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Bioefficacy of insecticides against major sucking insect pests of brinjal (*Solanum melongena* L.)

KR Meena, SK Khinchi, KC Kumawat, Akhter Hussain and Anita Sharma

Abstract
The bioefficacy of insecticides against the major sucking insect pests *viz.* jassid, *Amrasca biguttula biguttula* (Ishida) and Whitefly, *Bemisia tabaci* (Genn.) of brinjal, *solanum melongena* L. crop that the insecticide of imidacloprid 17.8 SL (0.005%) was found most effective against sucking insect pests on brinjal, followed by thiamethoxam 25 WG (0.005%), whereas, emamectin benzoate 5 SG (0.002%) and spinosad 45 SC (0.01%) were found to be least effective. The remaining treatments *viz.*, acetamiprid 20 EC (0.004%), acephate 75 SP (0.05%), indoxacarb 14.5 SC (0.005%) and fipronil 5 SC (0.01%) were found moderately effective. The maximum fruit yield was obtained in the treatment of imidacloprid 17.8 SL (220.73 q/ha), followed by thiamethoxam 25 WG (217.88 q/ha). The higher fruit yield was also obtained in the treatment of acetamiprid 20 EC (206.95 q/ha), followed by acephate 75 SP (205.27 q/ha), indoxacarb 14.5 SC (203.22 q/ha) and fipronil 5 SC (200.14 q/ha) and minimum fruit yield of 196.28 q/ hawas obtained in the treatment of emamectin benzoate 5 SG, followed by spinosad 45 SC (198.69 q/ha). The maximum net profit of rupees 124064/ha was obtained in the treatment of imidacloprid 17.8 SL, followed by thiamethoxam 25 WG (Rs. 120144/ha), while, the minimum net profit of rupees 91404 q/ha was obtained in the treatment of emamectin benzoate 5 SG followed by spinosad 45 SC (Rs. 93462 q/ha).

Keywords: Brinjal, jassids, whiteflies, insect pests, insecticides, Bioefficacy

Introduction
Brinjal, *solanum melongena* L. also known as eggplant belong to family solanaceae. Brinjal is often described as the 'King of vegetables 'due to its versatility use in Indian food (Choudhary and Gaur, 2009) [8]. It is an important and widely used vegetable crop grown in many countries *viz*, Central, South and South East Asia, some parts of Africa and Central America (Harish *et al.* 2011) [13]. in production and productivity, India is second in the world after China. In india the total area under brinjal cultivation was 6.80 lakh hectares with an annual production of 127.06 lakh tonnes (Anonymous, 2015) [3, 4]. During 2014-15, the area and production of brinjal in Rajasthan, India was 64.60 thousand hectares and 21.23 million tonnes, respectively (Anonymous, 2015) [3, 4]. Among the various causes of low productivity of the brinjal, one of the most important factors is the damage inflicted by the insect pests. It is subjected to attack by number of insect pests right from nursery stage to till harvesting. The important insect pests are shoot and fruit borer, *Leucinodes orbonalis* (L.) Guen.; jassid, *Amrasca biguttula biguttula* (Ishida) aphid, *Aphis gossypii* Glover; epilachna beetle, *Epilachna vigintioctopunctata* Fab.; whitefly and *Bemisia tabaci* (Gennadius.). Among sucking insect pests, jassids, *A. biguttula biguttula* and whitefly, *B. tabaci* cause damage by sucking cell sap on the leaves from the initial stage of crop growth. Yellow spot appear on the leaves, followed by curling and destroyed or "hopper burn". The damage caused by jassid on *S. melongena* have also reported by Gangwar *et al.* (2014) [10], Singh M (2015) [23], Borah and Saikia (2017) [7] and Kumar *et al.* (2019) [16]. To evolve the effective management strategy, the insect pests of brinjal including whitefly, *B. tabaci* and jassid, *A. biguttula biguttula* have been controlled by conventional insecticides recommended by many workers (Shivanna, 2011; Shaikh and Patel, 2012, Omprakash and Raju, 2013) [22, 19, 17]. These insecticides however, controlled the pests effectively but their continuous use creates problems like residue, resistance in insect pests and adverse effect on natural enemies *etc*. Therefore in the present studied, bio-efficacy of some insecticides were evaluated against whitefly, *B. tabaci* and jassid *A. biguttula biguttula* on brinjal, *S. melongena*.

