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Farmers participatory on farm evaluation of IPM technology and chemical pesticides against major pests of Brinjal

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Abstract
The present field experiment was carried out during the summer seasons of 2013 and 2014, respectively (March to August each year) with F1 brinjal hybrid, Chhaya in farmers participatory on farm evaluation of IPM technology and chemical pesticides against major pests of brinjal at three locations of Dehradun (Uttarakhand). The results of the investigation revealed that treatment 1 received lowest incidence of mean shoot damage, mean fruit damage of shoot and fruit borer, red spider mite and bacterial wilt. The infestation of mean shoot damage varied from 2.06 to 36.20 during 2013 and 3.21 to 39.73 during 2014. Similarly mean fruit damage ranges from 5.26 to 44.35 and 4.08 to 47.26 during 2013 and 2014, respectively. Incidence of red spider mite was also recorded which varied from 4.15 to 74.59 per cent in 2013 and 2.87 to 78.26 per cent in 2014. The incidence of bacterial wilt was also found which ranges from 1.02 to 31.66 and 0.80 to 37.28 per cent during 2013 and 2014, respectively. The incidence of bacterial wilt was managed successfully in treatment 1 due to introduction of bacterial wilt tolerant hybrid i.e. Chhaya. The experimentations also envisaged that treatment 1 fetched maximum mean fruit yield i.e. 556.24 Q/ha in 2013 and 544.80 Q/ha in 2014 which was significantly superior over all other treatments during both years.

Keywords: IPM technology, incidence, Chhaya, shoot damage, fruit damage, red spider mite, bacterial wilt, chemical pesticides

1. Introduction
Brinjal, *Solanum melongena* L. is one of the commercially important vegetable crops grown round the year in our country [9]. The area under brinjal has increased considerably from the last one decade due to introduction of high yielding hybrids and varieties and their suitability to grow even under hot summer and kharif seasons [2]. It occupies 0.60 million ha area with the total production of 10.37 million tonnes and the average productivity is 17.30 tonnes/ha and 13.97 tonnes/ha in Uttarakhand which are low as compared to potential yields recorded up to 55.05 tonnes/ha in the field experiments carried out at Dehradun (Uttarakhand) [1]. The low average productivity of brinjal in the country including Uttarakhand is due to various reasons. Amongst which poor availability and adoption of high yielding hybrids and varieties especially in remote areas of the country alongwith lack of proper production and protection technologies[9]. Incidence of pests is one of the major constraints often resultin cent percent loss in productivity and quality both, if left unchecked [13]. The shoot and fruit borer, *Leucinodes orbonalis* Guen., red spider mite, *Tetranychus cinnabarinus* Boisd, bacterial wilt *Ralstonia solanacearum* are considered as the most limiting factors[10]. Most of the farmers use chemical pesticides injudiciously to control these pests, which caused undesirable ecological changes including risk to human health. In view of the above, farmers participatory on farm evaluation on IPM and adoption of IPM technology in holistic manner incorporating judicious use of modern chemical pesticides seem to be best alternative. Hence, the present investigation was taken to study the effectiveness of IPM technology in brinjal at Dehradun region of Uttarakhand.

2. Materials and Methods
The present field experiments were carried out at three locations namely KVK, Dhakrani, Asanbagh and Bhimawala of Vikasnagar block near Govind Ballabh Pant University of Agriculture and Technology, Krishi Vigyan Kendra, Dhakrani, Dehradun (Uttarakhand) for two consecutive years 2013 and 2014.

The F1 hybrid 'Chhaya' was raised at 60x50 cm spacing adopting recommended agronomic practices in a randomized block design (RBD) with seven treatments including one untreated control, each replicated thrice. The size of each plot was 20 m^2 (5x4 m^2). Four-week-old seedlings were uprooted and then transplanted in all the plots during second week of March 2013 and 2014. Spraying of chemical pesticides was done with knapsack sprayer using 600 liter of spray fluid/ ha. Observations were made on three leaves from top, middle and bottom for red spider mite at weekly interval started 40 days after transplanting in all the three locations. Observations on percent shoot infestation were recorded at 5, 10 and 15 days of each spray from ten randomly selected plants of each plot. For percent fruit damage, the number of infested and healthy as well as weight of healthy and infested fruits from ten observational plants was recorded at each picking. The total weight of healthy and infested fruits for all picking was pooled and total yield per plot was computed and converted into quintals per hectare. The data on incidence of bacterial wilt were also recorded under investigation during observation of red spider mite at weekly intervals starting 40 days after transplanting. The number of infected plant was counted during each observation and finally the total infected plants with bacterial wilt per plot was recorded and presented in the tables 1and 2.

