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To study the efficacy of molecule combinations against gram pod borer (*Helicoverpa armigera* Hubner) in chickpea (*Cicer arietinum* L.)

KU Jadhav, AP Chavan, SA More, SR Kulkarni and RA Karande

Abstract
Field studies were undertaken to study the efficacy of molecule combinations *viz*., emamectin benzoate 5% + lufenuron 40% WG @ 27 (3 + 24) g a. i./ha, cyantraniliprole 10.26% OD + lufenuron 5.40% EC @ 5 + 3.75 g a.i./ha, chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC @ 30 g a. i./ha, ethion 40% + cypermethrin 5% EC @ 400 + 50 g a. i./ha , chlorantraniliprole 18.5% SC @ 25 g a. i./ha, profenofos 40% + cypermethrin 4% EC @ 440 + 660 g a. i./ha, novaluron 5.25% + indoxacarb 4.50% SC @ 43.31 + 37.13 g a. i./ha against gram pod borer, *H. armigera* during *Rabi* season 2020-21. The results revealed that emamectin benzoate 5% + lufenuron 40% WG (0.82 larvae/meter row length) was most superior to reduce the *H. armigera* population in chickpea , the next effective treatment was chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (1.13 larvae/meter row length), followed by cyantraniliprole 10.26% OD + lufenuron 5.40% EC (1.26 larvae/meter row length). Rest of the treatments were also effective in reducing larval population of *H. armigera* (1.33 -1.82 larvae/meter row length) as compared to untreated control (2.98 larvae/meter row length).

Keywords: chickpea, efficacy, *H. armigera*, insecticides combinations

Introduction
Gram pod borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is the most significant pest of chickpea. Farmers have become hesitant to cultivate chickpea due to its susceptibility to pod borer. Gram pod borer, *Helicoverpa armigera* (Hubner), a worldwide and polyphagous pest equipped with multivoltine, diapauses and is exaggerated due to its attack on reproductive stages, chiefly on fruiting bodies, highly mobile and nocturnal in nature spread quickly in wide areas, found to cause economic damage to numerous cultivated crops *viz*., chickpea, pigeonpea, tomato, chilli, okra, etc throughout the year in India and sub-continent. Many insecticides have been reported to be effective for controlling *H. armigera* in different crops (Dhaka *et al.*, 2015) [1]. Over-dependence on a particular group of chemicals is one of the important reasons for quick development of resistance. Their indiscriminate use has generated number of well-known problems. However, in the year of epidemic, use of conventional insecticides fails to regulate the damage. Among the several avenues to overcome the insecticidal resistance problem, use of pesticides in their combination is one of the important considerations for controlling pod borers on chickpea. Bearing in mind the above facts, the present experiment was carried out to study the efficacy of molecule combinations against gram pod borer (*H. armigera*) in chickpea.

Materials and Methods
The field experiments were undertaken to study the efficacy of molecule combination against gram pod borer (*H. armigera*) on chickpea (*Cicer arietinum* L.) during *Rabi* 2020-21 at Research farm, College of Agriculture, Pune-05, Dist. Pune (MS). The experiment was laid out in Randomized Block Design (RBD) with eight treatments replicated thrice using chickpea variety "Vikram". During the period of the experiment, the mentioned insecticides were sprayed for two times at 15 days interval early in the morning before 9:00 a.m. for achieving effective control. The survival larval population of gram pod borer, *H. amigera* larvae on chickpea was recorded per meter row length at three spots per treatment per replication one day before spray as pre-count and post-count at 3, 7 and 10 days after each spray. At the time of maturity per cent pod damage and grain yield was recorded.

$$\text{Pod damage (\%)} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Yield

The plants of chickpea were harvested separately from each treatment plot and yield of chickpea was recorded per replication per treatment after harvesting and was calculated on hectare basis.

Results and Discussion

Before spray, the larval population of *H. armigera* varied from 2.99 to 3.33 larvae/meter row length. It was statistically non-significant.

