



Plant Archives

Journal homepage: <http://www.plantarchives.org>

DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.293>

BIO-EFFICACY OF BIOFORMULATIONS AGAINST SPOTTED POD BORER, *MARUCA VITRATA* INFESTING COWPEA UNDER LABORATORY AND FIELD CONDITIONS

A.A. Darji^{1*}, C.B. Varma² and Puja Pandey³

¹Department of Entomology, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

²College of Agriculture, Anand Agricultural University, Vaso, Gujarat, India

³Department of Plant Pathology, B. A. College of Agriculture, Anand Agricultural University, Anand, India

*Corresponding author e-mail: darjia244@gmail.com,

(Date of Receiving : 08-06-2025; Date of Acceptance : 12-08-2025)

ABSTRACT

A field experiment was conducted to assess the efficacy of various bioformulations against the spotted pod borer infesting cowpea at the Main Vegetable Research Station (MVRS), Anand Agricultural University, Anand, during *kharif*, 2024. The most effective treatment in reducing *M. vitrata* population was NSKE 5%, followed by *Neemastra* and *Agniastra* 4%. *Brahmastra* 4% and custard apple leaf extract 5% were moderately effective, while *Lantana camara* leaf extract 5% and cow urine 5% were the least effective. A similar trend was observed in pod damage with NSKE recording the lowest (24.69%), followed by *Neemastra* (26.37%) and *Agniastra* 4% (28.88%). NSKE 5% treated plots also recorded the highest green pod yield (69.43 q/ha), followed by *Neemastra* (65.00 q/ha) and *Agniastra* 4% (61.39 q/ha). In terms of avoidable losses, *Neemastra* (6.39%) and *Agniastra* 4% (11.59%) showed the lowest values, while the untreated control recorded the highest yield loss (30.13%). Among the nine bioformulations evaluated against third instar larvae of *M. vitrata* under laboratory conditions the highest larval mortality was observed with *Agniastra* 4% and neem seed kernel extract 5%, which consistently demonstrated superior efficacy and were at par with each other across all time intervals. *Brahmastra* 4%, *Neemastra*, *Lantana camara* leaf extract 5% and custard apple leaf extract 5% showed moderate effectiveness while cow urine 5%, Kalmegh powder 10% and garlic bulb extract 5% recorded the lowest larval mortality.

Keywords : Spotted pod borer, Bioformulations, cowpea, *M. vitrata*.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] a legume of the Fabaceae family is widely cultivated for its drought resilience, soil-enriching ability and nutritional value. It originated in Africa and is now grown across tropical and subtropical regions (Huynh *et al.*, 2013). Cowpea plays a key role in sustainable farming due to its capacity for biological nitrogen fixation (Da Silva *et al.*, 2019). Its seeds are rich in protein (23.4%), carbohydrates (60.3%) and essential minerals, offering several health benefits (Jayathilake *et al.*, 2018).

According to recent data from world, the total global cowpea production is estimated at 9.78 million tonnes (Anonymous 2023). In Gujarat specifically,

cowpea is cultivated on approximately 0.033 million hectares, resulting in an annual production of 3.42 lakh tonnes, with an average productivity of 10.22 tonnes/ha (Anonymous, 2023).

Despite its agronomic value, cowpea yields are constrained by insect pests, with over 21 species reported throughout its growth stages (Sardana and verma, 1986). Among them, the spotted pod borer, *M. vitrata* (Fabricius) (Lepidoptera: Crambidae) is the most damaging, infesting floral and reproductive parts and causing up to 80% yield loss (Dannon, 2011). Additionally, it serves as a rich source of calcium and iron (Anusha *et al.*, 2016). Its cryptic feeding behaviour makes management difficult, often leading to excessive insecticide use. Therefore, the current

investigation was conducted to assess the performance of bioformulations treatments against *M. vitrata* in cowpea.

