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BIO-EFFICACY AND ECONOMIC ANALYSIS OF INSECTICIDES FOR THE MANAGEMENT OF POD BUGS IN MUNG BEAN (*VIGNA RADIATA* (L.) WILCZEK)

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ABSTRACT

The present study evaluates the bio-efficacy and economics of different insecticides used against pod bugs and was conducted at the Agricultural Research Station, Bapatla during *rabi* 2024–25. Insecticides were assessed for their effect on egg masses and nymph/adult populations and their effect on pod and seed damage and cost and economics were worked out. Results indicated that Commercial azadirachtin 10000 ppm achieved the highest reduction in egg masses (67.3% and 80.7% at 3 and 7 DAS, respectively). Spinosad 45 SC (175 ml/ha) proved most effective against nymphs and adults (59.4% and 72.1% reduction at 3 and 7 DAS, respectively), and also recorded the lowest pod damage (4.53%) and seed damage (6.47%). Spinosad resulted in the highest grain yield (1563 kg/ha), while chlorantraniliprole 18.5 SC (150 ml/ha) and neem seed kernel extract (NSKE) 5% also produced yields exceeding 1300 kg/ha. Among the treatments, chlorantraniliprole recorded the highest benefit–cost ratio (3.1). These findings highlight Spinosad and chlorantraniliprole as promising options for pod bug management in mung bean along with NSKE under Krishna delta region.

Key words: Benefit-cost ratio, Mung bean, Pod bugs, Pulses, Spinosad

INTRODUCTION

Mung bean (*Vigna radiata* L.) is an important pulse crop and a vital source of dietary protein for millions of people in India and across Asia. Despite its nutritional value, the productivity of mung bean is severely constrained by sap-sucking pod bugs such as *Clavigralla gibbosa* (Spinola), *Nezara viridula* (L.), Riptortus sp., and *Melanacanthus* sp., which are considered major pests in Andhra Pradesh and other mung bean-growing regions(Srujana and Keval, 2014). Both nymphs and adults attack the crop by piercing and sucking sap from flower buds, flowers, developing pods, and seeds (Bharat *et al*., 2019). Their feeding causes reddish-brown patches on pods, premature pod drying, and shrivelled, malformed, or aborted seeds. The damage leads to poor grain filling, reduced seed viability and significant yield losses. In addition, the injured seeds become more susceptible to fungal infections, further reducing thequality,quantity and complicating post-harvest storage. Yield losses due to pod

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bugs typically range from 25–40% with losses caused by *C. gibbosa* occasionally reaching up to 50%. Factors contributing to pest outbreaks include continuous monocropping, cultivation of early and extra-early maturing genotypes, and the indiscriminate use of the same insecticides (Hanumanthaswamy *et al.,* 2009).Conventional reliance on broad-spectrum insecticides for pod bug management faces substantial challenges. Frequent and inappropriate application often leads to the development of resistance in target pests, resurgence of secondary pests, decimation of beneficial natural enemies, ecosystem disruption, and human health concerns (Khade *et al*., 2014). Consequently, there is an urgent need for sustainable pest management strategies that mitigate these adverse effects.Biorational insecticides encompassing botanicals, microbial agents, and compounds with novel, selective modes of actionoffer a promising alternative. Their potential lies in effectively suppressing pest populations while minimizing harm to non-target organisms and preserving ecological balance. This approach aligns strongly with sustainable agriculture principles and the growing demand for residue-free pulses. Therefore, the study was conducted to evaluate the bio-efficacy and economic viability of selected biorational and conventional insecticides against pod bugs infesting mung bean.

MATERIAL AND METHODS

A field experiment was carried out during *rabi* 2024–25 at the Agricultural Research Station, Bapatla, to evaluate the bio-efficacy of different insecticides against pod bugs infesting mung bean. The mung bean variety 'LGG 574' was grown with the recommended package of practices,except for insect-pest management. The experiment was laid out in a randomized block design (RBD) with eight treatments, including an untreated control, and each treatment was replicated three times. The plot size for each treatment was 4.0 m × 3.0 m. Insecticidal treatments were applied twice: the first spray at the time of pod initiation stage and the second at the pod development stage.Observations were recorded on the number of pod bug egg masses, pod bug

