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Population Dynamics of Major Sucking Pests of Mung bean in Western Rajasthan and Their Management Using Newer Insecticides

Dindayal Tanwar[1], M.M. Kumawat[1*], M.M. Sundria[2] and Dama Ram[1]

[1]*College of Agriculture, Agriculture University, Jodhpur 342 304, India*

[2]*Agricultural Research Station, Agriculture University, Jodhpur 342 304, India*

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Correspondence
M.M. Kumawat
kumawatmm@gmail.com

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Abstract: A field experiment was conducted to study the seasonal incidence of major insect pests of mung bean [*Vigna radiata* (L.) Wilczek] under arid conditions of Rajasthan. A total of ten treatments were used to evaluate the bio-efficacy of insecticides against three sucking pests *viz*. leafhopper (*Empoasca kerri* Pruthi), whitefly (*Bemisia tabaci* (Genn.) and thrips [*Caliothrips indicus* (Bagnall)]. The incidence of leafhopper, whitefly and thrips began on mung bean in the second week of August peaked in the September, gradually declined thereafter. There was negative significant correlation between leafhoppers and maximum temperature, positive non-significant with whitefly and positive significant correlation between thrips and maximum temperature. Relative humidity showed positive significant correlation with leafhopper and positive non-significant with whitefly and thrips. Out of nine insecticides the standard check of Dimethoate 30 EC was found most effective against population of leafhopper, whitefly and thrips followed by thiamethoxam 25 WG and fipronil 5 SC. Lambda-cyhalothrin 17.8 SL, *Metarhizium anisopliae* 1.15 WP as well as *Beauveria bassiana* 1.15 WP ranked as less effective treatments against leafhoppers, whitefly and thrips. The maximum yield was recorded in the plots treated with thiamethoxam 25 WG. The highest benefit cost ratio was obtained with dimethoate 30 EC followed by thiamethoxam 25 WG, while lowest benfit cost ratio was computed in the plots treated with *Beauveria bassiana* and *Metarhizium anisopliae*.

Key words: Mung bean, bioefficacy, pests, white fly, leafhopper, thrips, weather.

Mung bean or green gram [*Vigna radiata* (L.) Wilczek] is rich source of high quality protein and minerals. Its grains contain 24 to 25% protein, 60% carbohydrate, 4.2% mineral, 2.9% vitamins, and 1.5% fat in dry seed (Patel *et al*., 2020). It is consumed as whole grains, sprouted form and split form in a variety of ways in homes. It is also used as green manuring crop. This crop is cultivated in three seasons, viz., kharif,

rabi and summer in India. It is self-pollinated crop and native to India belongs to family Leguminaceae, sub family Papilionaceae. Mung bean is third important pulse crop in India after chick pea and pigeon pea. It is mainly grown in Rajasthan, Andhra Pradesh, Maharashtra, Odisha, Gujarat, Madhya Pradesh, Punjab, Tamil Nadu, Bihar and Telangana. In India, the crop is cultivated in an area of 4.03 million hectare with the production of 1.95 million tons and productivity of 483 kg ha^{-1} (Anonymous, 2021). Rajasthan ranked first in India in the production and it is grown in an area of 22.2 lakh ha with production and productivity of 12.87 lakh tonnes and 534 kg ha^{-1}, respectively (Anonymous, 2020).

Numerous insect pests attack the mung bean. The loss in the production caused by them may reach up to 70% depending upon the severity of attack. The severity of the pests varied as per the region and climatic conditions. The major insect pests are leafhopper, *Empoasca kerri* Pruthi, whitefly, *Bemisia tabaci* (Genn.), thrips, *Caliothrips indicus* Bagnall, semilooper, *Plusia orichalcea* (Fab.), cutworm, *Agrotis ipsilon* (Hufn.), galerucid beetle, *Madurasia obscurella* Jacoby, tortricid moth, *Cydia ptychora* Meyr, pod borer, *Maruca testulalis* Geyer, *Maruca vitrata* (Fab.), stemfly, *Melanagromyza phaseoli* Tryon., green bug, *Nezara viridula* (Linn), pod bugs (*Riptortus pedestris, Clavigralla gibbosa* and *C. horrens*), cowpea aphid, *Aphis craccivora* (Koch), blue butterfly, *Lampides boeticus* Linn. and blue beetle, *Raphidopalpa intermedia* Jacoby (Borah, 1995; Dar *et al*., 2002; Duraimurugan and Tyagi, 2014). Among these, leafhopper, whitefly and thrips have been reported as one of the major sucking pests affecting mung bean in Rajasthan. They damage the crop by sucking the sap from leaves and tender pods from the seedling stage to the pod maturation stage, resulting in a significant reduction in yield. The whitefly not only suck the cell sap of plants but also transmits yellow mosaic virus (YMV) causing a yield loss of 30-70% (Marimuthan *et al*., 1981). The damage from all sucking insect pests results in blistering and cupping of leaves and loss of plant vitality in the early growth stage. Mung bean is a widely grown crop by farmers, and due to its drought tolerance and excellent nutritional properties, is well accepted crop in arid regions of the Rajasthan. This region experiences very low rainfall in *mansoon* season, providing a suitable breeding climate for sucking pests and in turn posing greatest threat to crop. In view of above, the present study explores the seasonal incidence of sucking pests in present climate change scenario and evaluates the efficacy of newer chemicals and bio-pesticides for management.

