/leaf), spinosad 45 SC @ 160 ml/ha (2.80 whiteflies/leaf), emamectin benzoate 5 SG @ 125 g/ha (3.40 whiteflies/leaf), neem oil 1500 ppm @ 3.0 lit/ha (3.80 whiteflies/leaf) and *B. thuringiensis* @ 1.0 kg/ha (4.86 whiteflies/leaf). The maximum whitefly population (6.53 whiteflies/leaf) was recorded in control plot. The order of effectiveness of these treatments was imidacloprid > fipronil > buprofezin > spinosad > emamectin benzoate > neem oil > *B. thuringiensis.*

It is evident from the above findings that all the treatments were effective in reducing white fly population at different intervals after each spray in comparison to untreated control. The most effective treatment was imidacloprid 17.8 SL @ 100 ml/ha followed by fipronil 5 SC @ 750 ml/ha for the control of whitefly in present study.

The effectiveness of imidacloprid and fipronil for the control of *B. tabaci* in recent time has also been reported by Das and Islam (2014) [7]; Yadav and Raghuram (2014) [29-30]; Ghosal and Chatterjee (2013) [13]; Kumar *et al.*, (2017) [17]. Buprofezin were found effective in present studies, which are in agreement with the results obtained by Das and Islam (2014) [7]; Yadav and Raghuraman (2014) [29-30]. The efficacy of spinosad against whitefly recorded in the present studies are in conformity with many other earlier reports like Yadav and Kumavat (2014) [29-30]; Devi *et al*., (2015) [9]; Sunda *et al*., (2015) [28]. The effect of emamectin benzoate in present studies are in accordance with the reports of Kalawate and Dethe MD (2012) [15]; Das and Islam (2014) [7]; Devi *et al*., (2015) [9]; Barati *et al.*, (2015). The efficacy of neem oil against white fly recorded in the present studies with the reports of Mhaske and Mote (2005) [20]; Omprakash and Raju (2013) [22]; Yadav and Kumavat (2014) [29-30]; Sunda *et al*., (2015) [28]. The effectiveness of *B. thuringiensis* for the control of whitefly has been reported by Konar *et al*., (2011) [16].

Table 1: Efficacy of different insecticides against whitefly

Treatments	Insecticides	Dose/ha	1 DBS	No. of whiteflies/leaf					
				First spray		Second spray		Third spray	
				7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
T_1	Imidacloprid 17.8 SL	100 ml	7.33 (2.88)	2.40 (1.83)	2.80 (1.94)	2.20 (1.78)	2.67 (1.91)	1.33 (1.52)	1.00 (1.27)
T_2	Buprofezin 25 SC	800 ml	7.80 (2.96)	3.93 (2.22)	4.10 (2.25)	3.60 (2.06)	3.67 (2.16)	2.00 (1.72)	2.00 (1.73)
T_3	Fipronil 5 SC	750 ml	7.40 (2.89)	3.46 (2.11)	3.46 (2.11)	2.73 (1.92)	3.33 (2.08)	1.67 (1.63)	1.67 (1.63)
T_4	Spinosad 45 SC	160 ml	7.67 (2.94)	4.46 (2.33)	4.80 (2.40)	3.86 (2.19)	4.00 (2.25)	2.33 (1.82)	2.80 (1.94)
T_5	Emamectin benzoate 5 SG	125 g	8.20 (3.03)	5.00 (2.45)	5.33 (2.51)	4.50 (2.34)	4.60 (2.36)	3.00 (2.00)	3.40 (2.09)
T_6	*Bacillus thuringiensis*	1.0 kg	8.67 (3.10)	6.00 (2.65)	6.67 (2.76)	5.67 (2.58)	5.80 (2.60)	4.33 (2.30)	4.86 (2.42)
T_7	Neem oil 1500 ppm	3.0 litre	7.86 (2.97)	5.60 (2.56)	5.93 (2.63)	5.16(2.48)	5.33 (2.51)	3.67 (2.15)	3.80 (2.19)
T_8	Control	-	8.33 (3.05)	8.00 (3.00)	8.40 (3.05)	7.33 (2.88)	7.67 (2.94)	6.00 (2.64)	6.53 (2.74)
	SE m (±)		0.06	0.03	0.039	0.04	0.03	0.047	0.05
	CD at 5 %			0.1	0.12	0.13	0.10	0.14	0.16

Figure in parenthesis are square root transformed values; DAS= Days after spray; DBS= Days before spray