Materials and methods

Experimental Details

The present experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) on brinjal, *S. melongena* crop during *Kharif*, 2016. Geographically, Jobner is located at longitude of 72º 28' East, latitude of 26º 06' North and at an elevation of 427 meters from mean sea level (MSL) in Jaipur district of Rajasthan, India. The climate of the region is typically semi-arid which is characterized by extremes of the temperature both during the summer and winter. During summer, temperature may rise as high as 45ºC and in winter it may fall as low as 0ºC. The total rainfall was 480 mm which is mostly received from July to September. This region provides a safe long growing season for most of the crop. A nursery bed of 3.0 m x 1.0 m x 0.15 m size was prepared for raising seedling of brinjal. The experiment was laid out in a simple Randomized Block Design (RBD) with nine treatments including untreated control, each replicated thrice. The seeds of variety 'Pusa Purple Round' were shown. The seedlings were ready for transplanting within five weeks of sowing. The beds of 9.0 m^2 size, paths and channels were also prepared. The recommended dose of fertilizers as per package of practices, *i.e.* NPK (80: 80: 60 kg/ha) were applied through Urea, DAP and Muriate of Potash. The plot size was 3 m x 3 m keeping row to row and plant to plant distance of 60 and 50 cm, respectively.

All the treatments were applied as foliar spray on brinjal by using pre-calibrated knapsack sprayer. Care was taken to check the drift of insecticides, by putting polythene sheet screen around the each plot the time of spraying. The first spray was given as soon as the incidence of jassid, *A. biguttula biguttula* and whitefly, *B. tabaci* were noticed and the subsequent sprays were applied after rebuild up of the pest population of brinjal, *S.melongena*. The untreated plots were sprayed with water only and total three sprays were given on brinjal against major sucking insect pests. The population of major sucking insect pests *viz*., jassid and whitefly were recorded at one day before and on 1^{st}, 3^{rd}, 7^{th} and 15^{th} day of each of three sprays and mean value of each spray was computed. Total yield of healthy fruit in each treatment was also computed. The per cent reductions of insect population were calculated and data were subjected to statistical analysis after angular transformation. The healthy fruits of all pickings in each treatment were pooled together to work out the total yield and ultimately the net profit and benefit: cost ratio was computed. The data obtained one day before and 1, 3, 7 and 15 days after the spray were taken into consideration to compute the percentage reduction in the population which was calculated by applying a formula given by Abbott (1925) [1]:

$$\text{Per cent control (reduction)} = \left(\frac{X-Y}{X}\right) X\ 100$$

Where,

X = Per cent living in the check (untreated control)

Y = Per cent living in the treated plot

X -Y = Per cent killed by the treatment

The statistical analysis (analysis of variance) was carried out by transforming the data of per cent reduction into angular transformation values (Gomez and Gomez, 1976) [12].

The percentage protection efficiency and yield loss of individual treatment was worked out by taking into account the mean fruit yield of best treatment and the fruit yield of individual treatment. The most effective and economical treatment, the net return and benefit-cost ratio was worked out by taking the expenditure on individual insecticidal treatment and the corresponding yield into account. The gross return was worked out by multiplying the yield with the wholesale price of brinjal, *S. melongena* prevailing in the market at the time of harvesting. The net return and benefit-cost ratio was evaluated by taking the expenditure on individual insecticidal treatment and the corresponding yield into account. The gross return was worked out by multiply the yield with the wholesale price of brinjal, *S. melongena* prevailing in the market at the time of harvesting. Healthy fruits of brinjal were harvested when they reached appropriate size and weight from each treatment was expressed as marketable yield in quintal per hectare and subjected to analysis of variance. The avoidable loss and increase in yield over control was calculated for each treatment.