Treatment 1

- Seed treatment with imidacloprid 70% WS @ 10g/kg of seeds.
- Use of neem cake @250 kg/ha before sowing.
- Planting of F1 hybrids of brinjal "chhaya" which is tolerant against bacterial wilt.
- Hand picking and destruction of infested leaves, shoots and fruits of shoot and fruit borer, red spider mite infected leaves at initial stage.
- Application of indoxacarb @ 0.5 ml/l water,40 and 60 days after planting (when incidence of shoot and fruit borer was recorded).
- Application of hexythiazox 1 ml/l water + propargite 1 ml/ l water 80 and 100 days after planting for control of red spider mite.

Treatment 2

- Planting of F1 hybrid Anamika,
- Spraying of spinosad 0.5 ml/l water 40 and 60 days after planting.
- Spraying ofimidacloprid 0.75 ml/l water 75 and 90 days after planting.
- Spraying of hexythiazox 1 ml/l water + propargite 1 ml/l water 80 and 100 days after planting.

Treatment 3

- Planting of F1 hybrid Anamika.
- Spraying of spinosad 0.5 ml/l water 40 and 60 days after planting.
- Application ofimidacloprid 0.75 ml/l water 75 and 90 days after planting.
- Three applications of dicofol 2 ml/l water 80, 90 and 100 days after planting for control of red spider mite.

Treatment 4

- Planting of F1 hybrid Anamika.
- Application of acetamiprid 0.5 ml/l water 40 and 60 days after planting.
- Spraying cypermethrin 1 ml/l water 75 and 90 days after planting.
- Three applications of fenzaquin 1 ml/l water 80, 90 and 100 days after planting.

Treatment 5

- Planting of F1 hybrid Anamika.
- Spraying of imidacloprid 0.75 ml/l water 40 and 60 days after planting
- Application of quinalphos 2 ml/l water 75 and 90 days after planting.
- Three applications of fenzaquin 1 ml/l water 80, 90 and 100 days after planting.

Treatment 6 (Farmers practice)

- Planting of F1 hybrid (Anamika).
- Application of wooden ash on the plants at 10 days interval upto 50 days.
- Two application of quinalphos 2 ml/l water 30 and 50 days after planting.
- Three applications of cypermethrin 1 ml/l water 60, 70 and 80 days after planting.
- Two applications of imidacloprid 1 ml/l water 90 and 100 days after planting
- Three sprays of dicofol 2 ml/l water 75, 85 and 105 days after planting for control of red spider mite.
- Drenching of streptocycline sulphate 6g + copper oxychloride 180 g in 60 l water. Drenching was done three times at 15 days interval starting 35 days after planting for the control of bacterial wilt.

Treatment 7

- Control (Anamika F1 hybrid was planted without adopting any control measures.

The study was conducted in a randomized block design (RBD) with seven treatments including one untreated control, each replicated thrice. Square root transformation was used to analyze the data.

3. Results and Discussion

The investigation laid out on impact of IPM technologies and other chemical pesticide treatments against major pests of brinjal showed that treatment 1 proved to be most effective in reduction of mean shoot damage and was significantly superior over all other treatments during both the years of studies except treatment 4 during 2014. The mean shoot damage varied from 2.06 to 36.20 per cent during 2013 and 3.21 to 39.73 per cent during 2014. The lowest mean shoot damage was recorded from treatment 1 i.e. 2.06 and 3.21 per cent during 2013 and 2014, respectively followed by treatment 4 in which mean shoot damage was 5.73 per cent in 2013 and 7.02 per cent in 2014 (Table 1). The maximum mean shoot damage was observed from treatment 7 (control) i.e. 36.20 per cent in 2013 and 39.73 per cent in 2014. The data recorded during experimentation revealed that treatment 6 (Farmers practice) received highest mean shoot damage which was 12.88 and 14.62 per cent during 2013 and 2014, respectively but they were lowest and significantly superior during both the years over control. The mean fruit damage was also recorded in all the treatments and varied from 5.26 to 44.35 per cent in 2013 and 4.08 to 47.26 per cent in 2014 (Table 1). The mean fruit damage was also minimum in treatment 1 during both the years. It was 5.26 per cent during 2013 and 4.08 per cent during 2014. The treatment 1 was significantly superior over all other treatments in respect of

