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Field efficacy and economics of selected insecticides against pod borer [*Helicoverpa armigera* (Hubner)] on green gram [*Vigna radiata* (L.) Wilczek]

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Abstract
The present experiment based on Field efficacy and economics of selected insecticides against pod borer [*Helicoverpa armigera* (Hubner)] on green gram [*Vigna radiata* (L.) Wilczek] was undertaken at central research field, Prayagraj, Uttar Pradesh, India during July, 2021 containing seven treatments viz, Flubendiamide 480SC (T1), Indoxacarb 14.5 SC (T2), Emamectin benzoate 5SG (T3), Spinosad 45SC (T4), NSKE 5% (T5), *Bacillus thuringiensis* 4% WSP (T6), Profenophos 50EC (T7) and untreated Control (T0) in RBD with three replications aiming to evaluate their efficacy of selected insecticides against pod borer, *Helicoverpa armigera*. Data was taken on green gram pod borer with number of larvae per infested pod and calculated per cent larval reduction. The per cent larval reduction of green gram pod borer *Helicoverpa armigera* on third, seventh and fourteen days after spraying revealed that the treatments Flubendiamide 480SC (T1), Indoxacarb 14.5 SC (T2), Emamectin benzoate 5SG (T3), Spinosad 45SC (T4), NSKE 5% (T5), *Bacillus thuringiensis* 4% WSP (T6), Profenophos 50EC (T7) were found superior over all the treatment first and second sprays respectively. Emamectin benzoate 5SG gave maximum per cent larval reduction followed by flubendiamide 480SC. When cost benefit ratio was worked out, interesting result was achieved. Among all the treatments, the best and most economical treatment was Emamectin benzoate 5SG (1:3.64) followed by Flubendiamide 480SC (1:3.55), Indoxacarb 14.5 SC (1:3.18), Spinosad 45SC (1:2.89), Profenophos 50EC (1:2.61), NSKE 5% (1:2.20), *Bacillus thuringiensis* 4% WSP(1:1.64), as compared to control plot (1:1.45).

Keywords: Economics, efficacy, green gram, *Vigna radiata, Helicoverpa armigera,* insecticides, pod borer

Introduction
Pulses constitute an excellent supplement of protein in the vegetarian diet of human being and plays a significant role in correcting the wide spread malnutrition all over the world. Pulses are excellent and rich source of plant protein and good substitute of animal protein so known as "poor man's meat" in the developing world. (Gorade *et al.*, 2014) [7].

Green gram *Vigna radiata* (L.) Wilczek (family: Leguminosae) is one of the most important *Kharif* pulse crop grown in India. It is called as "Queen of pulses". It is cultivated across seasons in different environments and in variable soil conditions in the South and South-East Asia, Africa, South America and Australia (Parihar *et al.*, 2017) [13]. India is the largest producer and consumer of green gram in the world which accounts about 10-12 per cent of the total pulse production in the country. It is one of the most widely cultivated pulse crop after chickpea and pigeon pea (Swaminathan *et al*., 2012) [19].

Gram pod borer, *Helicoverpa armigera* is a polyphagous pest of sporadic nature and inflicts losses of various magnitudes to cotton, pigeon pea, sorghum and other crops of economic importance. It is widely distributed throughout India and has been recorded feeding on 181 cultivated uncultivated plant species belonging to 45 families Gram pod borer, *Helicoverpa armigera* is one of the most devastating crop pest worldwide (Sigsgaard *et al*., 2002) [18]. Sixty cultivated and sixty- seven wild host plants attacked by *Helicoverpa armigera* have been recorded from India (Karim, 2000) [11]. *Helicoverpa armigera* is a polyphagous pest having more Host plants green gram, chickpea, pigeon pea, cotton and okra etc. Worldwide, losses due to *Helicoverpa* in cotton, legumes, vegetables, cereals, etc., exceed US$2 billion and the cost of insecticides used to control these pests is over US$1 billion annually.

Materials and Methods
The present study for the management of green gram pod borer through Field efficacy and

economics of selected insecticides against pod borer [*Helicoverpa armigera* (Hubner)] on green gram [*Vigna radiata* (L.) Wilczek] was carried out using an aarti variety at central research field, Uttar pradesh during *kharif*, 2021. The Plot size of (2m×2m) at a spacing of (30×10cm) with a recommended package of practices excluding plant protection. The soil of the experimental site was well drained and medium high. The experiment was conducted in randomize block design with three replications. A good tilth area was divided into three main blocks. Each main block was sub-divided into 8 sub- plots each of which was of 2m × 2m with maintaining 30cm borders as a bunds and the treatments was assigned randomly. The population of gram pod borer was recorded before 1-day spraying and on 3rd day, 7th day and 14th day after insecticidal application. The populations of gram pod borer was recorded on 5 randomly selected and tagged plants from each plot and then it was converted into per cent of reduction by following formula.