Materials and Methods

Population dynamics of sucking pests

To monitor the sucking insect pests on mung bean, the genotype GM-4 was sown on 15th July 2020 in five plots of 4.0 x 3.0 m^2 keeping row to row and plant to plant distance of 30 and 10 cm, respectively at College of Agriculture, Jodhpur. It is situated at 26°21'29" North latitude, 73°02'45" East longitude with an altitude (elevation) of 231 meters above mean sea level. The crop was left for natural infestation by the pests, and no pest control measure used. The observations on insect pest were recorded from five randomly selected and tagged plants in each plot at weekly interval from their appearance of insect pests till harvesting of the crop. The data recorded on pests and meteorological parameters were used for statistical analysis. Simple correlation was computed between pest population and abiotic factors viz. temperature, relative humidity and rainfall to interpret the results of seasonal abundance of insect pests on mung bean (Gomez and Gomez, 2012).

Bioefficacy of chemical and biopesticides

The present investigations were carried out at College of Agriculture, Jodhpur, during kharif, 2020. The experiment was laid out in a simple randomized block design (RBD) with ten treatments including the untreated control (Table 1) and each treatment replicated thrice. The individual plot size was 3.0 m x 4.0 m, keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively. The seeds of mung bean variety, GM-4 which is recommended in package of practices for this region were sown on 15th July, 2020. The first spray was given on 23rd August 2020 when population of pests was built up to cause the damage. All the insecticides were applied as a foliar spray. The sprays were carried out by using a pre-calibrated knap sack sprayer. The second spray was administered after three weeks of first spray when populations re-built

Table 1. Details of noval insecticides used as treatments

Treatment	Dosage a.i. ha^{-1}	Commercial formulation dose ha^{-1}*
Lambda-cyhalothrin 17.8 SL	0.01%	337.07 ml
Thiamethoxam 25WG	0.02%	480.00 ml
Bifenthrin 10% EC	0.025%	1500.00 mL
Chlorantraniliprole 18.5 SC	0.01%	324.32 mL
Buprofezin 25 SC	0.03%	720.00 mL
Fipronil 5% SC	0.01%	1200.00 mL
Metarhizium anisopliae 1.15 WP (1×10^8 spores/g)	5.0 g L^{-1}	3.00 kg
Beauveria bassiana 1.15 WP (1×10^8 spores/g)	5.0 g L^{-1}	3.00 kg
Dimethoate 30 EC	0.04%	800.00 mL
Untreated	-	-

*as per 600 liter of spray solution ha^{-1}

up. A total 600 liters of spray solution per hectare was used in each spray application as detailed in Table 1. The observations on insect population were recorded as per procedure regularly on one day before and 1, 3, 7 and 15 days after application of treatments in both the sprays. Three leaves, viz., one from top, middle and lower canopy of the plant were taken into account for recording the population of leafhoppers, whitefly and thrips.