Percentage reduction of egg masses over control =

$$1- \left\{ \frac{\text{Egg masses in Post treatment in treatment}}{\text{Egg masses in pretreatment in treatment}} \times \frac{\text{Egg masses in pretreatment in untreated control}}{\text{Egg masses in Post treatment in untreated control}} \right\} 100$$

Percentage reduction of pod bug population over control=

$$1- \left\{ \frac{\text{Pod bugs in Post treatment in treatment}}{\text{Pod bugs in pretreatment in treatment}} \times \frac{\text{Pod bugs in pretreatment in untreated control}}{\text{Pod bugs in Post treatment in untreated control}} \right\} 100$$

population (nymphs and adults), percent pod damage, percent seed damageand grain yield.

Egg masses of pod bugs:Number of pod bug egg masses were recorded per five plants in each plot at one day prior to insecticide application which was treated as pretreatment count and three and seven days after each treatment. It was expressed as number of egg masses per five plants.

Pod bug population: Number of pod bugs (adults + nymphs) were recorded per five plants in each plot at one day prior to insecticide application which was treated as pretreatment count and three and seven days after each treatment. It is expressed as number of pod bugs per five plants. Reduction of egg masses and pod bug population over control was calculated using the modified Abbots formula (Fleming and Ratnakaran ,1985) as given below.

Data pertaining to pod bug egg masses and pod bug population was recorded at pretreatment, three and seven days after each spray and mean of two sprays was arrived and presented in the results.

Pod Damage: The observations on pod damage were recorded on five randomly selected plants in each treatment. Pods which are shrunken, deformed and shrivelled were considered as damaged pods. The per cent pod damage was worked out by using following formula and expressed in percentage.

Pod damage (%) = (Number of damaged pods / Total number of pods observed) × 100

Seed Damage: The pods harvested from five randomly selected plants in each treatment were dehusked and the obtained seeds were segregated into healthy and damaged seeds. Seeds which were shrivelled, shrunken and malformed were considered as damaged seeds. The percent seed damage was estimated based on number of seeds damaged by pod bugs in a pod by using the formula and expressed as percentage.

Seed damage (%) = (Number of damaged seeds / Total number of seeds observed) × 100

Grain yield:The crop was harvested and threshed separately treatment and replications wise. The grain yield was recorded from the net plot of each treatmentand converted to kgs per hectare for statistical analysis. Further cost economics was worked out based on the grain yield, gross returns and total cost (Table4).

Statistical analysis

Data obtained on various aspects were subjected to statistical analysis according to standard RBD procedures. The obtained data on the population of insect pests were subjected to a square root transformation, and the data on the percentages of damaged pods and damage to grains were subjected to an angular transformation. The yield data were compared by their means. Overall effects of each treatment were subjected to Duncan's Multiple Range test (DMRT) to compare the means of data using R software.

RESULTS AND DISCUSSION

Effect of insecticides on Egg masses (Mean of first and second spray)

Pre-treatment data showed that the mean number of egg masses per five plants ranged from 0.70 to 1.50 without significant differences among the treatments. At three days after spray revealed that the egg masses per five plants ranged from 0.33 to 0.85 across the treatments and 2.27 egg masses per five plants were recorded in untreated control.Less number of egg masses (0.33) were recorded in T1 (commercial azadirachtin 10000 ppm @ 500 ml/ha). The treatments T2 (NSKE @ 5%), T4 (chlorantraniliprole 18.5 SC @ 150 ml/ha), T7 (profenophos 50 EC @ 500 ml/ha) and T5

(Spinosad 45 SC @175 ml/ha) were on par with 0.37, 0.40, 0.43 and 0.50 egg masses, respectively. The pooled data for seven days after spray revealed that the mean of number of pod bug egg masses per five plants were ranged from 0.21 to 0.67 among treatments, whereas, the untreated control recorded 2.30 mean number of egg masses per five plants. Less number of egg masses of 0.21 per five plants were recorded in T1(commercial azadirachtin 10000 ppm@ 500 ml/ha) and T2 (NSKE @ 5 %). T7 (profenophos 50 EC @500 ml/ha) was at par with T1 and T2 with 0.32 egg masses per five plants. (Table 1).