mean fruit damage except treatment 2 and treatment 4 during 2013. The treatment 4 was the next best treatment in which 8.77 and 9.54 per cent fruit damage was found during 2013 and 2014, respectively (Table 1). The highest fruit damage was recorded from treatment 7 (control) i.e. 44.35 per cent in 2013 and 47.26 per cent in 2014. The farmers practice (treatment 6) also received higher mean fruit damage that was 21.04 and 23.65 per cent during 2013 and 2014, respectively but they were significantly superior to control during both the years. It is clear from the investigation that infestation of shoot and fruit borer was observed in all the treatments but its level of incidence was varied due to effectiveness of insecticides applied in various treatments. It has been noted during experimentation that mean shoot damage and mean fruit damage was lowest in treatment 1 because of the application of indoxacarb at 40 and 60 days after planting. Earlier studies conducted by Rai *et al.* [7] and Singh [11] also reported that 2-3 sprays of indoxacarb provided effective control from mean shoot damage and mean fruit damage caused due to infestation of shoot and fruit borer in brinjal.

The incidence of red spider mite was also noticed and accordingly different types of acaricides were sprayed in various treatments. The data recorded on incidence of red spider mite among different treatments indicated that its incidence was lowest in treatment 1 i.e. 4.15 percent in 2013 and 2.87 percent in 2014 which was at par with treatment 2. The incidence of red spider mite in treatment 2 was 4.27 and 3.04 per cent during 2013 and 2014, respectively (Table 1). The incidence of red spider mite was maximum in treatment 7 (control) i.e. 74.59 per cent in 2013 and 78.26 per cent in 2014.The farmers practice (treatment 6) recorded maximum incidence of red spider mites which was 31.05 and 29.30 per cent during 2013 and 2014, respectively. However treatment 6 was significantly superior to control in respect of incidence of red spider mite during both the years of investigation. The survey and studies carried out from time to time in brinjal growing areas of Dehradun under Horticulture Technology Mission Project envisaged that incidence of red spider mite was earlier not a problem in brinjal. However, in recent years, red spider mite has become a serious pest of brinjal and caused enormous economic loss to the growers in June and July. It was also noticed that all the hybrids and varieties of brinjal were affected severely due to incidence of red spider mite under unprotected condition. In the present investigation, hexythiazox and propargite acaricides were applied at 80 and 100 days after planting which worked very effectively against the target pest. The incidence of red spider mite was very low in treatment 1 due to application of hexythiazox having ovicidal action and propargite having adulticidal action hence, combination of both the acaricides have managed the menace of mite very significantly which was in conformity with the studies laid out by Rai *et al.* [7].

The observations taken on incidence of bacterial wilt from various treatments revealed that incidence varied from 1.02 to 31.66 per cent during 2013 and 0.80 to 37.28 per cent during 2014. The lowest incidence was found in treatment 1 i.e. 1.02 percent in 2013 and 0.80 per cent in 2014 which was significantly superior over all other treatments in respect of incidence of bacterial wilt (Table 1). The data observed from time to time during experimentation exhibited that incidence of bacterial wilt was recorded in all the treatments except treatment 1 in which incidence was very low. However, in other treatments, incidence of bacterial wilt was higher and it was found maximum in treatment 7 (control) i.e. 31.66 and 37.28 per cent during 2013 and 2014, respectively. The treatment 3 received 24.02 per cent incidence of red spider mite in 2013, which was maximum but it was significantly superior to control. However, during 2014 treatment 2 recorded maximum incidence of red spider mite i.e. 27.68 but it was also significantly superior over control. In farmers practice (treatment 7), incidence of bacterial wilt was low as compared to few treatments. It was 19.48 per cent in 2013 and 21.62 per cent in 2014 (Table 1).The incidence of bacterial wilt in brinjal is one of the serious threats in its commercial cultivation. Most of the hybrids and varieties of brinjal have become susceptible against bacterial wilt but few hybrids and varieties released in the recent past having resistance properties against Chhaya is a F1 hybrid of brinjal is tolerant against bacterial wilt whose performance was very promising and incidence of bacterial wilt was almost negligible in this hybrid. However, Anamika is also a F1 hybrid of brinjal showed susceptibility against bacterial wilt. Use of tolerant and resistant hybrids and varieties against bacterial wilt and having good yield potential is one of the major thrust areas of any IPM programme as their adoption in commercial cultivation greatly reduces the consumption of chemical pesticides and increases the fruit yield. Keeping these realistic issues in consideration Chhaya hybrid of brinjal was used in treatment 1, which was based on IPM technology. Metcalf and Luckmann[6] also emphasized that tolerant and resistant cultivars are one of the viable component of IPM and proper attention need to be given in selection of cultivars for commercial cultivation in order to maximize the productivity and minimize the use of chemical pesticides.