Results and Discussion

Reduction in jassid, *A. biguttula biguttula* population

First insecticidal spray

The reduction in jassid, *A. biguttula biguttula* population as a result of first application of insecticides has been registered in table -1 one day after application of treatments on brinjal, *S. melongena*, the maximum reduction was recorded in imidacloprid 17.8 SL (0.005%) 85.80 per cent and thiamethoxam 25 WG (0.005%) 79.77 per cent which were found at par with each other but significantly superior over rest of the treatments. The effectiveness of most effective treatments *i.e.* imidacloprid are in agreement with those of Ghosal and Chatterjee (2013) [11] and Yadav and Kumawat (2014) [25] who reported imidacloprid was most effective against brinjal pest complex. Bharti and Shetgar (2016) [6], and Omprakash and Raju. (2013) [17] reported the lowest populations of major insect pests in brinjal in imidacloprid treated plots support the present study. The next effective treatment was found to beacetamiprid 20 EC (0.004%) 78.40 per cent. The minimum reduction of 63.03 and 66.13 per cent was recorded in emamectin benzoate 5 SG (0.002%) and spinosad 45 SC (0.01%), respectively, which were statistically at par with each other. Three days after application of the treatments, the maximum reduction injassid population was recorded in imidacloprid 17.8 SL (87.50%) and thiamethoxam 25 WG (82.92%) which were statistically at par each other and significantly superior over rest of the treatments. The minimum reductions of 65.03, 69.77 and71.47 per cent were recorded in emamectin benzoate 5 SG, spinosad 45 SG and fipronil 5 SC, respectively. After seven days of application of the treatments, the maximum reduction in jassid population was recorded in imidacloprid 17.8 SL (82.98%) closely followed by thiamethoxam 25 WG and acetamiprid 20 EC (76.53 and 76.10%). The next effective treatment was acephate 75 SP which reduced jassid population by 72.40 per cent. The minimum reduction of 60.10 and 63.47 per cent was recorded in emamectin benzoate 5 SG and spinosad 45 SC respectively, which were statistically at par with each other in their efficacy. The results are in agreement with those of Kalawate and Dethe (2012) [14] and Bharti *et al*. (2015) [5] reported both emamectin benzoate and spinosad is effective for management of sucking pests in brinjal. Sharma and Kaushik (2010) [21] and Yadav and Kumawat (2014) [25] reported that spinosad is effective for the management of pest complex in brinjal. Fifteen days after application of insecticides, the maximum reduction in jassid population was recorded in imidacloprid 17.8 SL (79.93%), closely followed by thiamethoxam 25 WG (74.77%), which were at par with each other and superior over rest of the treatments. The next effective treatments were found to be acetamiprid (73.03%) followed by acephate 75 SP resulting in 68.57 per cent reduction respectively. The minimum reduction of 57.03 and 60.67 per cent was recorded in emamectin benzoate 5 SG and fipronil 5 SC respectively, which were statistically at par with each other in their efficacy. The spinosad 45 SC and indoxacarb 14.5 SC which gave 62.33 to 64.98 per cent reduction in population, were statistically at par in their efficacy.

Table 1: Bioefficacy of newer insecticides against jassid, *Amrasca biguttula biguttula* (Ishida) on brinjal

S. No.	Treatments	Conc. (%)	Mean per cent reduction of jassid *A. biguttula biguttula* population after											
			First spray				Second spray				Third spray			
			1 day	3 days	7 days	15 days	1 day	3 days	7 days	15 days	1 day	3 days	7 days	15 days
1	Spinosad	0.01	66.13 (54.43)	69.77 (56.68)	63.47 (52.83)	62.33 (52.15)	61.67 (51.76)	71.40 (57.71)	64.33 (53.35)	61.43 (51.62)	67.33 (55.17)	71.47 (57.74)	70.20 (56.95)	64.60 (53.51)
2	Indoxacarb	0.005	71.98 (58.06)	74.80 (59.90)	68.65 (55.96)	64.98 (53.73)	69.03 (56.20)	78.57 (62.44)	68.85 (56.09)	62.53 (52.27)	72.77 (58.57)	75.15 (60.13)	77.40 (61.65)	68.53 (55.89)
3	Imidacloprid	0.005	85.80 (68.09)	87.50 (69.59)	82.98 (65.79)	79.93 (63.49)	79.98 (63.53)	86.50 (68.70)	82.94 (65.76)	78.98 (62.81)	86.94 (69.08)	88.30 (70.33)	88.15 (70.19)	82.96 (65.78)
4	Thiamethoxam	0.005	79.77 (63.66)	82.92 (66.19)	76.53 (61.28)	74.77 (60.06)	76.65 (61.37)	82.92 (66.19)	76.50 (61.26)	74.50 (59.88)	80.73 (64.40)	82.98 (66.24)	80.90 (64.53)	76.43 (61.21)
5	Acetamepried	0.004	78.40 (62.35)	80.03 (63.50)	76.10 (60.76)	73.03 (58.74)	72.43 (58.35)	79.03 (62.79)	76.03 (60.72)	72.03 (58.09)	79.20 (62.91)	81.23 (64.38)	80.43 (63.79)	76.03 (60.72)
6	Fipronil	0.01	67.53 (55.28)	71.47 (57.74)	64.77 (53.60)	60.67 (51.17)	62.90 (52.49)	70.67 (57.23)	64.77 (53.60)	62.73 (52.38)	68.50 (55.88)	68.67 (55.99)	71.53 (57.78)	64.47 (53.42)
7	Emamectin benzoate	0.002	63.03 (52.57)	65.03 (53.76)	60.10 (50.84)	57.03 (49.05)	61.03 (51.38)	66.33 (54.55)	60.20 (50.89)	56.03 (48.47)	63.15 (52.64)	65.50 (54.05)	67.07 (55.00)	56.53 (48.76)
8	Acephate	0.05	74.87 (60.01)	78.57 (62.57)	72.40 (58.38)	68.57 (55.95)	70.27 (57.02)	75.55 (60.39)	72.40 (58.38)	68.57 (55.95)	75.57 (60.48)	79.73 (63.26)	77.50 (61.81)	70.90 (57.42)
9	Control (untreated)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S.Em.±		1.82	2.02	1.66	1.54	1.60	1.93	1.66	1.52	1.88	1.96	1.96	1.64
	CD (p = 0.05)		5.46	6.06	4.97	4.62	4.79	5.78	4.98	4.57	5.65	5.88	5.88	4.94