Results and Discussion

The incidence of only sucking insect pests was noticed during the cropping season of mung bean. The major sucking insect pests were leafhopper, *Empoasaca kerri* Pruthi; whitefly, *Bemisia tabaci* (Genn.) and thrips, *Caliothrips indicus* (Bagnall) when the crop left for natural infestation (Table 2). The infestation of leafhopper, *E. kerri* was first recorded on crop in the second week of August i.e. during 33rd standard meteorological week (SMW), afterwards the population increased gradually and reached to its peak on 37th SMW with average of 13.9 $plant^{-1}$. Thereafter, the leafhopper population started to decline gradually and became negligible (1.05 leafhoppers $plant^{-1}$) by 41st SMW at the first week of October. Whitefly was first noticed on 33rd MSW and the peak activity (12.4 $plant^{-1}$) was recorded in 39th SMW, i.e. third week of September, subsequently the population of whitefly started to decline gradually and reached to minor level in the first week of October. The incidence of thrips, *C. indicus* commenced in the last week of August (35th SMW) with 0.1 average population $plant^{-1}$. The population of thrips also increased gradually and reached to its peak with the population of 3.9 $plant^{-1}$in the third week of September (38th SMW). Thereafter, its population decreased gradually and reached to zero at the time of maturity of the crop (42th SMW). The present finding also corroborates with the observations made by Nitharwal and Kumawat (2013) and Gehlot and Prajapat (2020) that leaf hopper population started appearing from first week of August and remained active throughout the crop season with peak during 36th SMW.

The correlation of insect pests and abiotic factors presented in Table 2 revealed that the maximum temperature had significant negative correlation (r= –0.703) while minimum temperature had negative non-significant correlation (r= –0.305) with the leafhoppers whereas, mean relative humidity had positive significant correlation (r= 0.690) and rainfall showed negative significant correlation (r= –0.566) with population of leafhoppers. In case of whitefly, the maximum temperature had positive non-significant correlation (r= 0.020), while minimum temperature had positive non-significant correlation (r= 0.319) with the whitefly. The mean relative humidity showed positive non-significant correlation (r= 0.129), whereas rainfall had positive non-significant correlation (r= 0.053) with population of whitefly. Thrips showed positive significant correlation with maximum and minimum temperature with coefficient value r= 0.690 and r= 0.600, respectively, whereas the mean relative humidity showed positive non-significant correlation (r= 0.494), and rainfall had negative non-significant correlation (r= -0.469) with population of thrips. These results are in partially agreement with Singh *et al.* (2019) that the relationship between leaf hopper

Table 2. Seasonal incidence of sucking pests on mung bean in relation to weather parameters

SMW#	Date of observation	Pests populations on three leaves per plant			Average Temperature (°C)		Average relative humidity (%)	Total rainfall (mm)
		Leafhoppers	Whitefly	Thrips	Maximum	Minimum		
33	12th August, 2021	4	3.1	0	28.0	35.5	69	18.2
34	19th August, 2020	8.4	4.6	0	28.7	33.9	84	20.3
35	26th August, 2020	12.2	7.2	0.1	25.8	31.8	78	26.1
36	02nd September, 2020	13.5	7.6	0.2	26.6	31.6	80	40.4
37	09th September, 2020	13.9	9.4	1.4	28.0	35.0	61	-
38	16th September, 2020	4.6	10.2	3.9	29.5	37.8	54	9.4
39	23rd September, 2020	3.8	12.4	2.1	28.1	35.9	60	4.2
40	30th September, 2020	3.1	5.9	1.0	28.0	34.0	50	-
41	07th October, 2020	1.05	1.3	0.9	26.5	37.0	36	-
Correlation coefficient (r) of maximum temperature		-0.703*	0.020	0.690*				
Correlation coefficient (r) of minimum temperature		-0.305	0.319	0.600				
Correlation coefficient (r) of relative humidity		0.690*	0.129	0.494				
Correlation coefficient (r) of rainfall		-0.566	0.053	-0.469				

#SMW- Standard Meteorological Week; * Significant at 5% level

population with maximum temperature, minimum temperature, relative humidity and rainfall revealed negative correlation. Kumar *et al.* (2004) also observed that highest population of whitefly in the second fortnight of September when the maximum and minimum temperature and relative humidity were low level. Mathur *et al.* (2012) and Nitharwal and Kumawat (2013) found significant negative correlation of leaf hopper, whitefly and thrips with maximum and minimum temperature and positive significant correlation with relative humidity and rainfall.