After first spray

At 3 DAS, all the insecticidal treatments were recorded to be significantly effective in lowering the larval population of gram pod borer when compared to untreated control. Among the different treatments emamectin benzoate 5% + lufenuron 40% WG (1.33 larvae/ meter row length) was found to be most effective in reducing larval population and it was at par with chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (1.66 larva/meter row length), cyantraniliprole 10.26% OD + lufenuron 5.40% EC 1.77 larvae/meter row length) and chlorantraniliprole 18.5% SC (1.88 larvae/meter row length). The treatments with ethion 40% + cypermethrin 5% EC and novaluron 5.25% + indoxacarb 4.50% SC with larval population of 2.33 and 2.33 larva/ meter row length, respectively were found comparatively less effective and maximum larval population (3.00 larvae/ meter row length) was recorded in untreated control. At 7 DAS, the treatment with emamectin benzoate 5% + lufenuron 40% WG recorded lowest (1.00 larvae/meter row length) larval population and it was at par with chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (1.33 larva/meter row length). The next effective treatments were cyantraniliprole 10.26% OD + lufenuron 5.40% EC, chlorantraniliprole 18.5% SC, profenofos 40% + cypermethrin 4% EC, ethion 40% + cypermethrin 5% EC and novaluron 5.25% + indoxacarb 4.50% SC with larval population of 1.55, 1.66, 1.89, 2.00, 2.11 larvae/ meter row length, respectively as against 2.89 larvae/ meter row length in untreated control. At 10 DAS, among the different treatments emamectin benzoate 5% + lufenuron 40% WG recorded lowest (1.11 larvae/meter row length) larval population and no any other treatment was found at par with it. The next effective treatments were chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC, cyantraniliprole 10.26% OD + lufenuron 5.40% EC, chlorantraniliprole 18.5% SC, profenofos 40% + cypermethrin 4% EC, ethion 40% + cypermethrin 5% EC and novaluron 5.25% + indoxacarb 4.50% SC with larval population of 1.66, 1.66, 1.77, 2.00, 2.33, 2.33 larvae/ meter row length, respectively as against 3.00 larvae/ meter row length in untreated control.

Table 1: Efficacy of different insecticides combinations against gram pod borer, *H. armigera* on chickpea after first spray.

SN	Treatment	Dose (ml or g/ha)	Pre-count	Population of *H. armigera* larvae /meter row length after first spray		
				Post count		
				3 DAS	7 DAS	10 DAS
1.	Emamectin benzoate 5% + Lufenuron 40% WG	60	3.22 (2.05)*	1.33 (1.53)	1.00 (1.41)	1.11 (1.45)
2.	Cyantraniliprole 10.26% OD + Lufenuron 5.40%EC	125	3.11 (2.03)	1.77 (1.66)	1.55 (1.59)	1.66 (1.63)
3.	Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC	200	3.00 (2.00)	1.66 (1.63)	1.33 (1.53)	1.66 (1.63)
4.	Ethion 40% + Cypermethrin 5% EC	1000	3.33 (2.08)	2.33 (1.82)	2.00 (1.73)	2.33 (1.82)
5.	Chlorantraniliprole 18.5% SC	125	3.00 (2.00)	1.88 (1.70)	1.66 (1.63)	1.77 (1.66)
6.	Profenofos 40% + Cypermethrin 4% EC	1000	2.99 (1.99)	2.11 (1.76)	1.89 (1.70)	2.00 (1.73)
7.	Novaluron 5.25% + Indoxacarb 4.50% SC	825	3.22 (2.05)	2.33 (1.82)	2.11 (1.76)	2.33 (1.82)
8.	Untreated control	-	3.00 (2.00)	3.00 (2.00)	2.89 (1.97)	3.00 (2.00)
SE ±			0.06	0.06	0.05	0.05
CD at 5%			NS	0.18	0.16	0.16
CV(%)			5.25	5.75	5.41	5.44

*Figures in parentheses are $\sqrt{x+1}$ transformed values
DAS- Days after spraying