Materials and Methods

Laboratory Trial

For the bioassay, studies were conducted using laboratory-cultured third instar larvae of *M. vitrata*. Unsprayed cowpea twigs bearing young pods were collected and arranged in a bouquet-like manner. These bouquets were placed in conical flasks (diameter: 4.45 cm, height: 14 cm) containing water and the mouths of the flasks were plugged with cotton. A 500 ml solution of the required concentration of selected bioformulations was prepared in the laboratory and ten third instar starved larvae were released onto each bouquet before spraying the bioformulations using a small atomizer. Each treatment was repeated three times in a completely randomized design. The flower bouquets sprayed with water served as the control. Larval mortality was recorded at 24, 48 and 72 hours after treatment. To maintain uniform food quality and avoid deterioration of plant material the flower bouquets were replaced with fresh untreated ones at 24 and 48 hours post-treatment.

The percentage mortality was calculated using the modified Abbott's formula (Henderson and Tilton, 1955) as given below.

Corrected Per cent Mortality =

$$\left[1 - \frac{n \text{ in Co before treatment} \times n \text{ in T after treatment}}{n \text{ in Co after treatment} \times n \text{ in T before treatment}} \right] \times 100$$

Where, n = Number of living larvae; T = Treatment;

Co = Control

The collected data were converted into percentage values and analyzed using standard statistical methods (Steel and Torrie, 1980) after applying an arcsine transformation to ensure valid conclusions.

Field Trial

Cowpea (AVCP 1) was raised by following recommended agronomical practices except for the plant protection measures. The first spray of the respective bioformulations was made after the appearance of pod borer larvae in the experimental plot and subsequent sprays were applied at 10-day intervals. Treatment-wise application of bioformulations was carried out using a manually operated knapsack sprayer fitted with a duromist nozzle at the slight runoff stage.

For recording the observations of the larval population of the pod borer, *M. vitrata*, five plants

were randomly selected from each net plot area. The selected plants were critically observed and the number of larvae was counted. Observations were recorded before the first spray and at 3, 7, and 10 days after each spray. Cowpea pods were periodically harvested and the total number of healthy and damaged pods (out of 50 pods) was recorded at each picking. Based on these observations, the percentage of pod damage was calculated. The green pod yield of cowpea per plot was recorded and converted into a hectare for each treatment.

The per cent increase in yield relative to the control was estimated using the standard formula given by Pradhan (1969).

$$\text{Per cent increase in yield over control} = \frac{T - C}{C} \times 100$$

Where, T = Yield of treatment (kg/ha)

C = Yield of control (kg/ha)

The avoidable yield loss was computed using the formula given by Paul (1976):

Avoidable loss (%) =

$$\frac{\text{Highest yield in treated plot} - \text{Yield in treated plot}}{\text{Highest yield in treated plot}} \times 100$$

The data on the *M. vitrata* larvae population and cowpea pod yield were analyzed using Analysis of Variance (ANOVA). Prior to analysis, the larvae population data underwent square root transformation ($\sqrt{x + 0.5}$) to normalize the distribution. Treatment means were compared through Duncan's New Multiple Range Test (Steel & Torrie, 1980). To assess the consistency and overall effectiveness of the treatments, the periodical data on larvae population were pooled across different time intervals as well as across both time intervals and bioformulations sprays.

Results and Discussion

The data on the population of the pod borer, *M. vitrata*, collected following the first, second third spray applications are summarized in Table 1. Prior to the initiation of the spray treatments no significant differences were found among the various treatment groups, suggesting that the insect pest was evenly distributed across all experimental units at the start of the study.

Laboratory trial

Larval Mortality at 24 Hours:

The data on larval mortality revealed that the highest larval mortality was recorded in *Agniastrea* 4% (30.00%), which was statistically at par with neem

seed kernel extract (NSKE) 5% (26.52%), demonstrating comparable efficacy. Treatments such as *Neemastra*, *Brahmastra* 4%, *L. camara* leaf extract 5% and custard apple leaf extract 5% (20.00%) were at par showing moderate effectiveness against *M. vitrata*. In contrast, cow urine 5% (10.00%) showed the lowest mortality, statistically similar to kalmegh powder 10% and garlic bulb extract 5% (10.00%), indicating limited pesticidal activity.