Figures in parentheses are angular values

Second insecticidal spray

After one day of the second spray, the maximum reduction in jassid, *A. biguttula biguttula* population was observed in imidacloprid 17.8 SL (79.98%) and thiamethoxam 25 WG (76.65%). Bharti and Shetgar (2016) [6], and Omprakash and Raju. (2013) [17] reported the lowest populations of major insect pests in brinjal in imidacloprid treated plots support the present funding. Contrary to this, the reduction was minimum in plots treated with emamectin benzoate 5 SG (61.03%), spinosad 45 SC (61.67%) and fipronil 5 SC (62.90%), which were at par with each other. After three days of the second spray, the maximum reduction in jassid population was observed in imidacloprid 17.8 SL (86.50%) and thiamethoxam 25 WG (82.92%), and acetamiprid 20 EC (79.03%), followed by indoxacarb 14.5 SC (78.57%).These results are agreement with Anand *et al*. (2013) [2] reported acetamiprid was effective against both jassid and whitefly. These results are in agreement with those of Kumar *et al*. (2017) [15] and Yadav and Kumawat (2014) [25] who reported acephate was effective in reducing pest population in brinjal ecosystem. The present results are also corroborate with that of Sinha and Vishwa Nath (2011) [24] reported indoxacarb was to be effective in controlling the pests population in brinjal. These results are in agreement with those of Das and Islam (2014) [9] & Sinha and Vishwa Nath (2011) [24] reported fipronil as effective against brinjal sucking insect pests. The minimum reduction in jassidpopulation was observed in emamectin benzoate 5 SG, fipronil 5 SC and spinosad 45 SC (66.33-71.40%), these were found at par with each other. The other treatments, acephate 75 SP and indoxacarb 14.5 SC were found to be moderately effective. After seven days of the second spray, the maximum reduction in jassid population was observed in imidacloprid 17.8 SL (82.94%) and thiamethoxam 25 WG (76.50%), and acetamiprid 20 EC (76.03%), proved less effective than imidacloprid 17.8 SL. The reduction was minimum inemamectin benzoate 5 SG and spinosad 45 SC (60.20- 64.33%).After fifteen days of the second application of insecticides, imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 EC (78.98-72.03%) still maintained their efficacy.