The findings revealed that the Neem Seed Kernal Extract (NSKE) @ 5 per cent recorded significantly higher per cent reduction of pod bugs than the other treatments which may be due to multiple action of neem products against insects such as feeding deterrent, ovipositional inhibition and interfering with insect metamorphosis and it was supported by Purwar and Yadav, 2004 in cowpea. Mitchell *et al*. (2004) also reported that the extracts of neem negatively affected the feeding and development on *Clavigralla gibbosa.*

Effect of insecticides on Pod bug population

The pre-treatment data revealed that the pod bug population per five plants ranged from 2.63 to 4.73 without significant differences among the treatments. Three days after the spray revealed that the mean number of pod bugs per five plants ranged from 1.47 to 2.30 in the treatments and 5.43 pod bugs per five plants were recorded in untreated control.Lowest number of pod bugs (1.47) were recorded in T5 (spinosad 45 SC @175 ml/ha). The treatments T2 (NSKE @ 5%) and T8 (deltamethrin 2.8 EC@ 500 ml/ha) were at par with T5 (spinosad 45 SC @175 ml/ha) with pod bug population of 1.70 and 1.77 per five plants, respectively.Mean pod bug population at seven days after spray per five plants ranged from 1.03 to 5.57 across treatments and the control. Spinosad (@ 175 ml/ha) maintained superior efficacy, recording the lowest population count of 1.03 bugs per five plants, significantly lower than the untreated control (5.57 bugs per five plants) (Table 2).

Similar findings were observed by Hernowo *et al*. (2020) where spinosad is effective against *Nezara viridula* (L.) and red banded stink bug, *Piezodorus guildinii*in lab test. According to Chethan *et al.* (2024), the application of NSKE 5% significantly reduced pod bug population, pod damage, and grain damage, leading to a grain yield of 1229.10 kg/ha with a benefit-cost ratio of 2.45 in pigeonpea.

Effect of insecticidal treatments on pod and seed damage caused by pod bugs

During *rabi* 2024, the percent pod damage inflicted by pod bugs on mung bean in different treatments ranged from 4.53 to 14.5 per cent. The least percent pod damage (4.53) was recorded in T5 (spinosad 45 SC @175 ml/ha). The treatments T2 (NSKE @ 5%), T4 (chlorantraniliprole 18.5 SC @ 150 ml/ha) and T1 (commercial azadirachtin 10000 ppm@ 500 ml/ha) were at par with T5 (spinosad 45 SC @175 ml/ha) with per cent pod damage of 4.97, 5.00 and 5.13, respectively (Table 3).The next best treatments were T8 (deltamethrin 2.8 EC@ 500 ml/ha), T7 (profenophos 50 EC @500 ml/ha) and T3 (*Beauveria bassiana* formulation(NBAIR Strain 5a) @ 2500 g/ha) with 6.13 ,6.91 and 8.10 percent pod damage, respectively. High pod damage of 14.50 per cent was recorded in untreated control.

The percent seed damage caused by pod bugs on mung bean ranged from 6.47 to 16.33 percent. The lowest percent seed damage (6.47) was recorded in T5 (spinosad 45 SC @175 ml/ha). The treatments T4 (chlorantraniliprole 18.5 SC @ 150 ml/ha), T2

Table 1. Effect of insecticides on pod bug egg mass during *rabi*, 2024-25 (Mean of two sprays)