Larval Mortality at 48 Hours:

Agniastra 4% recorded the highest larval mortality at 40.00 per cent which was statistically at par with NSKE 5% (36.60%). Moderate effectiveness was observed with *Neemastra* (26.52%) and *Brahmastra* 4% (30.00%), followed by *L. camara* leaf extract 5% and custard apple leaf extract 5% (30.00%),

which showed comparable mortality rates. Cow urine 5%, kalmegh powder 10% and garlic bulb extract 5% (20.00%) showed the lowest mortality, making them the least effective treatments.

Larval Mortality at 72 Hours:

Agniastra 4% recorded the highest larval mortality (73.48%), which was statistically at par with NSKE 5% (63.40%), indicating their superior efficacy against *M. vitrata*. These were followed by *Brahmastra* 4% and *Neemastra* (56.69%) and *L. camara* leaf extract 5% and custard apple leaf extract 5% (60.00%), all showing moderate but significant control. The lowest mortality was recorded in cow urine 5% and kalmegh powder 10% (46.65%) and garlic bulb extract 5% (43.31%), confirming their limited effectiveness.

Table 1: Evaluation of different bioformulations against spotted pod borer, *M. vitrata* infesting Cowpea under laboratory conditions

Tr. No.	Bioformulations	Larval mortality (%) at indicated intervals		
		24 hrs	48 hrs	72 hrs
T ₁	<i>Neemastra</i>	26.55 ^b (20.00)	30.98 ^b (26.52)	48.82 ^b (56.69)
T ₂	<i>Agniastra</i> 4%	33.19 ^a (30.00)	39.21 ^a (40.00)	59.98 ^a (73.48)
T ₃	<i>Brahmastra</i> 4%	26.55 ^b (20.00)	33.19 ^b (30.00)	48.82 ^b (56.69)
T ₄	Neem Seed Kernel Extract (NSKE) 5%	30.90 ^a (26.52)	37.20 ^a (36.60)	52.75 ^b (63.40)
T ₅	<i>Lantana camara</i> leaf extract 5%	26.55 ^b (20.00)	33.19 ^b (30.00)	50.74 ^b (60.00)
T ₆	Custard apple leaf extract 5%	26.55 ^b (20.00)	33.19 ^b (30.00)	50.74 ^b (60.00)
T ₇	Cow urine 5%	18.42 ^c (10.00)	26.55 ^c (20.00)	43.05 ^c (46.65)
T ₈	Kalmegh powder 10%	18.42 ^c (10.00)	26.55 ^c (20.00)	43.05 ^c (46.65)
T ₉	Garlic bulb extract 5%	18.42 ^c (10.00)	26.55 ^c (20.00)	41.13 ^c (43.31)
T ₁₀	Control	0.57 ^d (0.01)	0.57 ^d (0.01)	0.57 ^d (0.01)
S. Em. ± Treatment (T)		0.70	0.94	1.65
F test T		Sig.	Sig.	Sig.
C.V. (%)		5.37	5.71	6.54

Note: 1) Treatment means with common letter(s) are/is not significant at 5% level of significance by DNMR

2) Figures in the parentheses are re-transformed values and those outside are arc-sin transformed values

These results are in line with the findings of Mahankuda and Tiwari (2020), who also reported that *Agniastra* caused the highest larval mortality (59.98%) after 72 hours, followed by NSKE 5% (52.75%), while *Brahmastra* and *Neemastra* (48.82%) showed moderate control.

Table 2: Effect of bioformulations against of *M. vitrata* in cowpea (Pooled over spray)