Third insecticidal spray

Slightly higher reduction in jassid population as compared to second spray was observed after one day of third spray. It was highest in imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 EC (86.94-79.20%) followed by acephate 75 SP (75.57%), *vis-a-vis*, lowest in emamectin benzoate 5 SG (63.15%).The effectiveness of thiamethoxam are in agreement with those of Ghosal and Chatterjee (2013) [11], Omprakash and Raju (2013) [17], Shaik *et al*. (2014), Shaik and Patel (2012) reported thiamethoxam as the most effective against brinjal pest complex. The indoxacarb 14.5 SC and fipronil 5 SC exhibited reduction of 72.77 and 68.50 per cent. The emamectin benzoate 5 SG was found in the lowest order and ranked next to spinosad 45 SC (67.33% reduction).After three days, the imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 EC were highly effective (88.30-81.23% reduction) which differed from acephate 75 SP (79.73% reduction). The emamectin benzoate 5 SG, fipronil 5 SC and spinosad 45 SC (65.50-71.47% reduction) were found in lowest order, while indoxacarb 14.5 SC (75.15% reduction) ranked in the middle order. A gradual increase in population level was observed after seven days of application with more or less same order except the fact that the emamectin benzoate 5 SG and spinosad 45 SC ranked in the lowest order of effectiveness (67.07-70.20% reduction). Further decreasing trend in reduction of jassid population was evident after fifteen days of spray, the order of effectiveness were imidacloprid 17.8 SL > thiamethoxam 25 WG > acetamiprid 20 EC > acephate 75 SP > indoxacarb 14.5 SC > spinosad 45 SC fipronil 5 SC >> emamectin benzoate 5 SG.

Reduction in Whitefly, *B. tabaci* population

First insecticidal spray

The whitefly, *B. tabaci* infestation appeared on second week of August, 2016.At one day after application of treatments on brinjal, it was observed that all the insecticides significantly reduced whitefly, *B. tabaci* population over untreated control (Table2). The maximum reduction was recorded in imidacloprid 17.8 SL (87.85%) which was significantly superior over rest of the insecticides. This was followed by thiamethoxam 25 WG (84.33%) which were statistically at par with each other, but significantly superior over rest of all the treatments. The minimum reduction of 61.85 to 72.13 per cent was recorded in emamectin benzoate 5 SG, spinosad 45 SC and fipronil 5 SG. The effectiveness of emamectin benzoate against sucking insect pests on brinjal get support with the finding of Patel *et al*. (2015) [18] who reported emamectin benzoate effective in reducing pest population in brinjal. Three days after application of the treatments, maximum reduction in whitefly population was in imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 EC (90.30- 81.46%). The minimum reductions of 66.50 to 74.32 per cent were recorded in emamectin benzoate 5 SG, spinosad 45 SC and fipronil.5 SC. Seven days after application of the treatments, the maximum reduction in whitefly population were recorded in imidacloprid 17.8 SL (83.45%) and thiamethoxam 25 WG (81.30%) which were at par with each other closely followed by acetamiprid 20 EC (76.47%) and marginally superior over acephate 75 SP (76.73% reduction). Spinosad 45 SC, fipronil 5 SC and indoxacarb 14.5 SC brought about moderate reduction in population (74.45- 75.30%), while emamectin benzoate 5 SG were least effective (67.53% reduction).Fifteen days after application of the insecticides, the reduction in whitefly population was still around 76 per cent in imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid treated plots which were superior over rest of the treatments.

Table 2: Bioefficacy of newer insecticides against whitefly, *Bemisia tabaci* (Genn.) on brinjal