Tr.No.	Treatments	Dose g or ml/ha	Number of pod bugs/ 5 plants *			Per cent reduction of pod bugs over control **		
			Pre Treat-ment	3 DAS	7 DAS	3 DAS	7 DAS	Mean
T1	Commercial azadirachtin 10000 ppm	500 ml/ha	0.70	0.33 ^{a}(0.58)	0.21 ^{a}(0.46)	67.3 ^{a}(55.13)	80.7 ^{a}(63.92)	74.0
T2	NSKE	5%	0.73	0.37 ^{a}(0.61)	0.22 ^{a}(0.47)	66.5^{a}(54.66)	80.9^{a}(64.07)	73.7
T3	*Beauveria bassiana* formulation (NBAIR Strain 5a)	2500 g/ha	0.84	0.60 ^{b}(0.77)	0.63 ^{c}(0.80)	52.0 ^{abc}(46.15)	50.8 ^{cd}(45.46)	51.4
T4	Chlorantraniliprole 18.5 SC	150 ml/ha	0.89	0.40 ^{a}(0.63)	0.59 ^{cd}(0.77)	69.2 ^{a}(56.32)	56.9^{bc}(48.95)	63.1
T5	Spinosad 45 SC	175 ml/ha	0.87	0.50 ^{ab}(0.71)	0.40 ^{bc}(0.63)	61.9 ^{ab}(51.87)	70.0^{abc}(56.77)	65.9
T6	Flonicamid 50 WG	150 g/ha	0.74	0.60 ^{b}(0.77)	0.67 ^{c}(0.82)	46.1^{bc}(42.76)	36.2^{d}(37.00)	41.2
T7	Profenophos 50 EC	500 ml/ha	0.87	0.43 ^{a}(0.66)	0.32 ^{ab}(0.56)	67.0^{a}(54.96)	76.2^{ab}(60.77)	71.6
T8	Deltamethrin 2.8 EC	500 ml/ha	1.07	0.85 ^{c}(0.92)	0.63 ^{c}(0.79)	43.5^{c}(41.24)	60.5 ^{bc}(51.03)	52.0
T9	Untreated control	-	1.50	2.27 ^{d}(1.51)	2.30 ^{e}(1.52)	-	-	-
	F Test		NS	S	S	S	S	
	S.E(m)±		-	0.04	0.04	3.30	3.71	
	CD (P=0.05)		-	0.14	0.13	9.24	10.4	
	CV (%)		8.09	10.7	10.5	12.7	13.5	

*Values in parenthesis are square root+1 transformation. **Values in parenthesis are arc sign transformation. Means in columns with similar alphabets are not significant ($P<0.05$). Grouping was done based on the Duncan's Multiple Range Test (DMRT).

Table 2. Effect of insecticides on pod bug population (Adult +nymphs) during*rabi*, 2024-25 (Mean of two sprays)

Tr.No.	Treatments	Dose g or ml/ha	Number of pod bugs/ 5 plants *			Per cent reduction of pod bugs over control **		
			Pre Treat-ment	3 DAS	7 DAS	3 DAS	7 DAS	Mean
T1	Commercial azadirachtin 10000 ppm	500 ml/ha	3.60	1.87 b(1.37)	1.50 ^{b}(1.22)	53.3 ^{ab}(46.89)	63.7 ^{abc}(52.92)	49.88
T2	NSKE	5%	3.53	1.70 ^{ab}(1.30)	1.38 ^{b}(1.18)	58.1^{a}(49.67)	66.1^{ab}(54.41)	52.02
T3	*Beauveria bassiana* formulation (NBAIR Strain 5a)	2500 g/ha	3.50	1.93 ^{bc}(1.39)	1.43 ^{b}(1.20)	50.5 ^{ab}(45.31)	64.1 ^{abc}(53.19)	49.21
T4	Chlorantraniliprole 18.5 SC	150 ml/ha	3.20	1.97 ^{bc}(1.40)	1.53 ^{b}(1.24)	46.3 ^{abc}(42.89)	59.1^{bc}(50.25)	46.56
T5	Spinosad 45 SC	175 ml/ha	3.17	1.47 ^{a}(1.21)	1.03 ^{a}(1.01)	59.4 ^{a}(50.41)	72.1^{a}(58.10)	54.17
T6	Flonicamid 50 WG	150 g/ha	3.00	2.30 ^{d}(1.52)	2.20^{c}(1.48)	32.9^{d}(35.02)	37.3^{d}(37.65)	36.34
T7	Profenophos 50 EC	500 ml/ha	2.70	1.93 ^{bc}(1.39)	1.56 ^{b}(1.25)	36.5^{cd}(37.17)	49.6^{cd}(44.79)	41.01
T8	Deltamethrin 2.8 EC	500 ml/ha	2.63	1.77 ^{ab}(1.33)	1.40 ^{b}(1.18)	41.2^{bcd}(39.92)	53.0 ^{bc}(46.72)	43.33
T9	Untreated control	-	4.73	5.43 ^{e}(2.33)	5.57 ^{d}(2.36)	-	-	-
	F Test		NS	S	S	S	S	
	S.E(m)±		-	0.04	0.04	3.30	3.71	
	CD (P=0.05)		-	0.14	0.13	9.24	10.41	
	CV (%)		8.09	10.66	10.55	12.74	13.54	

*Values in parenthesis are square root+1 transformation . **Values in parenthesis are arc sign transformation. Means in columns with similar alphabets are not significant (P<0.05). Grouping was based on the Duncan's Multiple Range Test (DMRT).