Tr. No.	Treatments	No. of larvae/ plant				
		Before spray	First spray	Second spray	Third spray	Pooled over spray
T ₁	<i>Neemastra</i>	1.92 (3.18)	1.47 ^{ab} (1.66)	1.45 ^a (1.60)	1.44 ^a (1.35)	1.46 ^{ab} (1.63)
T ₂	<i>Agniastra</i> 4%	1.98 (3.42)	1.56 ^{ab} (1.93)	1.51 ^{ab} (1.78)	1.48 ^a (1.69)	1.52 ^b (1.81)
T ₃	<i>Brahmastra</i> 4%	1.89 (3.07)	1.61 ^{ab} (2.09)	1.61 ^{bc} (2.09)	1.65 ^b (2.22)	1.62 ^c (2.12)
T ₄	NSKE 5%	1.91 (3.15)	1.43 ^a (1.54)	1.38 ^a (1.40)	1.39 ^a (1.43)	1.41 ^a (1.49)
T ₅	<i>Lantana camara</i> leaf extract 5%	1.97 (3.38)	1.71 ^{ab} (2.42)	1.69 ^c (2.36)	1.75 ^{bc} (2.56)	1.72 ^d (2.46)
T ₆	Custard apple leaf extract 5%	1.98 (3.42)	1.68 ^{ab} (2.32)	1.66 ^{bc} (2.26)	1.69 ^b (2.36)	1.68 ^{cd} (2.32)
T ₇	Cow urine 5%	1.96 (3.34)	1.76 ^b (2.60)	1.73 ^c (2.49)	1.79 ^{bc} (2.70)	1.76 ^d (2.60)
T ₈	Control	2.01 (3.54)	2.16 ^c (4.17)	2.23 ^d (4.47)	2.16 ^d (4.17)	2.19 ^e (4.30)
S. Em. ±		Treatments (T)		0.04	0.04	0.03
		Period (P)		0.03	0.03	0.02
		Spray (S)		-	-	0.02
		T × P		0.08	0.09	0.05
		T × S		-	-	0.05
		P × S		-	-	0.03
		T × P × S		-	-	0.08
F test		T		Sig.	Sig.	Sig.
C.V. (%)				8.25	9.33	8.61

Note: (1) Figures outside the parentheses are $\sqrt{x + 0.5}$ transformed values and those inside the parentheses are retransformed values

(2) Treatment means followed by the same letter are not significantly differed by DNMRT at 5% level of significance

(3) Significant parameters and its interactions: P, T × P, T × S, P × S and T × P × S

Field trial

Population of spotted Pod Borer, *M. vitrata*:

The pooled analysis of three consecutive sprays presented in Table 2 indicated that neem seed kernel extract (NSKE) 5% was the most effective treatment, recording the lowest larval population of *M. vitrata* (1.49 larvae/plant). Its efficacy was statistically on par with *Neemastra* 5% (1.63 larvae/plant) and *Agniastra* 4% (1.81 larvae/plant), both of which also provided strong control. *Brahmastra* 5% (2.12 larvae/plant) showed a moderate level of effectiveness. While the botanical extracts of *L. camara* leaf extract 5% (2.46 larvae/plant) and custard apple leaf extract 5% (2.32 larvae/plant) offered intermediate suppression of the pest, cow urine 5% (2.60 larvae/plant) was the least effective among all treatments. However, it still significantly reduced larval numbers compared to the untreated control (4.30 larvae/plant), which recorded the highest infestation of *M. vitrata*.

These findings are consistent with previous literature, particularly the results of Muhammad *et al.* (2017), who observed a gradual decline in larval

density when using NSKE 5% on cowpea, reporting larval numbers decreasing from 10.19 at 10 weeks after sowing to 7.96 at 14 weeks and 5.74 at 18 weeks in treated plots. By comparison, untreated controls showed much higher and persistent larval populations ranging from 12 to 13 larvae per plant throughout the crop season. The current field study's lower observed larval incidence (1.49 larvae/plant with NSKE 5%) suggests improved efficacy of NSKE under these conditions and possibly better application techniques or more favourable environmental interactions.

Pod Damage:

The pod damage caused by *M. vitrata* was recorded at each picking (Table 3). During the first picking, the lowest pod damage (17.25%) was observed in plots treated with NSKE 5%, which was statistically at par with *Neemastra* (18.61%), *Agniastra* 4% (20.62%), *Brahmastra* 4% (22.60%) and custard apple leaf extract 5% (22.12%). In contrast, *Lantana camara* leaf extract 5% (25.20%) and cow urine 5% (31.89%) recorded higher pod damage.