The fruit yield, cost of cultivation, gross income, net income and C:B ratio was also recorded during investigation and calculated. The data recorded from time to time on mean fruit yield showed that yield varied from 141.05 to 556.24 Q/ha during 2013 and 126.65 to 544.80 Q/ha during 2014 (Table 2). The observations taken during field trials revealed that treatment 1 gave maximum yield i.e. 556.24 Q/ha in 2013 and 544.80 Q/ha in 2014 which was significantly superior over all other treatments during both years of studies. The treatment 2 was the next effective treatment in which 407.72 Q/ha and 378.64 Q/ha mean fruit yield was observed during 2013 and 2014, respectively. The lowest mean fruit yield was noticed in treatment 7 (control) in which 141.05 Q/ha in 2013 and 126.65 Q/ha in 2014 yield was obtained. The treatment 6 (farmers practice) recorded comparatively low mean fruit yield i.e. 298.17 and 311.70 Q/ha during 2013 and 2014, respectively but they were significantly superior to treatment 7 (control). The gross income calculated after the completion of experiments envisaged that maximum gross income was found in treatment 1 which was Rs. 528428 per ha in 2013 and Rs. 544800 per ha in 2014 followed by treatment 2 which exhibited gross income of Rs. 326176 and 340776 per ha during 2013 and 2014, respectively (Table 2). Due to poor fruit yield in treatment 7 (control) gross income was only Rs. 70525 per ha in 2013 and Rs. 75990 per ha in 2014. It was lowest among all the treatments observed in field trials during both the years. The gross income was also low in treatment 6 (farmers practice) i.e. Rs. 238536 per ha during 2013 and 280530 per ha during 2014 but this treatment was superior to control. Almost same trend was recorded in net income. The treatment 1 manifested highest net income which was Rs. 396728 and 407900 per ha during 2013 and 2014, respectively followed by treatment 2 which received net income of Rs. 217626 per ha in 2013 and Rs. 226176 per ha in 2014. The minimum net income of Rs. 29325 and Rs. 31290 per ha was noticed in treatment 7 (control) during 2013

and 2014, respectively. The farmers practice (treatment 6) recorded net income Rs. 139736 per ha in 2013 and Rs. 177930 per ha in 2014 which was superior to control but low as compared to other treatments investigated during field trials. The C:B ratio varied from 1.71 to 4.01 in 2013 and 1.70 to 3.97 in 2014 (Table 2). According to earlier parameters, C:B ratio was also maximum in treatment 1 ie. 4.01 and 3.97 during 2013 and 2014, respectively followed by treatment 2 in which C:B ratio was 3.00 in 2013 and 2.97 in 2014. The treatment 7 showed lowest C:B ratio which was 1.71 and 1.70 during 2013 and 2014, respectively. The C:B ratio in farmers practice treated plots observed better C:B ratio than control which was 2.41 in 2013 and 2.73 in 2014. The C:B ratio noticed in farmers practice was close to other treatments like treatments 2 to 5. The result of the field trials revealed that mean fruit yield, net income and C:B ratio was maximum in treatment 1 because of adoption of IPM technology in which tolerant hybrid against bacterial wilt, promising insecticide for management of shoot and fruit borer, effective acaricides having ovicidal and adulticidal action were incorporated besides seed treatment and other IPM practices.

The present findings are in conformity with Eswara Reddy SG, Srinivasan N [3] Kumar *et al*. [4], Kumar *et al.* [5], Sharma *et al*. [8] who also reported that IPM program based on judicious use of selective insecticides and acaricides along with improved cultural practices and tolerant varieties significantly reduced the number of application of chemical pesticides and also kept the pest population below economic injury level as compared to conventional pest management program. Some researchers Sinha & Sharma [12] and Sidhu & Dhatt [9] have evaluated different IPM modules with combination of different control measures in their investigations against pests of brinjal in different parts of the country, whose recommendations support the present findings.

4. Conclusion

It is clear from the investigation that treatment 1, which was based on IPM technology fetched very remunerative income by effective management of shoot and fruit borer, red spider mite and bacterial wilt. It is also important to note that average productivity of brinjal was 55.05 tonnes per ha harvested from treatment 1. It became possible due to adoption of various IPM practices including tolerant hybrid and use of selective chemical pesticides at proper time which also reduced the unnecessary consumption of chemical pesticides in brinjal.