Table 3. Effect of insecticides on pod and seed damage

	Treatments	Doseg orml /ha	Per cent Pod Damage	Per cent Seed Damage
T1	Commercial azadirachtin 10000 ppm	500 ml/ha	5.13^{de}(13.10)	7.13^{cd}(15.49)
T2	NSKE	5%	4.97^{e}(12.88)	6.93^{cd}(15.27)
T3	*Beauveria bassiana* formulation (NBAIR Strain 5a)	2500 g/ha	8.10^{b}(16.54)	7.97^{bc}(16.39)
T4	Chlorantraniliprole 18.5 SC	150 ml/ha	5.00^{e}(12.92)	6.67^{cd}(14.96)
T5	Spinosad 45 SC	175 ml/ha	4.53^{e}(12.29)	6.47^{d}(14.73)
T6	Flonicamid 50 WG	150 g/ha	7.93^{bc}(16.36)	9.17^{b}(17.62)
T7	Profenophos 50 EC	500 ml/ha	6.91^{bcd}(15.24)	7.47^{cd}(15.86)
T8	Deltamethrin 2.8 EC	500 ml/ha	6.13^{cde}(14.34)	7.43^{cd}(15.82)
T9	Untreated control	-	14.50^{a}(22.38)	16.33^{a}(23.84)
	F Test		S	S
	S.E(m)±		0.72	0.50
	CD (P=0.05)		2.02	1.41
	CV (%)		8.30	5.24

**Values in parenthesis are arcsign transformation. Means in columns with similar alphabets are not significant (P<0.05).

Grouping was based on the Duncan's Multiple Range Test (DMRT)

(NSKE @ 5%), T1 (commercial azadirachtin 10000 ppm@ 500 ml/ha), T8 (deltamethrin 2.8 EC@ 500 ml/ha), T7 (profenophos 50 EC @500 ml/ha) and T3 (*Beauveria bassiana* formulation(NBAIR Strain 5a) 2500 g/ha) were on par with T5 (spinosad 45 SC @175 ml/ha) with per cent seed damage of 6.67, 6.93, 7.13, 7.43, 7.47 and 7.97 respectively. High percent seed damage (16.33%) was recorded in untreated control (Table 3).

The research findings are in agreement with Pawar and Das (2020) who reported the efficacy of various insecticides in minimizing pod and grain damage in pigeonpea and the results indicated that Spinosad 45 SC at 73 g a.i./ha was the most effective treatment, exhibiting the lowest pod damage of 2.72% and grain damage of 1.17%. This was followed by rynaxypyr 20 SC, flubendamide 20 WG, endosulfan 35 EC, pyridalyl 10 EC, and fenpropathrin 30 EC which recorded pod damage of 3.63%, 4.54%, 5.45%, 6.04% and 7.27% and grain damage of 1.49%, 1.70%, 2.36%, 2.75% and 3.33% respectively.

Effect of insecticidal treatments on grain yield in mung bean

The grain yield of mung bean in different treatments ranged from 1027 to 1563 kg/ha. The highest grain yield of 1563 kg/ha was recorded inT5 (spinosad 45 SC @175 ml/ha). The treatments T4 (chlorantraniliprole 18.5 SC @ 150 ml/ha) and T2 (NSKE @ 5%), were at par with T5 (spinosad 45 SC @175 ml/ha) with grain yield of 1477 kg/ha and 1340 kg/ha respectively. A yield increase of 65 percent was recorded in spinosad 45 SC @175 ml/ha over