Table 3: Effect of bioformulation against pod damage caused by *M. vitrata* infesting cowpea

Tr. No.	Bioformulations	Pod damage (%) at different number of pickings							
		1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	Pooled
T ₁	<i>Neemastra</i>	25.55 ^{ab} (18.61)	30.80 ^a (26.23)	31.44 ^{ab} (27.21)	28.33 ^{ab} (22.52)	32.60 ^{ab} (29.04)	33.10 ^{ab} (29.82)	34.42 ^{cd} (31.97)	30.89 ^{ab} (26.37)
T ₂	<i>Agniastra</i> 4%	27.00 ^{ab} (20.62)	32.33 ^{ab} (28.61)	32.76 ^{abc} (28.34)	30.14 ^{abc} (25.21)	34.42 ^{abc} (31.97)	35.20 ^{abc} (33.23)	35.63 ^{cd} (33.95)	32.50 ^{bc} (28.88)
T ₃	<i>Brahmastra</i> 4%	28.38 ^{ab} (22.60)	33.13 ^{ab} (29.88)	33.97 ^{abc} (31.22)	33.57 ^{bcd} (30.59)	35.60 ^{abcd} (33.89)	36.39 ^{abcd} (35.20)	36.78 ^{cd} (35.86)	33.97 ^{cd} (31.24)
T ₄	NSKE 5%	24.53 ^a (17.25)	30.16 ^a (25.24)	30.06 ^a (25.09)	30.75 ^a (26.15)	31.48 ^a (27.28)	32.75 ^a (28.81)	33.23 ^a (30.03)	29.79 ^a (24.69)
T ₅	<i>Lantana camara</i> leaf extract 5%	30.13 ^{bc} (25.20)	35.23 ^{abc} (33.29)	36.04 ^{bcd} (34.63)	34.41 ^{bcd} (31.95)	38.01 ^{bcd} (37.92)	39.20 ^{bcd} (39.96)	40.16 ^{cd} (41.61)	36.40 ^{ef} (35.22)
T ₆	Custard apple leaf extract 5%	28.05 ^{ab} (22.12)	34.02 ^{ab} (31.31)	36.03 ^{abcd} (34.60)	33.90 ^{bcd} (31.11)	37.20 ^{abcd} (36.56)	38.36 ^{abcd} (38.53)	38.39 ^{bcd} (38.58)	35.26 ^{de} (33.34)
T ₇	Cow urine 5%	34.38 ^{cd} (31.89)	36.63 ^{bc} (35.60)	38.41 ^{cd} (38.61)	36.03 ^{cd} (34.60)	39.98 ^{cd} (41.29)	40.36 ^{cd} (41.94)	40.35 ^{cd} (41.93)	38.02 ^f (37.94)
T ₈	Control	30.41 ^d (25.63)	40.36 ^c (41.94)	41.09 ^d (43.20)	39.16 ^d (39.89)	41.89 ^d (44.58)	42.27 ^d (45.25)	44.21 ^d (48.62)	41.17 ^g (43.34)
S. Em. ± Treatments (T)		1.42	1.71	1.74	1.86	1.92	1.90	1.83	0.58
F test T		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. (%)		8.32	8.71	8.54	9.84	9.12	8.86	8.40	8.86

Note: 1. Figures outside the parentheses are arcsine transformed values and those inside the parentheses are retransformed values

2. Significant parameter: T, P

3. Treatments means with the letter(s) in common are not significantly different by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance

A similar trend was observed in the second and third pickings, with NSKE 5% continuing to show the lowest pod damage (25.24% and 25.09%, respectively), followed by *Neemastra* (26.23%, 27.21%) and *Agniastra* 4% (28.61%, 28.34%). Treatments such as *Brahmastra* 4%, custard apple leaf extract 5%, *L. camara* leaf extract 5% and cow urine 5% recorded comparatively higher damage, while the untreated control consistently showed the maximum damage. In the fourth and fifth pickings, NSKE 5% (26.15% and 27.28%) maintained its effectiveness and was statistically at par with *Neemastra* and *Agniastra* 4%. Cow urine 5% and the control plots recorded the highest levels of pod damage across both pickings.