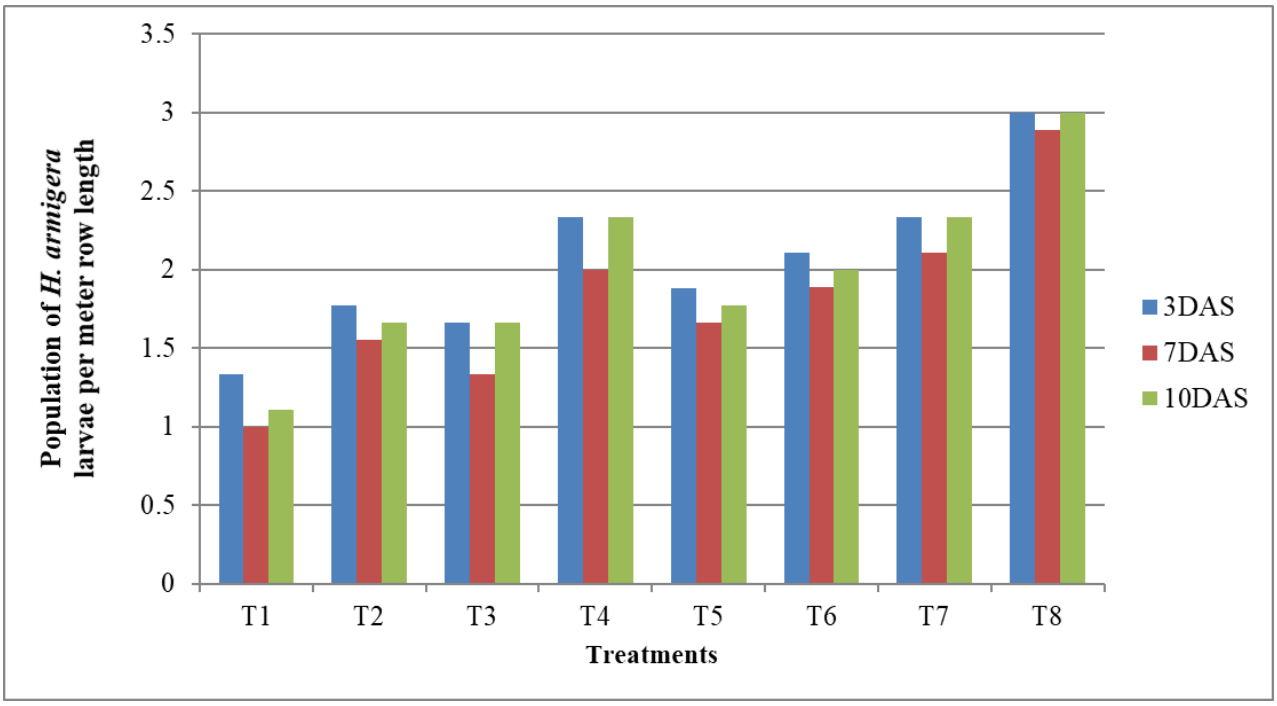

Fig 1: Efficacy of different insecticides combinations against gram pod borer, *H. armigera* on chickpea after first spray.

Table 2: Efficacy of different insecticides combinations against gram pod borer, *H. armigera* on

SN	Treatment	Dose (ml or g/ha)	Pre-count	Population of *H. armigera* larvae /meter row length after first spray		
				Post count		
				3 DAS	7 DAS	10 DAS
1.	Emamectin benzoate 5% + Lufenuron 40% WG	60	1.55 (1.60)*	0.66 (1.29)	0.33 (1.15)	0.44 (1.20)
2.	Cyantraniliprole 10.26% OD + Lufenuron 5.40%EC	125	2.11 (1.76)	1.00 (1.41)	0.66 (1.29)	0.89 (1.37)
3.	Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC	200	1.66 (1.63)	0.77 (1.33)	0.55 (1.24)	0.77 (1.33)
4.	Ethion 40% + Cypermethrin 5% EC	1000	2.44 (1.85)	1.33 (1.53)	1.11 (1.45)	1.22 (1.49)
5.	Chlorantraniliprole 18.5% SC	125	2.22 (1.79)	1.00 (1.41)	0.77 (1.33)	0.89 (1.37)
6.	Profenofos 40% + Cypermethrin 4% EC	1000	2.22 (1.79)	1.11 (1.45)	0.89 (1.37)	1.00 (1.41)
7.	Novaluron 5.25% + Indoxacarb 4.50% SC	825	2.55 (1.88)	1.55 (1.60)	1.22 (1.49)	1.33 (1.53)
8.	Untreated control	-	3.00 (2.00)	3.11 (2.03)	3.00 (2.00)	2.89 (1.97)
SE ±			0.04	0.04	0.04	0.04
CD at 5%			0.13	0.13	0.12	0.11
CV(%)			4.22	4.96	4.72	4.33

chickpea after second spray

*Figures in parentheses are $\sqrt{x+1}$ transformed values
DAS- Days after spraying