S. No.	Treatments	Conc. (%)	Mean per cent reduction of whitefly, *B. tabaci* population after											
			First spray				Second spray				Third spray			
			1 day	3 days	7 days	15 days	1 day	3 days	7 days	15 days	1 day	3 days	7 days	15 days
1	Spinosad	0.01	71.93 (58.05)	72.93 (58.69)	74.45 (59.68)	73.47 (59.04)	74.57 (59.76)	73.57 (59.10)	73.43 (59.01)	71.20 (57.58)	72.50 (58.41)	67.80 (55.45)	70.67 (57.24)	72.53 (58.43)
2	Indoxacarb	0.005	76.51 (61.04)	77.43 (61.67)	75.30 (60.23)	71.03 (57.45)	76.60 (61.10)	77.53 (61.74)	77.67 (61.84)	72.23 (58.22)	74.92 (59.97)	75.98 (60.68)	79.96 (63.45)	72.03 (58.09)
3	Imidacloprid	0.005	87.85 (69.91)	90.30 (71.97)	83.45 (66.04)	81.27 (64.39)	85.53 (67.70)	89.43 (71.13)	85.13 (67.37)	80.67 (63.95)	85.33 (67.53)	88.66 (70.41)	85.03 (67.29)	79.33 (62.98)
4	Thiamethoxam	0.005	84.33 (67.43)	86.12 (69.18)	81.30 (64.85)	76.13 (61.00)	81.92 (65.35)	83.67 (66.84)	79.92 (63.77)	77.41 (61.91)	81.03 (64.64)	83.80 (66.95)	79.85 (63.72)	77.03 (61.64)
5	Acetamiprid	0.004	79.53 (63.15)	81.46 (64.58)	76.47 (61.03)	74.90 (59.97)	80.03 (63.53)	81.43 (64.56)	74.20 (59.51)	75.53 (60.39)	78.50 (62.43)	80.33 (63.74)	78.40 (62.36)	76.20 (60.85)
6	Fipronil	0.01	72.13 (58.16)	74.32 (59.58)	73.04 (58.75)	68.30 (55.75)	72.67 (58.51)	76.23 (60.86)	72.50 (58.40)	68.33 (55.77)	73.67 (59.16)	75.85 (60.61)	70.90 (57.38)	70.50 (57.13)
7	Emamectin benzoate	0.002	61.85 (51.87)	66.50 (54.66)	67.53 (55.29)	64.53 (53.46)	67.69 (55.38)	69.85 (56.73)	69.03 (56.21)	65.17 (53.85)	68.20 (55.70)	69.01 (56.20)	69.21 (56.33)	65.21 (53.87)
8	Acephate	0.05	78.53 (62.54)	81.50 (64.64)	76.73 (61.22)	71.65 (57.87)	78.53 (62.48)	83.56 (66.22)	78.13 (62.19)	72.65 (58.51)	76.63 (61.16)	79.30 (63.02)	76.30 (60.93)	72.50 (58.41)
9	Control (untreated)	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S.Em.±		2.10	1.69	1.33	1.13	1.37	1.50	1.28	1.17	1.32	1.49	1.28	1.16
	CD (p = 0.05)		6.83	5.07	4.00	3.39	4.13	4.50	3.84	3.51	3.98	4.47	3.84	3.48

Figures in parentheses are angular values

Second insecticidal spray

After one day of the second spray, the maximum reduction in whitefly population was observed in the treatment of imidacloprid 17.8 SL (85.53%) followed by next effective group of treatments, thiamethoxam 25 WG and acetamiprid (81.92 and 80.03% reduction). The minimum reduction were in emamectin benzoate 5 SG (67.69%) and fipronil 5SC (72.67%). These results are in agreement with those of Sinha and Vishwa Nath (2011) [24] and Das and Islam (2014) [9] reported fipronil as effective against brinjal sucking insect pests. After three days of the second spray, the reduction in whitefly population further slightly increased and maximum in imidacloprid 17. 8 SL (89.43%) and thiamethoxam 25 WG (83.67%) which were at par with each other. The next effective treatment were found acephate 75 SP (83.56%) followed by acetamiprid 20 EC (81.43%), while emamectin benzoate 5 SG, spinosad 45 SC and fipronil 5 SC (69.85 and 76.23%) were least effective and indoxacarb 14.5 were in the middle order of effectiveness (77.53% reduction).After seven and fifteen days, there was gradual decrease in effectiveness of the treatments. Seven days after the treatments, the maximum reduction in whitefly population was observed in imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 EC (85.13- 79.92%). The reduction was minimum in emamectin benzoate 5 SG (69.03%) and fipronil 5 SC (72.50%), which were found at par each other and differed significantly over rest of the treatments.

Third insecticidal spray

After one day of the third spray, the highest reduction of whitefly population was recorded in imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 EC (85.33-78.50%) which differed from acephate 75 SP (76.63%), *vis-a-vis*, lowest in emamectin benzoate 5 SG, spinosad 45 SC and fipronil 5 SC, (68.20-73.67%). The indoxacarb 14.5 SC exhibited reduction (74.92%) in the middle order. After three days, the imidacloprid 17.8 SL, thiamethoxam 25 WG and acetamiprid 20 EC were highly effective (88.66-80.33% reduction) which differed from acephate 75 SP (79.30% reduction). The order of effectiveness after fifteen days was: imidacloprid 17.8 SL > thiamethoxam 25 WG > acetamiprid 20 EC > acephate 75 SP > indoxacarb 14.5 SC > fipronil 5 SC >spinosad 45 SC > emamectin benzoate 5 SG.