Pooled data from all seven pickings revealed that NSKE 5% (24.69%) was the most effective in reducing pod damage caused by *M. vitrata*, followed by *Neemastra* (26.37%) and *Agniastra* 4% (28.88%). *Brahmastra* 4% (31.24%) and custard apple leaf extract 5% (33.34%) provided moderate control, while *L. camara* leaf extract 5% (35.22%) and cow urine 5% (37.94%) were the least effective among the bioformulations. The untreated control recorded the highest mean pod damage (43.34%).

Several studies have demonstrated the potential of botanical and natural farming-based formulations in managing *M. vitrata* infestation in legumes. Among these, neem seed kernel extract has consistently shown

high efficacy in reducing pod damage. In field evaluations, Divya Bharathi (2018) reported that NSKE (5%) reduced pod damage by 50 per cent in Indian bean (*L. purpureus*).

Effect on green cowpea pod yield:

The study evaluated the effects of various bioformulations on green pod yield of cowpea under infestation by *M. vitrata*. Among the treatments, NSKE 5% recorded the highest green pod yield (69.43 q/ha) indicating its superior efficacy in enhancing productivity. This was followed by *Neemastra* (65.00 q/ha) and *Agniastra* 4% (61.39 q/ha), both of which also showed notable improvements over the control. *Brahmastra* 4% yielded 57.33 q/ha while custard apple leaf extract 5% (56.89 q/ha) and *L. camara* leaf extract 5% (53.88 q/ha) recorded moderate yields. Cow urine 5% showed the lowest yield among the treatments (52.33 q/ha).

Control had the minimum yield of 48.50 q/ha, underscoring the positive impact of bioformulations in mitigating yield losses due to *M. vitrata* infestation. The above results were more or less aligned with previous study conducted by Chauhan *et al.* (2009) who reported that the application of neem seed kernel extract (NSKE) at 5% significantly enhanced the yield of cowpea recording 980 kg/ha. compared to the untreated control which yielded only 529 kg/ha.

Table 4: Impact of bioformulations on green pod yield and avoidable losses due to *M. vitrata* infesting cowpea

Tr. No	Bioformulations	Green pod yield (q/ha)	Increase in yield over control (%)	Avoidable loss (%)
1	<i>Neemastra</i>	65.00 ^{ab}	34.02	6.39
2	<i>Agniastra</i> 4%	61.39 ^{abc}	26.53	11.59
3	<i>Brahmastra</i> 4%	57.33 ^{bcd}	18.22	17.44
4	NSKE 5%	69.43 ^a	43.17	-
5	<i>Lantana camara</i> leaf extract 5%	53.88 ^{cd}	11.08	22.41
6	Custard apple leaf extract 5%	56.89 ^{bcd}	17.22	18.07
7	Cow urine 5%	52.33 ^{cd}	7.92	24.62
8	Control	48.50 ^d	-	30.13
S. Em. $\pm$	Treatments (T)	3.30	-	-
F test	T	10.00	Sig.	Sig.
C.V. (%)		9.80	-	-