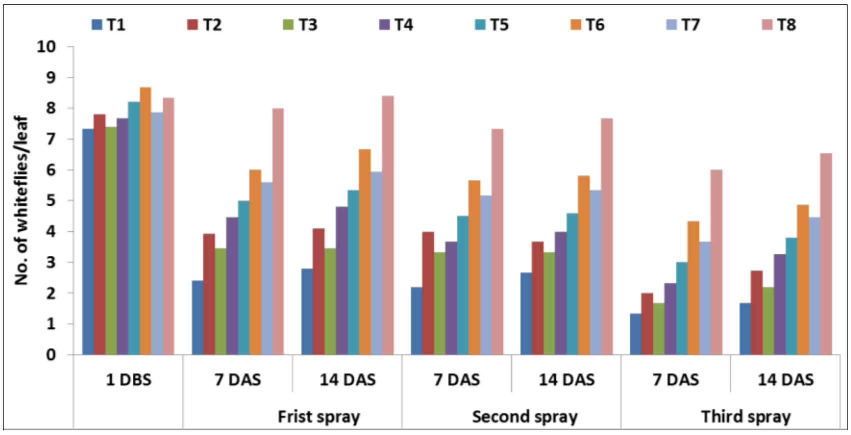

Fig 1: Efficacy of different treatments against whitefly, *Bemisia tabaci*

3.2 Economics of different treatments

The data recorded on healthy fruit yield of different treatments is presented in Table 2; Figure 2. All the treated plots resulted significantly higher fruit yield ranging between 120.67 to 135.80 q/ha than untreated control (113.75 q/ha). The maximum yield (135.80 q/ha) was obtained in the treatment with spinosad 45 SC @ 160 ml/ha which was superior over rest of the treatments. Emamectin benzoate 5 SG @ 125 g/ha was second most effective treatment with fruit yield of 133.94 q/ha followed by imidacloprid 17.8 SL @ 100 ml/ha, fipronil 5 SC @ 750 ml/ha, buprofezin 25 SC @ 800 ml/ha, neem oil 1500 ppm @ 3.0 lit/ha and *B. thuringiensis* @ 1.0 kg/ha with the yield of 132.50, 130.40, 129.20, 122.80 and 120.67 q/ha, respectively. Among the different treatments lowest yield (120.67 q/ha) was found in case of *B. thuringiensis* 1500 ppm @ 1.0 kg/ha. Increase in yield over control varied from 06.92 to 22.05 q/ha in different treatments. Maximum yield (22.05 q/ha) was recorded in spinosad 45 SC @ 160 ml/ha followed by imidacloprid 17.8 SL @ 100 ml/ha, fipronil 5 SC @ 750 ml/ha, buprofezin 25 SC @ 800 ml/ha, neem oil 1500 ppm @ 3.0 lit/ha and *B. thuringiensis* @ 1.0 kg/ha in which increase in yield was 20.19, 18.75, 16.65, 15.45, 9.05 and 06.92 q/ha respectively. However, lowest increase in yield 06.92 q/ha was recorded in plot treated with *B. thuringiensis* @ 1.0 kg/ha. Perusal of Table 2 indicates that maximum gain in net income of Rs. 21528.00/ha was found from emamectin benzoate 5 SG @ 125 g/ha treated plot followed by spinosad 17.8 SL@ 100 ml/ha, imidacloprid 17.8 SL @ 100 ml/ha, fipronil 5 SC @ 750 ml/ha, buprofezin 25 SC @ 800 ml/ha and neem oil 1500 ppm @ 3.0 lit/ha with net profit of Rs. 21110, 20700, 17730, 16290, and 8310/ha, respectively. The minimum net profit (Rs. 6054/ha) was obtained from *B. thuringiensis* @ 1.0 kg/ha. Cost benefit ratio of the treatments showed that imidacloprid 17.8 SL @ 100 ml/ha ranked first indicating the maximum return Rs. 11.50 per rupee invested followed by emamectin benzoate 5 SG @ 125 g/ha, fipronil 5 SC @ 750 ml/ha, buprofezin 25 SC @ 800 ml/ha, spinosad 17.8 SL@ 100 ml/ha and neem oil 1500 ppm @ 3.0 lit/ha with 1:7.97, 1:7.88, 1:7.24, 1:3.94 and 1:3.25 cost benefit ratio, respectively. The lowest cost benefit ratio (1:2.69) was obtained in *B. thuringiensis* @ 1.0 kg/ha. Earlier Dhanlaxmi and Mallapur (2008) reported that the application of emamectin benzoate 5 SG @ 0.2 g/litre and spinosad 45 SC @ 1.0 ml/ha were the most effective against sucking pest and getting maximum fruit yield of brinjal. The higher yield recorded in the treatment of neem oil are in agreement with the finding of Dehariya *et al*., (2018) [8].