Bioefficacy against leafhopper, Empoasca kerri Pruthi

It was observed that the efficacy of the insecticidal treatment were exhibited maximum after three days of spray (Table 3) against *Empoasca kerri* Pruthi. Among nine insecticides tested, standard check of dimethoate 30 EC was found most effective followed by thiamethoxam 25 WG and fipronil 5% SC. The next best effective insecticides/botanicals were buprofezin 25 SC, chlorantraniliprole 18.5 SC, bifenthrin 10% EC and Lambda-cyhalothrin 17.8 SL. The treatments of *Beauveria bassiana* 1.15 WP and *Metarhizium anisopliae* 1.15 WP proved least effective in reducing the leafhopper population. The descending order of insecticides/ botanicals based on per cent reduction of leafhopper population was dimethoate 30 EC > thiamethoxam 25 WG > fipronil 5% SC > buprofezin 25 SC > chlorantraniliprole 18.5 SC > bifenthrin 10% EC > lambda-cyhalothrin 17.8 SL > *Beauveria bassiana* 1.15 WP > *Metarhizium anisopliae* 1.5 WP. These observations are also supported by the finding of Singh *et al.* (2019) who reported the treatments of thiamethoxam (0.005%) and dimethoate (0.03%) stood in middle order of efficacy, while Duraimurugan and Alivelu (2017) reported that dimethoate was most effective insecticides against leafhopper. Thiamethoxam 25 WG (0.01%) and imidacloprid 70 WG (0.014%) were more effective against sucking pests (Sujatha and Bharpoda, 2017).

Bioefficacy against whitefly, Bemisia tabaci (Genn.)

The bio-efficacy of the treatments evaluated against whitefly, *Bemisia tabaci* (Genn.) in respect of per cent reduction in population revealed that treatment of Dimethoate 30 EC was found most effective followed by Thiamethoxam 25 WG and Fipronil 5% SC (Table 4). The treatments of Bifenthrin 10% EC, Chlorantraniliprole 18.5 SC, Buprofezin 25 SC and Lambda-cyhalothrin 17.8 SL were observed in moderately effective group. While treatments of *Metarhizium anisopliae* 1.15 WP and *Beauveria bassiana* 1.15

Table 3. Bio-efficacy of novel insecticides against leafhopper on mung bean

Treatments	Concentration (%)/dose	PTP#	Mean per cent reduction days after first spray				PTP	Mean per cent reduction days after Second spray			
			One day	Three days	Seven days	Fifteen days		One day	Three days	Seven days	Fifteen days
Lambda-cyhalothrin 17.8 SL	0.01%	17.89	43.37 (41.19)*	51.08 (45.62)	48.95 (44.40)	47.68 (43.67)	10.89	45.70 (42.53)	49.18 (44.53)	44.70 (41.96)	41.86 (40.32)
Thiamethoxam 25WG	0.02%	16.00	77.34 (61.58)	96.25 (78.85)	92.51 (74.12)	74.06 (59.38)	10.54	90.13 (71.69)	94.95 (77.05)	86.06 (68.08)	67.53 (55.27)
Bifenthrin 10% EC	0.025%	17.95	68.55 (55.89)	82.90 (66.01)	80.88 (64.10)	63.19 (52.65)	10.95	84.91 (67.20)	87.96 (69.78)	81.89 (64.85)	54.95 (47.84)
Chlorantraniliprole 18.5 SC	0.01%	18.15	71.17 (57.54)	84.32 (66.72)	83.21 (65.89)	66.12 (54.41)	11.25	84.92 (67.20)	89.02 (70.65)	83.56 (66.08)	56.82 (48.92)
Buprofezin 25 SC	0.03%	19.25	70.47 (57.09)	82.19 (65.04)	79.77 (63.27)	64.60 (53.49)	11.00	90.08 (71.65)	94.93 (77.00)	85.18 (67.36)	65.72 (54.16)
Fipronil 5% SC	0.01%	11.54	77.14 (61.44)	96.35 (79.01)	91.09 (72.64)	76.13 (60.75)	11.15	86.12 (68.19)	90.48 (72.17)	85.23 (67.46)	58.76 (50.05)
Metarhizium anisopliae 1.15 WP @ 5 g L^{-1}	1×10^8 spores/g	17.55	40.85 (39.73)	48.00 (43.85)	46.64 (43.07)	45.52 (42.43)	9.98	44.73 (41.98)	48.23 (43.99)	43.69 (41.37)	40.76 (39.67)
Beauveria bassiana 1.15 WP @ 5 g L^{-1}	1×10^8 spores/g	16.89	42.83 (40.88)	50.06 (45.04)	47.40 (43.51)	46.61 (43.05)	10.55	43.77 (41.42)	47.50 (43.56)	42.84 (40.88)	39.06 (38.68)
Dimethoate 30EC	0.04%	18.62	78.39 (62.41)	96.85 (80.20)	92.91 (74.80)	75.02 (60.13)	10.36	91.11 (72.82)	95.39 (78.21)	88.16 (70.00)	68.97 (56.22)
Untreated	--	18.25	-	-	-	-	21.23	-	-	-	-
S.Em±			0.79	1.30	0.92	0.80		0.73	1.22	0.80	0.71
CD (P=0.05%)			2.36	3.86	2.74	2.38		2.76	3.63	2.39	2.12