$$\text{Per cent reduction} = \frac{\text{Population in control} - \text{Population in treatment}}{\text{Population in control}} \times 100$$

$$\text{B: C Ratio} = \frac{\text{Gross returns}}{\text{Total cost of cultivation}}$$

Where,
B:C Ratio = Benefit Cost Ratio

Results and Discussion

Over all mean analysis of 3rd, 7thand 14 days after First insecticidal spray indicated that all the insecticidal treatments were significantly effective in reducing the larval population of *Helicoverpa armigera* as compared to untreated plots. Emamectin benzoate 5SG (76.204%) was found significantly superior among all the treatments. Flubendiamide 480SC (70.251%) is the next best treatment for reducing the population of gram pod borer. It is followed by Indoxacarb 14.5 SC (66.492%), Spinosad 45SC (62.742%) and Profenophos 50EC (57.404%), NSKE 5% (49.470%) followed by *Bacillus thuringiensis* 4% WSP (43.516%) which is less effective against gram pod borer.

The data on per cent population reduction of *Helicoverpa armigera* over control on second spray revealed that all the treatments were significantly superior over control. Among all treatments, Emamectin benzoate 5SG (48.168%) was found significantly superior among all the treatments. Flubendiamide 480SC (40.060%) is the next best for reducing the population of gram pod borer. It is followed by Indoxacarb 14.5 SC (36.954%), Spinosad 45SC (33.105%) and Profenophos 50EC (28.078%), NSKE 5% (25.601%) followed by *Bacillus thuringiensis* 4% WSP (23.080%) was the least effective among all treatments.

The data on the mean per cent population reduction of first spray and second spray, revealed that all the treatments except untreated control are effective and at par. with each other Among all the treatments highest per cent reduction of *Helicoverpa armigera* was recorded in Emamectin benzoate 5SG (62.186%). Similar findings made by Yadav *et al.*, (2019), Abbas *et al.*, (2021) [1]. Flubendiamide 480SC (55.156%) is found to be the next best treatment which is in linewith the findings of (Dinesh *et al*., 2014) [6], and (Yadav and Verma 2007) [20] they reported that Flubendiamide 480SC was found most effective in reducing per cent population reduction of *Helicoverpa armigera* as well as increasing the yield. Indoxacarb 14.5 SC (51.723%) is found to be the next best treatment which is in line with the findings of Rashid *et al*. (2003) [15], (Dinesh *et al*., 2014) [6] and Yogeeswarudu (2014) [21]. Spinosad 45SC (47.924%) is found to be the next effective treatment which is in line with the findings of (Dinesh *et al.,* 2014) [6] and Reddy *et al.,* (2021) [16]. Profenophos 50EC (42.741%) is found to be next best treatments is found to be the next effective treatment which is in line with the findings of Iqbal *et al.*, (2014) [9]. The result of NSKE 5% (37.536%) which is in support with. *Bacillus thuringiensis* 4% WSP (33.298%) is found to be least effective but comparatively superior over the control, these findings are supported by Joshi *et al*., (2019) [10].

Cost benefit ratio and yield

The yields among the different treatments was significant. The highest yield was recorded in Emamectin benzoate 5SG (12.95q/ha) followed by Flubendiamide 480SC (12.4 q/ha), Indoxacarb 14.5 SC (11.75 q/ha), Spinosad 45SC (10.85 q/ha), Profenophos 50EC (9.2 q/ha), NSKE 5% (7.65 q/ha), *Bacillus thuringiensis* 4% WSP (7.3 q/ha), as compared to control plot (4.8 q/ha). These findings are supported by Babariya *et al*., (2010) [2], Priyadarshini *et al*., (2013) [14], Shekhara *et al*., (2016) [17] and Joshi *et al*., (2019) [10].

When cost benefit ratio was worked out, interesting result was achieved. Among the treatments studied, the best and most economical treatment was Emamectin benzoate 5SG (1:3.64) in which similar with (Deshmukh *et al.*, 2010) [5] followed by Flubendiamide 480SC (1:3.55), finds similar with (Dinesh *et al.*, 2014) [6], Indoxacarb 14.5 SC (1:2.99) similar with (Dinesh *et al*., 2014) [6] (1:1.25), followed by Spinosad 45SC (1:2.69),which is similar with (Dinesh *et al.,* 2014) [6], Profenophos 50EC (1:2.58), NSKE 5% (1:2.20),similar with (Bhushan *et al*., 2011) [3], followed by *Bacillus thuringiensis* 4% WSP (1:2.12),finds similar with (Bhushan *et al*., 2011) [3] as compared to control plot (1:1.45).