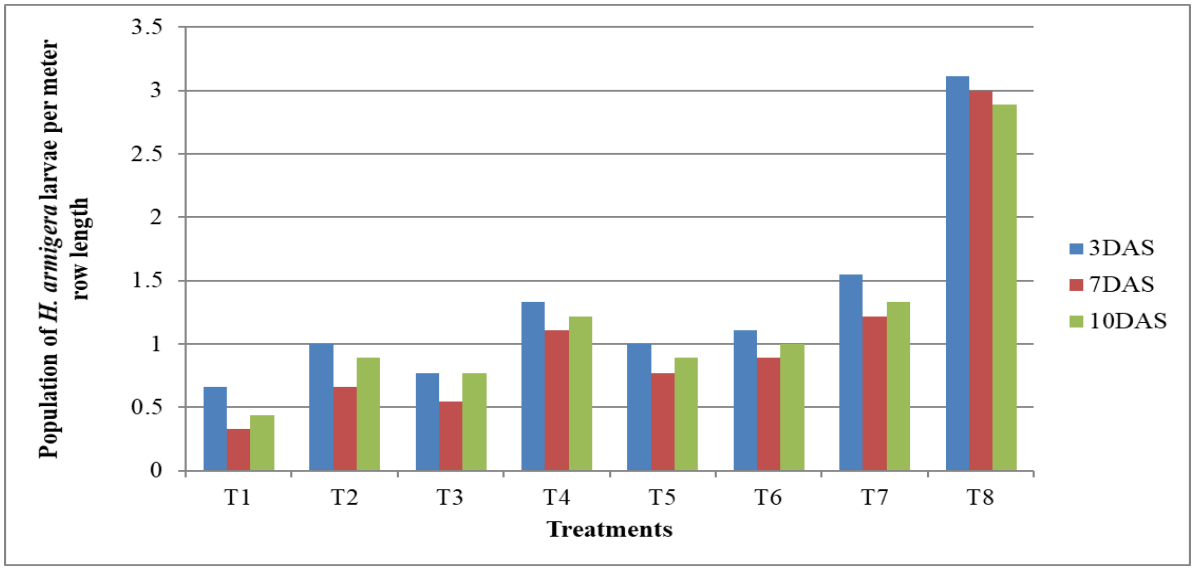

Fig 2: Efficacy of different insecticides combinations against gram pod borer, *H. armigera* on chickpea after second spray

Table 3: Cummulative efficacy of different insecticides combinations against gram pod borer, *H. armigera* on chickpea

SN	Treatment	Dose (ml or g/ha)	Pre-count	Population of *H. armigera* larvae / meter row length			
				Post count			
				3 DAS	7 DAS	10 DAS	Pooled Mean
1.	Emamectin benzoate 5% + Lufenuron 40% WG	60	2.39 (1.83)*	1.00 (1.41)	0.67 (1.28)	0.76 (1.33)	0.82 (1.34)
2.	Cyantraniliprole 10.26% OD + Lufenuron 5.40% EC	125	2.61 (1.90)	1.39 (1.54)	1.11 (1.44)	1.28 (1.50)	1.26 (1.50)
3.	Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC	200	2.33 (1.82)	1.22 (1.48)	0.94 (1.39)	1.22 (1.48)	1.13 (1.45)
4.	Ethion 40% + Cypermethrin 5% EC	1000	2.89 (1.97)	1.83 (1.68)	1.56 (1.59)	1.78 (1.66)	1.72 (1.64)
5.	Chlorantraniliprole 18.5% SC	125	2.61 (1.90)	1.44 (1.56)	1.22 (1.48)	1.33 (1.52)	1.33 (1.52)
6.	Profenofos 40% + Cypermethrin 4% EC	1000	2.61 (1.90)	1.61 (1.61)	1.39 (1.54)	1.50 (1.57)	1.50 (1.57)
7.	Novaluron 5.25% + Indoxacarb 4.50% SC	825	2.89 (1.97)	1.94 (1.71)	1.67 (1.63)	1.83 (1.68)	1.82 (1.67)
8.	Untreated control	-	3.00 (2.00)	3.06 (2.02)	2.95 (1.98)	2.95 (1.98)	2.98 (1.99)
SE ±			0.03	0.04	0.04	0.04	0.01
CD at 5%			0.08	0.12	0.11	0.11	0.03
CV(%)			2.50	4.17	4.00	3.81	1.13

*Figures in parentheses are $\sqrt{x+1}$ transformed values
DAS- Days after spraying