Table 1: Impact of IPM technologies and other pesticidal treatments on reduction of major pests of brinjal

Treatments	Mean shoot damage (%)		Pooled mean	Mean fruit damage (%)		Pooled mean	Incidence of red spider mite (%)		Pooled mean	Incidence of bacterial wilt (%)		Pooled mean
	2013	2014		2013	2014		2013	2014		2013	2014	
T 1	2.06 (1.60)	3.21 (1.93)	2.64 (1.77)	5.26 (2.40)	4.08 (2.14)	4.67 (2.27)	4.15 (2.16)	2.87 (1.84)	3.51 (2.00)	1.02 (1.23)	0.80 (1.14)	0.91 (1.19)
T 2	6.84 (2.71)	7.89 (2.90)	7.37 (2.81)	9.18 (3.11)	10.24 (3.28)	9.71 (3.20)	4.27 (2.18)	3.04 (1.88)	3.66 (2.04)	23.50 (4.90)	27.68 (5.31)	25.59 (5.11)
T 3	6.15 (2.58)	8.84 (3.06)	7.50 (2.83)	10.07 (3.25)	9.12 (3.10)	9.60 (3.18)	28.65 (5.40)	30.96 (5.61)	29.81 (5.51)	24.02 (4.95)	22.10 (4.75)	23.06 (4.85)
T 4	5.73 (2.50)	7.02 (2.74)	6.38 (2.62)	8.77 (3.04)	9.54 (3.17)	9.16 (3.11)	11.88 (3.52)	13.04 (3.68)	12.46 (3.60)	22.89 (4.84)	20.76 (4.61)	21.83 (4.73)
T 5	9.05 (3.09)	11.54 (3.47)	10.30 (3.29)	16.58 (4.13)	14.91 (3.93)	15.75 (4.03)	14.01 (3.81)	12.45 (3.60)	13.23 (3.71)	20.75 (4.61)	23.84 (4.93)	22.30 (4.77)
T6 (Farmers Practice)	12.88 (3.66)	14.62 (3.89)	13.75 (3.77)	21.04 (4.64)	23.65 (4.91)	22.35 (4.78)	31.05 (5.62)	29.30 (5.46)	30.18 (5.54)	19.48 (4.47)	21.62 (4.70)	20.55 (4.59)
T7 (control)	36.20 (6.06)	39.73 (6.34)	37.97 (6.20)	44.35 (6.70)	47.26 (6.91)	45.81 (6.81)	74.59 (8.67)	78.26 (8.87)	76.43 (8.77)	31.66 (5.67)	37.28 (6.15)	34.47 (5.91)
SE at 5 %	0.574	0.282	0.257	0.258	0.282	0.196	0.607	0.611	0.390	0.083	0.290	0.318
CD at 5 %	0.785	0.877	0.798	0.801	0.878	0.611	1.889	1.901	1.212	0.259	0.901	0.989

Table 2: Impact of IPM technologies and other pesticidal treatments on fruit yield of brinjal

Treatments	Mean fruit yield (Q/ha)		Pooled mean (Q/ha)	Cost of cultivation (Rs./ha)		Gross income (Rs./ha)		Net income (Rs./ha)		C:B Ratio	C:B Ratio	Pooled C:B ratio
	2013	2014		2013	2014	2013	2014	2013	2014	2013	2014	
T 1	556.24 (23.60)	544.80 (23.35)	550.52	131700	136900	528428	544800	396728	407900	4.01	3.97	3.99
T 2	407.72 (20.20)	378.64 (19.47)	393.18	108550	114600	326176	340776	217626	226176	3.00	2.97	2.98
T 3	384.50 (19.62)	371.84 (19.29)	378.17	105800	109750	307600	334656	201800	224906	2.90	3.04	2.97
T 4	354.15 (18.83)	339.04 (18.42)	346.59	99100	107800	283320	305136	184220	197336	2.85	2.83	2.84
T 5	331.74 (18.22)	318.90 (17.87)	325.32	97900	103950	265392	287010	167492	183060	2.71	2.76	2.73
T6 (Farmers Practice)	298.17 (17.28)	311.70 (17.66)	304.93	98800	102600	238536	280530	139736	177930	2.41	2.73	2.57
T7 (control)	141.05 (11.90)	126.65 (11.28)	163.85	41200	44700	70525	75990	29325	31290	1.71	1.70	1.71
SE at 5 %	0.643	0.484	65.269									
CD at 5 %	2.001	1.505	202.987									

- Price of Chhaya hybrid was Rs. 950 per Q. During 2013 and Rs. 1000 per Q. During 2014.
- Price of Anamika was Rs. 800 per Q. During 2013 and Rs. 900 per Q. During 2014.
- Price of Anamika planteed in the control was sold @ Rs. 600 pe rQ. During both the years.

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