Economics of insecticides used against major sucking insect pests of brinjal

Brinjal, *S. melongena* fruit yield in different insecticides treated plots were found to be in the range of 196.28 – 220.73 q/ ha, *vis-a-vis*., 114.26 q/ha in untreated control (Table 3). The highest yield was recorded in plots treated with imidacloprid 17. 8 SL (220.73 q/ha), which was at par with thiamethoxam 25 WG (217.88 q/ ha). Acetamiprid 20 EC (206.95 q/ha), acephate 75 SP (205.27 q/ha), indoxacarb 14.5 SC (203.22 q/ha) and fipronil 5 SC (200.14 q/ha) were found in the middle order. The present finding is in full conformity with that Ghosal and Chatterjee (2013) [11] and Yadav and Kumawat (2014) [25] imidacloprid as effective insecticide in reducing the sucking insects pests and increasing the fruit yield in brinjal. Ghosal and Chatterjee (2013) [11], and Omprakash and Raju. (2013) [17] observed lowest population of sucking pests on brinjal crop in the treatment of thiamethoxam with highest fruit yield.The minimum fruit yield of brinjal was obtained in emamectin benzoate 5 SG (196.28 q/ha) which was found at par with spinosad 45 SC (198.69 q/ha).

The maximum net profit of Indian rupees 124064/ha was obtained in the treatment of imidacloprid 17.8 SL followed by thiamethoxam 25 WG (Rs. 120144 /ha), while, the minimum net profit of rupees 91404 q/hawas obtained in the treatment of emamectin benzoate 5 SG followed by spinosad 45 SC (Rs. 93462 q/ha). The maximum benefit cost ratio of 33.53 was obtained in the treatment of imidacloprid 17.8 SL followed by acetamiprid 20 EC (33.33), acephate 75 SP (29.94), thiamethoxam 25 WG (28.31), indoxacarb 14.5 SC (19.93) and fipronil 5 SC (14.34) while, minimum was in spinosad 45 SC and emamectin benzoate 5 SG. The present findings are in agreement with those of Kumar *et al.* (2017) [15] recorded highest B:C ratio in the treatment of imidacloprid followed by thiamethoxam. Likewise, Shaik and Patel (2012) recorded highest B:C ratio in imidacloprid followed by thiamethoxam.

Table 3: Comparative economics of insecticidal treatments on brinjal, *S. melongena* crop

S. No.	Treatments	Conc. (%)	Yield of healthy fruits (q ha^{-1})	Total Increase in yield over control (q ha^{-1})	Per cent increase in yield over control	Return of increased yield (Rs)	Total cost / expenditure (Rs)	Net profit (rs ha^{-1})	B:C ratio
1	Spinosad 45 SC	0.01	198.69	84.43	73.89	101316	7853	93462	11.90
2	Indoxacarb 14.5 SC	0.005	203.22	88.96	77.86	106752	5101	101651	19.93
3	Imidacloprid 17.8 SL	0.005	220.73	106.47	93.18	127764	3699	124064	33.53
4	Thiamethoxam 25 WG	0.005	217.88	103.62	90.69	124344	4200	120144	28.61
5	Acetamiprid 20 EC	0.004	206.95	92.69	81.12	111228	3240	107988	33.33
6	Fipronil 5 SC	0.01	200.14	85.88	75.16	103056	6720	96336	14.34
7	Emamectin benzoate 5 SG	0.002	196.28	82.02	71.78	98424	7020	91404	13.02
8	Acephate 75 SP	0.05	205.27	91.01	79.65	109212	3530	105682	29.94
9	Control	-	114.26	0.00	0.00	0.00	0.00	0.00	0.00