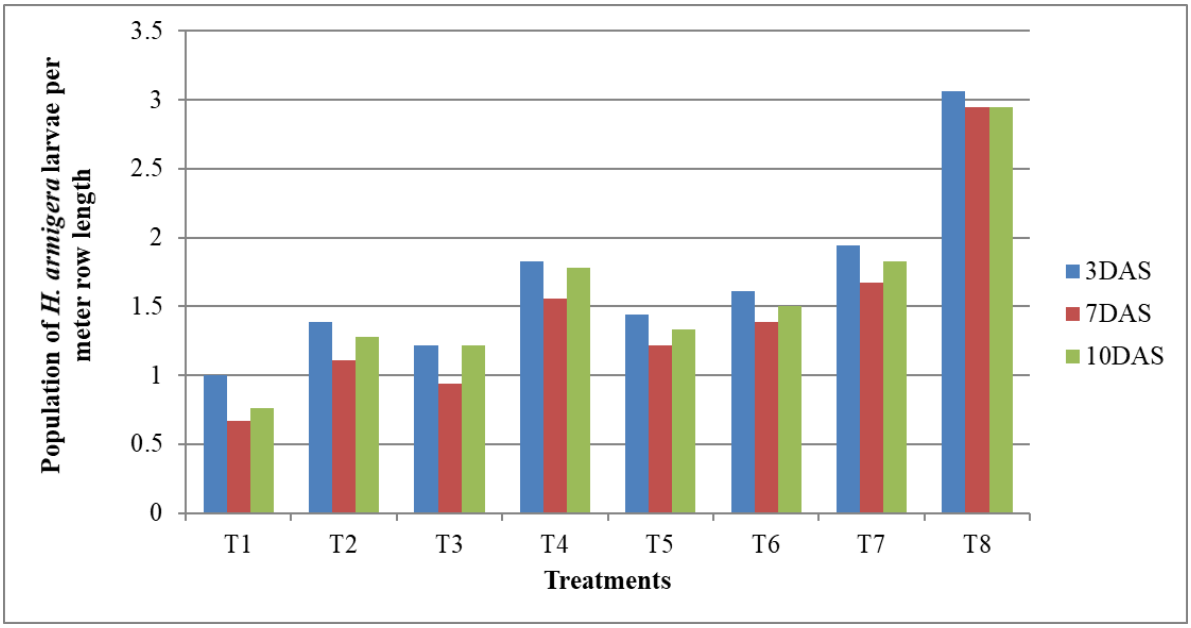

Fig 3: Cummulative efficacy of different insecticides combinations against gram pod borer, *H. armigera* on chickpea.

After second spray

All the insecticidal treatments were recorded to be significantly effective in lowering the larval population of gram pod borer when compared to untreated control. At 3 DAS, among the various treatments emamectin benzoate 5% + lufenuron 40% WG (0.66 larvae/ meter row length) was found most effective in reducing larval population and it was at par with chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (0.77 larva/meter row length), cyantraniliprole 10.26% OD + lufenuron 5.40% EC (1.00 larvae/meter row length) and chlorantraniliprole 18.5% SC (1.00 larvae/meter row length). The treatments with ethion 40% + cypermethrin 5% EC and novaluron 5.25% + indoxacarb 4.50% SC with larval population of 1.33 and 1.55 larva/ meter row length, respectively were found comparatively less effective and maximum larval population (3.11 larvae/ meter row length) was recorded in untreated control. At 7 DAS, the treatment with emamectin benzoate 5% + lufenuron 40% WG recorded lowest (0.33 larvae/meter row length) larval population and it was at par with chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (0.55 larva/meter row length). The next effective treatments were cyantraniliprole 10.26% OD + lufenuron 5.40% EC, chlorantraniliprole 18.5% SC, profenofos 40% + cypermethrin 4% EC, ethion 40% + cypermethrin 5% EC and novaluron 5.25% + indoxacarb 4.50% SC with larval population of 0.66, 0.77, 0.89, 1.11, 1.22 larvae/ meter row length, respectively as compared to 3.00 larvae/ meter row length in untreated control. At 10 DAS, all insecticidal treatments were still recorded to be significantly effective in lowering the larval population of gram pod borer ten days after spraying when compared to the untreated control. Among the different treatments emamectin benzoate 5% + lufenuron 40% WG recorded lowest (0.44 larvae/meter row length) larval population and there was no other treatment found at par with it. The next effective treatments were chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC, cyantraniliprole 10.26% OD + lufenuron 5.40% EC, chlorantraniliprole 18.5% SC, profenofos 40% + cypermethrin 4% EC, ethion 40% + cypermethrin 5% EC and novaluron 5.25% + indoxacarb 4.50% SC with larval population of 0.77, 0.89, 0.89, 1.00, 1.22, 1.33 larvae/ meter row length, respectively as compared to 2.89 larvae/ meter row length in untreated control.