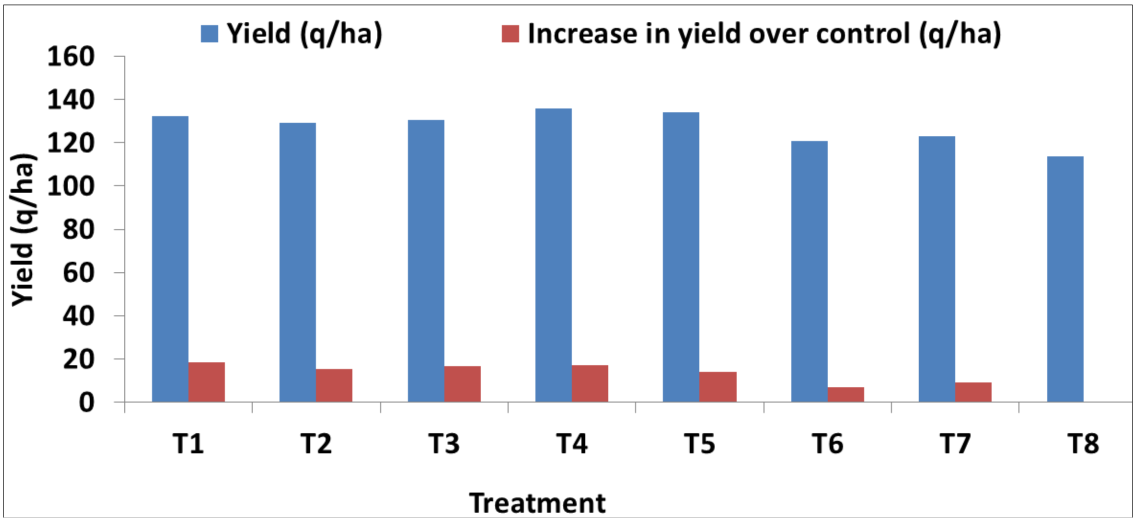

Fig 2: Effect of different treatments on yield of Brinjal

Table 2: Economics of different insecticides against whitefly

S. No.	Name of treatment	Brinjal Yield (q/ha)	Increase in yield over control (q/ha)	Value of Increase yield (Rs./ha)	Total cost of treatment application (Rs./ha)	Net income (Rs./ha)	Cost : benefit ratio
1.	Imidacloprid 17.8 SL	132.50	18.75	22500	1800	20700	1:11.50
2.	Buprofezin 25 SC	129.20	15.45	18540	2250	16290	1:7.24
3.	Fipronil 5 SC	130.40	16.65	19980	2250	17730	1:7.88
4.	Spinosad 45 SC	135.80	22.05	26460	5350	21110	1:3.94
5.	Emamectin benzoate 5SG	133.94	20.19	24228	2700	21528	1:7.97
6.	*Bacillus thuringiensis*	120.67	06.92	8304	2250	6054	1:2.69
7.	Neem oil 1500 ppm	122.80	9.05	10860	2550	8310	1:3.25
8.	Control	113.75					

Labour charge @ Rs. 200/day/labour 2. Sale price of product @ Rs. 1200/q 3. Charge of sprayer @ Rs. 50/day

4. Conclusion
The above findings showed that the most effective treatment in reducing the population of whitefly was imidacloprid 17.8 SL @ 100ml/ha followed by fipronil 5 SC @ 750 ml/ha, buprofezin 25 SC @ 800 ml/ha, spinosad 45 SC @ 160 ml/ha, emamectin benzoate 5 SG @ 125 g/ha at all-time intervals after first, second and third sprays. The *Bacillus thuringiensis* @ 1.0kg/ha was found least effective but it was significantly superior over control. The maximum yield was obtained with application of spinosad 45 SC @ 160 ml/ha giving 135.80 q/ha and was superior over the rest of the treatments. Cost benefit ratio of the treatments showed that imidacloprid 17.8 SL @ 100ml/ha ranked first indicating the maximum return Rs. 11.50 per rupee invested. Pesticide residues can remain as in the soil, water and even air, and impact flora and fauna, including humans and human health. The study's findings suggest that the imidacloprid 17.8 SL @ 100ml/ha was the most effective insecticide in reducing whiteflies population so present scenario there is need to more research work on imidacloprid required because their impact of non-targeted insects and their residues in the soil as well as on brinjal is limited findings.

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