Table 1: Efficacy of selected insecticides and bio pesticides on the incidence of pod borer (*H.armigera*) on green gram during *Kharif* 2021

S. No	Treatments	First spray				Second spray				Mean
		Per cent reduction in larval population				Per cent reduction in larval population				
		3DAS	7DAS	14DAS	Mean	3DAS	7DAS	14DAS	Mean	
T1	Flubendiamide 480SC	41.273	39.730	39.177	40.060	71.467	70.023	69.263	70.251	55.156
T2	Indoxacarb 14.5SC	37.213	37.980	35.670	36.954	69.800	65.027	64.650	66.492	51.723
T3	Emamectin benzoate 5SG	50.747	47.367	46.390	48.168	78.353	76.450	73.810	76.204	62.186
T4	Spinosad 45SC	33.290	34.057	31.967	33.105	63.097	63.587	61.543	62.742	47.924
T5	NSKE 5%	25.437	26.417	24.950	25.601	49.847	50.873	47.690	49.470	37.536
T6	*Bacillus thuringiensis* 4% WSP	25.203	22.497	21.540	23.080	42.963	44.437	43.147	43.516	33.298

T7	Profenophos 50EC	29.357	28.173	26.703	28.078	58.063	58.813	55.337	57.404	42.741
T0	Control	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	F-test									
	S. Ed. (±)	3.84	3.20	4.99	0.79	2.58	3.94	2.22	1.04	
	C.D. (P = 0.05)	8.242	6.861	5.710	1.700	5.537	8.447	4.771	2.221	7.12

Table 2: Effect of treatments on green gram yield:

	Treatments	Yield (q/ha)
T1	Flubendiamide 480SC	12.4
T2	Indoxacarb 14.5SC	11.75
T3	Emamectin benzoate 5SG	12.95
T4	Spinosad 45SC	10.85
T5	NSKE 5%	7.65
T6	*Bacillus thuringiensis* 4% WSP	7.3
T7	Profenophos 50EC	9.2
T0	Control	4.8

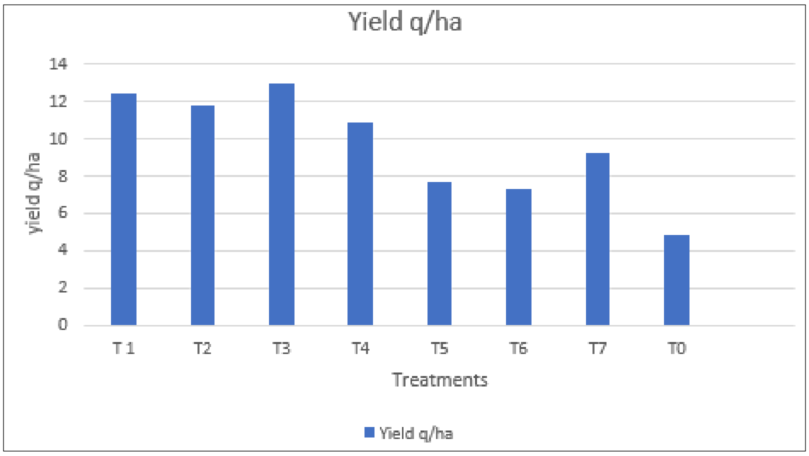

Fig 1: Effect of different treatments on green gram yield

Table 3: Economics of Cultivation

T. No	Treatments	Yield of q/ha	Cost of yield / ₹/ qtl	Total cost of Com yield (₹)	Moncost (₹)	Treatment cost (₹)	Total cost(₹)	C:B ratio
1	Flubendiamide 480SC	12.4	6000	74400	19742	1200	20942	1:3.55
2	Indoxacarb 14.5SC	11.75	6000	70500	19742	2300	22042	1:3.19
3	Emamectin benzoate 5SG	12.95	6000	77700	19742	1550	21292	1:3.64
4	Spinosad 45SC	10.85	6000	65100	19742	2709	22451	1:2.89
5	NSKE 5%	7.65	6000	45900	19742	1100	20842	1:2.20
6	*Bacillus thuringiensis* 4% WSP	7.3	6000	33800	19742	848	20590	1:1.64
7	Profenophos 50EC	9.2	6000	55200	19742	1400	21142	1:2.61
8	Control	4.8	6000	28800	19742	0	19742	1:1.45

Conclusion

From the critical analysis of the present findings, it can be concluded that, the new insecticides like Emamectin benzoate 5SG, Flubendiamide 480SC, Indoxacarb 14.5 SC, Spinosad 45SC, Profenophos 50EC, NSKE 5%, *Bacillus thuringiensis* 4% WSP can be suitably incorporated in integrated pest management schedule against *Helicoverpa armigera* as an effective tool. The botanicals and biopesticides also achieve certain range of mortality but are less effective when compared to new insecticide molecules i.e. which are highly specific, low dose and effective.

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