Pooled mean

The data relating to overall pooled mean efficacy of the treatments during the *Rabi* 2020-21 revealed that among the treatments, emamectin benzoate 5% + lufenuron 40% WG was the most superior (0.82 larvae/meter row length) and no any other treatment was found at par with it. The next effective treatments were chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (1.13 larvae/meter row length), cyantraniliprole 10.26% OD + lufenuron 5.40% EC (1.26 larvae/meter row length), chlorantraniliprole 18.5% SC (1.33 larvae/meter row length), profenofos 40% + cypermethrin 4% EC (1.50 larvae/meter row length), ethion 40% + cypermethrin 5% EC (1.72 larvae/meter row length) and novaluron 5.25% + indoxacarb 4.50% SC (1.82 larvae/meter row length). Maximum larval population was recorded in untreated control (2.98 larvae/meter row length).

The current findings are in agreement with the results reported by earlier workers Prakash *et al.* (2021) Prakash recorded minimum larval incidence of *H. armigera* on pigeonpea in the treatment with emamectin benzoate 5% + lufenuron 40% WG followed by lufenuron 5.4% EC. These findings were in support with Yadav *et al.* (2019) [3] recorded lowest *H. armigera* larval population in the treatment with emamectin benzoate 5 SG followed by flubendiamide 480 SC in chickpea. This is in line with observations recorded by Jakhrejo *et al*. (2020) [4] reported emamectin benzoate 2.1 EC was the most effective treatment on chickpea, followed by indoxacarb 16.5 EC. Basavanneppa and Balikai (2016) [5] reported that the flubendiamide and emamectin benzoate were the most effective treatments free from pod borer infestation in chickpea, followed by cyantraniliprole, chlorantraniliprole, spinosad and indoxacarb. These findings corroborate with Patel *et al.* (2015) [6] observed lowest larval population of gram pod borer in the treatment with chlorantraniliprole 18.5% SC, chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC and chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC.

Per cent pod damage

All the insecticidal treatments were found to be significantly effective in lowering the per cent pod damage (1.33 to 7.18) of gram pod borer when compared to untreated control (16.80%). Amongst the various treatments emamectin benzoate 5% + lufenuron 40% WG recorded significantly least pod per cent damage (1.33%) and it was at par with cyantraniliprole 10.26% OD + lufenuron 5.40% EC (2.87%) and chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (4.05%). The next best treatment were chlorantraniliprole 18.5% SC (5.80%), profenofos 40% + cypermethrin 4% EC (6.30%), ethion 40% + cypermethrin 5% EC (6.47%) and novaluron 5.25% + indoxacarb 4.50% SC (7.18%) were also effective in reducing the pod infestation on chickpea as compared to untreated control (16.80%).

Chauhan *et al*. (2016) [7] reported that emamectin benzoate 5% SG was found most effective in reducing pod damage (4.32%) followed by indoxacarb 14.5% SC (4.36%) and chlorantraniliprole 18.5% SC (4.40%) which support the present finding. The current findings are in close agreement with the results reported by Prakash *et al.* (2021) [2] observed significantly lower pod damage in pigeonpea due to the larvae of *H. armigera* in the treatment emamectin benzoate 5% + lufenuron 40% WG (4.2%) followed by lufenuron 5.4% EC (10.6%). These findings are in line with Chaukikar *et al.* (2017) [8] who reported the pooled data of two years among different treatments on chickpea and the treatment with emamectin benzoate 5% WG found most effective in reducing pod damage (1.28% and 1.29%). These finding corroborate with Waseem *et al*. (2018) [9] who reported that spinetoram 120 SC and flubendamide 480 SC recorded minumum pod borer damage (4.62 and 5.25%) followed by emamectin benzoate 1.9 EC (6.61%) and lufenuron 50 EC (9.67%).

Grain yield

The data displayed that the yield obtained from all treatments ranged between 8.57 to 15.93 qt/ha. Among the insecticidal treatments highest (15.93 qt/ha.) grain yield was recorded from the plot treated with emamectin benzoate 5% + lufenuron 40% WG and it was at par with chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC (15.26 qt/ha.) and cyantraniliprole 10.26% OD + lufenuron 5.40% EC (14.60 qt/ha.). The next effective treatments were chlorantraniliprole 18.5% SC, profenofos 40% + cypermethrin 4% EC, novaluron 5.25% + indoxacarb 4.50% SC and ethion 40% + cypermethrin 5% EC with significantly higher yield of 13.67, 12.83, 11.87 and 11.32 qt/ha., respectively than untreated control (8.57 qt/ha.).