*Figures in the parentheses are angular transformation values; #PTP: Pre-Treatment Population

Table 4. Bio-efficacy of novel insecticides against whitefly on mung bean

Treatments	Concentration (%) / dose	PTP#	Mean per cent reduction days after First spray				PTP	Mean per cent reduction days after Second spray			
			One day	Three days	Seven days	Fifteen days		One day	Three days	Seven days	Fifteen days
Lambda-cyhalothrin 17.8 SL	0.01%	13.11	42.07 (40.44)*	48.64 (44.21)	47.34 (43.48)	44.94 (42.10)	10.39	42.02 (40.41)	44.20 (41.67)	41.28 (39.98)	38.62 (38.42)
Thiamethoxam 25WG	0.02%	11.16	77.24 (61.51)	95.24 (77.41)	92.51 (74.12)	74.21 (59.48)	10.14	78.97 (62.70)	83.25 (65.84)	73.85 (59.25)	62.78 (52.41)
Bifenthrin 10% EC	0.025%	13.00	72.08 (58.12)	90.99 (72.69)	89.07 (70.80)	70.77 (57.28)	9.65	71.93 (58.02)	75.52 (60.35)	69.15 (56.26)	56.21 (48.57)
Chlorantraniliprole 18.5 SC	0.01%	11.55	68.55 (55.89)	85.03 (67.29)	84.92 (67.21)	67.74 (55.40)	9.35	72.29 (58.25)	75.22 (60.16)	69.05 (56.21)	58.74 (50.04)
Buprofezin 25 SC	0.03%	13.14	42.89 (40.91)	50.24 (45.14)	48.88 (44.36)	46.16 (42.80)	9.68	78.11 (62.10)	81.28 (64.37)	72.89 (58.63)	63.12 (52.60)
Fipronil 5% SC	0.01%	11.19	77.14 (61.44)	95.14 (77.27)	92.41 (74.01)	72.69 (58.49)	9.11	73.23 (58.85)	76.56 (61.07)	71.17 (57.54)	62.58 (52.29)
Metarhizium anisopliae 1.15 WP @ 5 g L^{-1}	1×10^8 spores/g	11.95	42.07 (40.44)	48.64 (44.21)	47.34 (43.48)	44.94 (42.10)	11.24	40.22 (39.36)	43.82 (41.45)	39.28 (38.81)	37.54 (37.79)
Beauveria bassiana 1.15 WP @ 5 g L^{-1}	1×10^8 spores/g	12.95	41.22 (39.95)	48.06 (43.89)	46.52 (43.00)	44.05 (41.58)	10.35	39.54 (38.96)	42.45 (40.66)	38.44 (38.32)	36.36 (37.08)
Dimethoate 30 EC	0.04%	12.39	77.34 (61.69)	95.34 (77.76)	92.61 (74.35)	75.83 (60.67)	10.35	80.31 (63.82)	85.72 (68.20)	76.08 (60.82)	63.69 (52.98)
Untreated	--	12.35	-	-	-	-	19.24	-	-	-	-
S.Em±			0.84	1.02	0.78	0.81		0.89	1.08	0.76	0.64
CD (P=0.05%)			2.48	3.03	2.31	2.40		2.65	3.20	2.25	1.90

*Figures in the parentheses are angular transformation values, #PTP: Pre Treatment Population

WP were grouped into least effective. The present findings are corroborates with the finding of Singh *et al.* (2019) who reported the treatments of thiamethoxam (0.005%) and dimethoate (0.03%) moderately effective. These results are in partial agreement with Singh and Singh (2018) who reported the *Metarhizium anisopliae* (1×10^8 Spores/g) 5 g L^{-1} and *Beauveria bassiana* (2×10^8 Spores/g) 2.5 g L^{-1} were found to be least effective with maximum population and minimum per cent reduction over control. The descending order of insecticides/botanicals based on per cent reduction of whitefly was found to be dimethoate 30 EC > thiamethoxam 25 WG > fipronil 5% SC > bifenthrin 10% EC > chlorantraniliprole 18.5 SC > buprofezin 25 SC > lambda-cyhalothrin 17.8 SL > *Metarhizium anisopliae* 1.5 WP > *Beauveria bassiana* 1.15 WP.