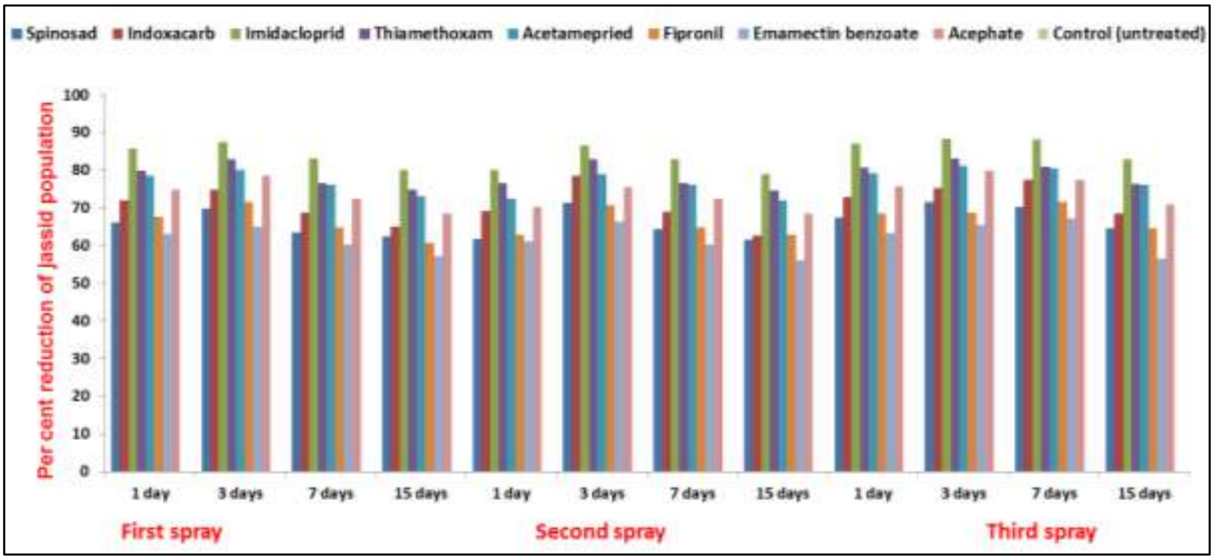

Fig 1: Bioefficacy of newer insecticides against jassid, *Amrasca biguttula biguttula* (Ishida) on brinjal

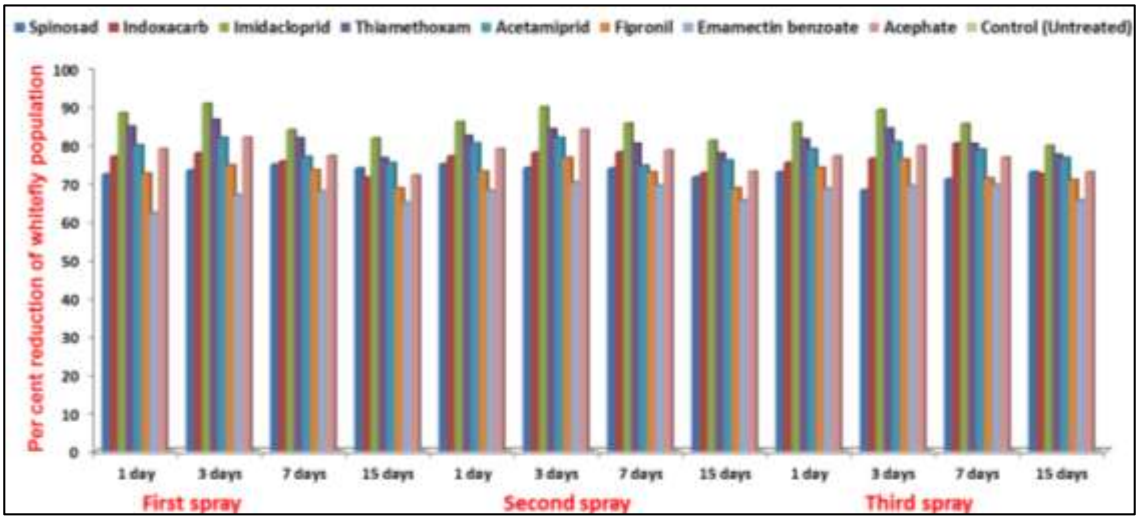

Fig 2: Bioefficacy of newer insecticides against whitefly, *Bemisia tabaci* (Genn.) on brinjal

Conclusion

The bio-efficacy of insecticides against the major sucking insect pests of brinjal crop that the treatment of imidacloprid 17.8 SL was found most effective whereas, emamectin benzoate 5 SG and spinosad 45 SC were found to be least effective. The maximum fruit yield was obtained in the treatment of imidacloprid 17.8 SL. The minimum fruit yield was obtained in the treatment of emamectin benzoate 5 SG. The maximum net profit of rupees was obtained in the treatment of imidacloprid 17.8 SL, followed by thiamethoxam 25 WG, while, the minimum net profit was obtained in the treatment of emamectin benzoate 5 SG. The maximum benefit cost ratio was obtained in the treatment of imidacloprid 17.8 SL while, minimum was in spinosad 45 SC and emamectin benzoate 5 SG.

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