This is in agreement with Patel *et al.* (2015) [6] who observed that chlorantraniliprole 18.5% SC recorded highest grain yield of pigeonpea. While, profenophos 50 EC, chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC @ 37.5 g a.i./ha, chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC @ 30 g a.i./ ha and indoxacarb 14.5% SC rank second in controlling the pod borer complex and yield. Similarly, Chitralekha *et al.* (2018) [10] reported highest yield in the plots treated with chlorantraniliprole 18.5 SC (1494.72 kg/ha) followed by novaluron 10 EC (1392.37) which support the current findings.

Table 4: Per cent pod damage due to *H. armigera* in different insecticides combination treatments at maturity stage in chickpea during *Rabi* 2020-21.

SN	Treatment	Dose (ml or g/ha)	Pod damage (%)
1.	Emamectin benzoate 5% + Lufenuron 40% WG	60	1.33 (6.60)*
2.	Cyantraniliprole 10.26% OD + Lufenuron 5.40% EC	125	2.87 (9.64)
3.	Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC	200	4.05 (11.36)
4.	Ethion 40% + Cypermethrin 5% EC	1000	6.47 (14.57)
5.	Chlorantraniliprole 18.5% SC	125	5.80 (13.72)
6.	Profenofos 40% + Cypermethrin 4% EC	1000	6.30 (14.33)
7.	Novaluron 5.25% + Indoxacarb 4.50% SC	825	7.18 (15.36)
8.	Untreated control	-	16.80 (24.12)
SE ±			1.62
CD at 5%			4.91
CV(%)			20.45

*Figures in parentheses are arcsine transformed values

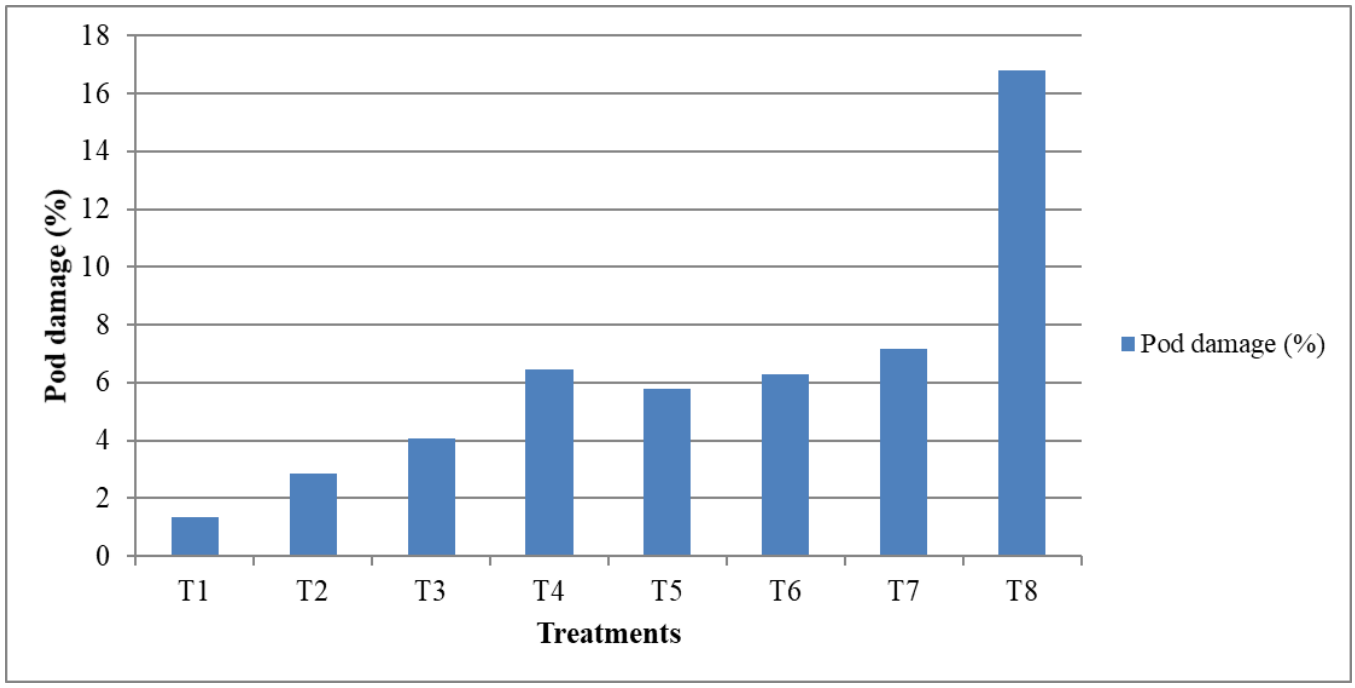

Fig 4: Per cent pod damage due to *H. armigera* in different insecticides combination treatments at maturity stage in chickpea during *Rabi* 2020-21.