Bioefficacy against thrips, Caliothrips indicus (Bagnall)

Dimethoate 30 EC, thiamethoxam 25 WG and fipronil 5% SC was observed as best effective treatments in reducing the population of thrips, *Caliothrips indicus* (Bagnall). The treatments of buprofezin 25 SC, bifenthrin 10% EC and chlorantraniliprole 18.5 SC were ranked in middle order of efficacy (Table 5), whereas the *Metarhizium anisopliae* 1.15 WP followed by Lambda-cyhalothrin 17.8 SL and *Beauveria bassiana* 1.15 WP were least effective. These results are also in agreement with that of Ahirwar *et al.,* (2015) and Khade *et al.* (2014) who reported that dimethoate @ 300 mL was effective in controlling thrips and other sucking pests. The present findings are partially corroborates with the finding of Sujatha and Bharpoda (2017) who found thiamethoxam 25 WG (0.01%) and imidacloprid 70 WG (0.014%) were more effective against sucking pests on mung bean. The descending order of treatments against thrips was found to be dimethoate 30 EC > thiamethoxam 25 WG > fipronil 5% SC > buprofezin 25 SC > bifenthrin 10% EC > *Metarhizium anisopliae* 1.5 WP > chlorantraniliprole 18.5 SC > lambda-cyhalothrin 17.8 SL > *Beauveria bassiana* 1.15 WP.

Economics of the treatments

Maximum yield was recorded in the treatment thiamethoxam 25WG with 1015 kg ha^{-1} grain yield which was 35.5% increased over control (655 kg ha^{-1}). This was followed by plots

Table 5. Bio-efficacy of novel insecticides against thrips on mung bean

Treatments	Concentration (%)/dose	PTP#	Mean per cent reduction days after First spray				PTP	Mean per cent reduction days after Second spray			
			One day	Three days	Seven days	Fifteen days		One day	Three days	Seven days	Fifteen days
Lambda-cyhalothrin 17.8 SL	0.01%	4.22	40.56 (39.56)*	47.47 (43.55)	44.72 (41.97)	41.68 (40.21)	3.32	46.83 (43.18)	48.92 (44.38)	43.44 (41.23)	38.90 (38.59)
Thiamethoxam 25 WG	0.02%	3.18	76.03 (60.72)	96.75 (79.78)	91.19 (72.89)	69.05 (56.24)	2.97	90.03 (71.79)	95.54 (78.34)	88.26 (70.21)	71.73 (57.94)
Bifenthrin 10% EC	0.025%	2.81	66.60 (54.70)	79.26 (62.94)	78.66 (62.51)	62.68 (52.35)	2.29	78.96 (62.72)	82.99 (65.69)	70.97 (57.41)	61.72 (51.78)
Chlorantraniliprole 18.5 SC	0.01%	4.28	41.32 (40.00)	48.00 (43.85)	44.84 (42.03)	42.56 (40.72)	3.72	77.04 (61.39)	81.89 (64.85)	68.75 (56.02)	60.86 (51.28)
Buprofezin 25 SC	0.03%	4.48	68.04 (55.58)	82.19 (65.09)	80.27 (63.63)	62.99 (52.53)	3.22	79.91 (63.40)	85.83 (67.89)	71.88 (57.98)	62.72 (52.37)
Fipronil 5% SC	0.01%	3.33	74.92 (60.00)	96.65 (79.74)	91.09 (72.67)	67.74 (55.39)	2.92	90.01 (71.58)	95.74 (78.11)	88.16 (69.88)	71.58 (57.78)
Metarhizium anisopliae 1.15 WP @ 5 g L^{-1}	1×10^8 spores/g	4.33	63.95 (53.10)	80.68 (63.97)	77.09 (61.43)	61.92 (51.90)	3.18	46.29 (42.87)	48.70 (44.25)	43.10 (41.04)	38.26 (38.21)
Beauveria bassiana 1.15 WP @ 5 g L^{-1}	1×10^8 spores/g	5.28	39.40 (38.88)	47.04 (43.30)	43.44 (41.23)	40.80 (39.70)	4.22	47.35 (43.48)	49.52 (44.73)	43.64 (41.35)	39.71 (39.06)
Dimethoate 30 EC	0.04%	4.23	77.14 (61.45)	96.85 (79.85)	91.29 (73.00)	71.78 (57.91)	2.91	90.04 (71.61)	95.24 (77.41)	88.06 (69.79)	72.84 (58.59)
Untreated	--	5.32	-	-	-	-	5.81	-	-	-	-
S.Em±			0.83	1.06	0.88	0.66		0.91	1.01	0.81	0.64
CD (P=0.05%)			2.46	3.15	2.60	1.95		2.71	3.02	2.42	1.90