Table 4. Effect of insecticides on grain yield and economics of mung bean crop

Tr.No.	Treatments	Dose g or ml /ha	Grain yield (Kg/ha)	Gross returns (Rs.)	Cost of cultivation (Rs./ha)	B:C Ratio	Treatment cost (Rs.)A	Yield increases over control (Kg/ha)	Increased returns (Rs.)B	ICBR
T1	Commercial azadirachtin 10000 ppm	500 ml/ha	1310	113970	39898	2.9	3800	283	24650	6.5
T2	NSKE	5%	1340	116580	39098	3.0	3000	313	27260	9.1
T3	*Beauveria bassiana* formulation (NBAIR Strain 5a)	2500 g/ha	1300	113100	38348	2.9	2250	273	23780	10.6
T4	Chlorantraniliprole 18.5 SC	150 ml/ha	1477[a]	128470	41888	3.1	5790	450	39150	6.8
T5	Spinosad 45 SC	175 ml/ha	1563[a]	136010	44798	3.0	8700	537	46690	5.4
T6	Flonicamid 50 WG	150 g/ha	1248	108605	40848	2.7	4750	222	19285	4.1
T7	Profenophos 50 EC	500 ml/ha	1333	116000	38148	3.0	2050	307	26680	13.0
T8	Deltamethrin 2.8 EC	500 ml/ha	1190	103530	38046	2.7	1948	163	14210	7.3
T9	Untreated control	-	1027	89320	36098	2.5	-	-	-	
	CD (P=0.05)	161.8								
	CV (%)	7.6								

* Market price = Rs. 8700 per quintal

untreated control (Table 4).The above findings corroborate with that of Randhawa and Saini (2015), who reported spinosad accounted to the minimum damage to the pod and highest grain yield in pigeon pea.

Effect of insecticidal treatments on cost and economics of mung bean

The B:C Ratio was computed to assess the economic viability of each treatment based on yield, market price, gross and net returns. Highest B:C Ratio of 3.1 was arrived for the treatment T4: chlorantraniliprole 18.5 SC @150 ml/ha and B:C Ratio of 3.0 was recorded for T2: NSKE @ 5 %, T5: spinosad 45 SC @ 175 ml/ha and T7: profenophos 50 EC @ 500 ml/ha. (Table 4.18).Incremental Cost Benefit Ratio (ICBR) was calculated and high ICBR of 13.0 was recorded with T7: profenophos 50 EC @ 500 ml/ha followed by 10.6 in T3: *Beauveria bassiana* formulation(NBAIR Strain 5a) @ 2500 g/ha and 9.1 in NSKE @5% treated plots. Among all the treatments tested profenophos 50 EC, Spinosad 45 SC, NSKE and *Beauveria bassiana* formulation(NBAIR Strain 5a) recorded good economic returns in terms of B:C ratio and ICBR in mung bean. (Table 4).

The ICB ratio of the above treatments are in complementary to the findings of Sonune and Bhamare (2018) who also reported insecticides Spinosad 0.0070 per cent and Flubendamide 0.0070 per cent was effective against pigeonpea pod pest complex *viz*., pod fly, *M. obtusa* and plume moth, *E. atomosa* management and given pigeonpea grain yield (17.36q/ha) and (17.69q/ha) with ICBR (1:2.8) and (1:2.1) respectively.

CONCLUSION

Among the insecticides evaluated against pod bugs in mungbean, commercial azadirachtin 10,000 ppm @ 500 ml ha^{-1} and NSKE @ 5% recorded lower egg masses at 3 and 7 DAS, while spinosad 45 SC @ 175 ml ha^{-1} recorded the lowest pod bug population (1.70 and 1.03 bugs plant^{-1}). Spinosad also resulted in the low pod (4.53%) and seed damage (6.47%), followed by NSKE @ 5 % and chlorantraniliprole 18.5 SC @ 150 ml ha^{-1}. Highest grain yield (1563 kg/ha) was recorded in spinosad 45 SC followed by NSKE and *Beauveria bassiana* NBAIR strain 5a with more than 1300 kg/ha.Economic analysis indicated that chlorantraniliprole recorded the highest B:C ratio (3.1), while the highest ICBR was observed in profenophos (13.0), followed by Beauveria bassiana and NSKE. Overall, spinosad proved most effective in suppressing pod bug infestation and minimizing yield losses, while chlorantraniliprole and NSKE were economically viable options for integrated pod bug management in mungbean.

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