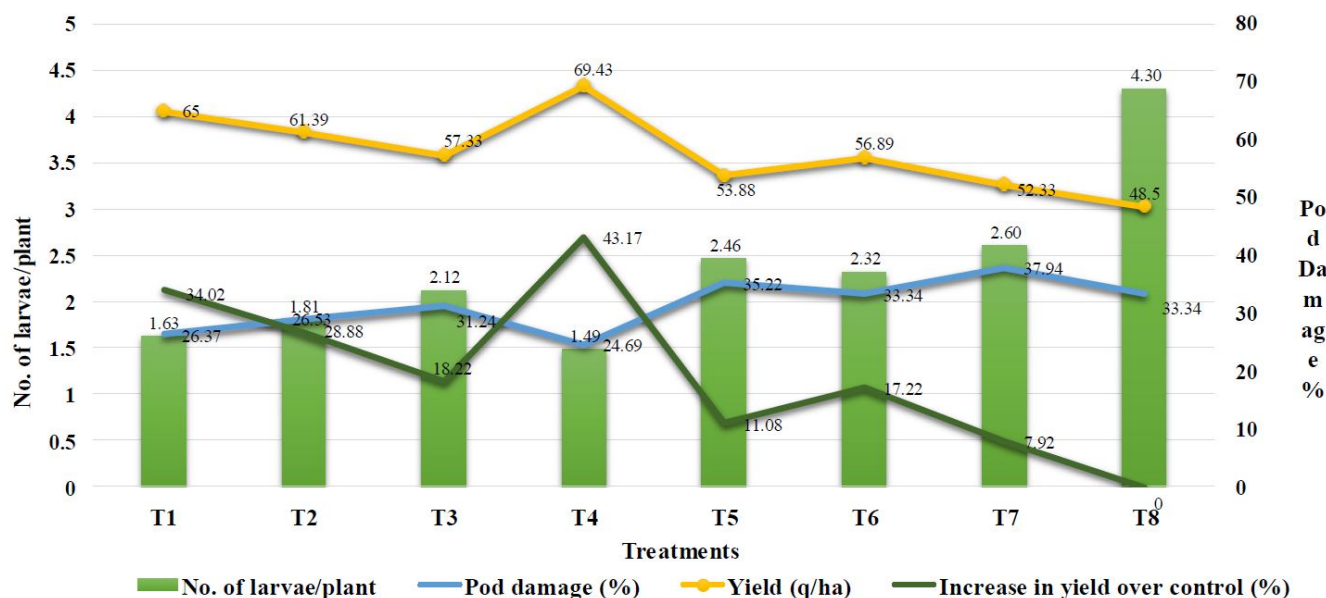
Note: Treatments means with the letter(s) in common are not significantly different by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance

Increase in Yield Over Control:

The increase in green cowpea pod yield over the untreated control was calculated for various bioformulation treatments, showing a range from 7.92 to 43.17 per cent. The highest increase was recorded in plots treated with NSKE 5% (43.17%), making it the most effective treatment. *Neemastra* (34.02%) and *Agniastra* 4% (26.53%) also resulted in substantial yield increases over the control, followed by *Brahmastra* 4% (18.22%). Comparatively lower increases were noted with custard apple leaf extract 5% (17.22%) and *L. camara* leaf extract 5% (11.08%). The lowest was observed in cow urine 5% treated plots (7.92%). These results reflect the differing efficacy of the tested bioformulations in improving cowpea yield.

Avoidable Losses:

The avoidable losses in yield of cowpea varied from 6.39 to 30.13 per cent across different treatments. The lowest avoidable loss (6.39%) was observed in *Neemastra*, followed by *Agniastra* 4% (11.59%) and *Brahmastra* 4% (17.44%). The avoidable losses ranged from 18.07 to 24.62 per cent in the treatments involving custard apple leaf extract 5%, *L. camara* leaf extract 5% and cow urine 5%. Among the tested treatments, the highest avoidable loss (30.13%) was recorded in the untreated control, highlighting the significant impact of bioformulations in minimizing yield losses due to *M. vitrata* infestation.

**Fig. 1:** Evaluation of bioformulations against spotted pod borer, *M. vitrata* in cowpea

Conclusion

The most effective treatments were NSKE 5%, *Neemastra*, and *Agniastra* 4%, which significantly reduced *M. vitrata* larval population and pod damage. Among these, NSKE 5% recorded the highest green pod yield, followed closely by *Neemastra* and *Agniastra*, with yield increases over the control of 43.17, 34.02, and 26.53 per cent, respectively. Moderate effectiveness was observed with *Brahmastra* 4% and custard apple leaf extract 5%. *L. camara* and cow urine 5% were the least effective across all parameters. A similar trend was also observed in avoidable yield losses. In laboratory trial *Agniastra* 4% and NSKE 5% emerged as the most potent treatments across all time intervals, indicating their strong larvicidal potential against *M. vitrata*.

Conflict of Interest: The authors declare that they have no conflict of interest.

Acknowledgement: This study was funded by the Main Vegetable Research Station (MVRs), Anand Agricultural University, Anand as a part of the master's research in Agricultural Entomology, carried out during 2024-25.

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