Table 5: Marketable yield in different insecticides combinations treatments in chickpea during *Rabi* 2020-21.

SN	Treatment	Dose (ml or g/ha)	Marketable Yield (q/ha)
1.	Emamectin benzoate 5% + Lufenuron 40% WG	60	15.93
2.	Cyantraniliprole 10.26% OD + Lufenuron 5.40% EC	125	14.60
3.	Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC	200	15.26
4.	Ethion 40% + Cypermethrin 5% EC	1000	11.32
5.	Chlorantraniliprole 18.5% SC	125	13.67
6.	Profenofos 40% + Cypermethrin 4% EC	1000	12.83
7.	Novaluron 5.25% + Indoxacarb 4.50% SC	825	11.87
8.	Untreated control	-	8.57
SE ±			0.41
CD at 5%			1.25
CV(%)			5.48

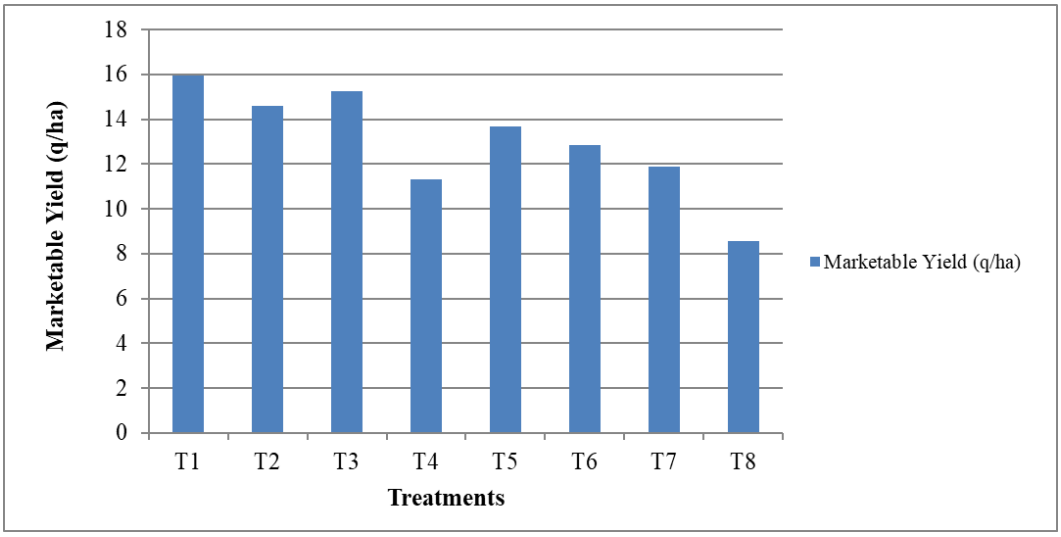

Fig 5: Marketable yield in different insecticides combinations treatments in chickpea during *Rabi* 2020-21.

Conclusion

Among the insecticides combination, emamectin benzoate 5% + lufenuron 40% WG @ 27 (3 + 24) g a. i./ha was found to be the most effective treatment against *H. armigera* on chickpea. The next effective treatment recorded was chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC @ 30 g a. i./ha and cyantraniliprole 10.26% OD + lufenuron 5.40% EC @ 5 + 3.75 g a. i./ha.

With respect to per cent pod damage emamectin benzoate 5% + lufenuron 40% WG was found to be the best treatment in recording minimum pod damage followed by cyantraniliprole 10.26% OD + lufenuron 5.40% EC and chlorantraniliprole

10% + lambda-cyhalothrin 5% ZC.

The highest grain yield was obtained from emamectin benzoate 5% + lufenuron 40% WG @ 27 (3 + 24) g a. i./ha followed by chlorantraniliprole 10% + lambda-cyhalothrin 5% ZC @ 30 g a. i./ha and cyantraniliprole 10.26% OD + lufenuron 5.40% EC @ 5 + 3.75 g a. i./ha.

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