*Figures in the parentheses are angular transformation values; #PTP: Pre Treatment Population

Table 6. Economics and cost benefit ratio of different treatments in mung bean

Treatments	Conc.%/ dosage ha^{-1}	Grain yield (kg ha^{-1})	Increased yield over control (kg ha^{-1})	Cost of increased yield over control (Rs. ha^{-1})	Cost of insecticide application (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	C:B ratio
Lambda-cyhalothrin 17.8 SL	0.01%	840	185	13312	3004	10308	1:3.43
Thiamethoxam 25WG	0.02%	1015	360	25906	4960	21000	1:4.23
Bifenthrin 10% EC	0.025%	910	255	18350	4680	13670	1:2.92
Chlorantraniliprole 18.5 SC	0.01%	900	245	17630	6242	11338	1:1.82
Buprofezin 25 SC	0.03%	835	180	12953	3472	9481	1:2.73
Fipronil 5% SC	0.01%	878	223	16047	5064	10983	1:2.16
Metarhizium anisopliae 1.15 WP @ 5 g L^{-1}	1×10^{8} spores/g	760	105	7556	3160	4395	1:1.40
Beauveria bassiana 1.15 WP @ 5 g L^{-1}	1×10^{8} spores/g	750	95	6836	3060	3676	1:1.20
Dimethoate 30 EC	0.04%	990	335	24107	3120	21050	1:6.91
Untreated	-	655	-	-	-	-	-

Rate of insecticides applied: Lambda-cyhalothrin 17.8 SL- Rs. 1915/lit; Thiamethoxam 25 WG- Rs. 2500/kg; Bifenthrin 10% EC- Rs. 1040/lit.
Chlorantraniliprole 18.5 SC- Rs. 7218/lit; Buprofezin 25 SC- Rs. 1327/lit; Fipronil 5% SC- Rs. 1460/lit;
Metarhizium anisopliae 1.15 WP- RS. 800/kg; *Beauveria bassiana*1.15 WP- Rs. 750/lit.
Dimethoate 30EC-780/lit.
Labour charges @ Rs 260 / labour/day (3 labour/spray ha^{-1})
Sale price of mung bean grain-Rs 7196/q

treated with dimethoate 30EC and bifenthrin 10EC in which the the yield over control was increased 335 and 255 kg ha^{-1}, respectively (Table 6). The minimum yield was recorded in the plots treated with *Beauveria bassiana* 1.15 WP and *Metarhizium anisopliae* 1.15 WP in which the increase in yield over control was 95 and 105 kg ha^{-1}, respectively. The highest benefit cost ratio (1:6.91) was obtained from the plot treated with dimethoate 30EC followed by thiamethoxam 25WG (1:4.23) and lambda-cyhalothrin 17.8 SL(1:3.43), these treatment were proved to be most economic. The lowest benefit-cost ratio was computed in the plot treated with *Beauveria bassiana* 1.15 WP (1:1.20) and *Metarhizium anisopliae* 1.15 WP (1:1.40).

Conclusion

Mung bean stands out as a significant crop due to its rich nutritional content and adaptability to arid regions, particularly in Rajasthan, India. However, its production faces significant challenges from various insect pests, notably sucking pests like leafhoppers, whiteflies, and thrips. These pests can cause substantial yield losses, emphasizing the need for effective pest management strategies. Through the evaluation of chemical and bio-pesticides, this study sheds light on promising solutions for pest control. Thiamethoxam 25 WG, bifenthrin 10EC and fipronil 5 SC emerge as effective treatments against leafhoppers, whiteflies, and thrips, with favorable economic returns. Such findings offer valuable insights for sustainable mung bean cultivation in the face of evolving climatic conditions and pest pressures.

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