The Andhra Agric. J 68 (1): 51-58, 2021

Field Evaluation of Microbial Control Agents Against Spotted Pod Borer *Maruca vitrata* on Blackgram.

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ABSTRACT

Field efficiency of nine microbial bioinsecticides *Bacillus thuringiensis* isolates (16, 49, 51, 52, 55, 493, HD1, Dipel, *M. anisopliae*) and spinosad 45 % SC were evaluated against *M. vitrata* infesting blackgram during *rabi* season of 2020-21. The results revealed that spinosad 45% SC followed by Dipel, *Metarhizium anisopliae, Bt* isolate HD1and *Bt* isolate 493 were found to be the most effective in reducing the larval population and also in per cent reduction of the bud, flower and pod damage of blackgram. The maximum increase of seed yield (166 kg) of blackgram over control was recorded in spinosad 45% SC. The next effective treatments were Dipel, *M. anisopliae, Bt* isolate HD1and *Bt* isolate 493. The treatments of spinosad 45% SC and Dipel gave the highest ICBR of 1:7.24 and 1:6.75, respectively followed by *M. anisopliae* (1:6.24) *Bt* isolate HD1 (1:5.62) and *Bt* isolate 493 (1:4.70). Thus, three sprays of microbial bioinsecticides, at the time of bud initiation, flowering and pod developmental growth stages were found efficacious on the field management of *M. vitrata* on blackgram with higher yields.

Keywords: *Biopesticides*, *native Bacillus thuringiensis isolates, Metarhizium anisopliae, Maruca vitrata and blackgram.*

The grain legumes being the richest sources of vegetable proteins with high nutritional value, occupied as a key component in human diet. Pulses contain nearly 30 per cent of protein to supplement the energy rich cereal diet. The legume production in recent years is not sufficient to meet the protein requirements of the growing population owing to various biotic and abiotic constraints, which need to be immediately addressed. Among the pulses, blackgram (*Vigna mungo* L. Hepper) is the fourth most important short-duration pulse crop grown in India, contributing 10 per cent of national pulse production.

A large number of insects have been recorded feeding on blackgram from sowing to harvesting. The yield loss on blackgram due to insect pests at various stages of the crop growth accounts to 30 to 54.3 per cent in India (Nayar *et al.,* 1976; Singh and Allen, 1980; Dhuri and Singh, 1983; Saxena, 1983; Pandey *et al.,* 1991; Justin *et al.*, 2015).

Among the pod borers which infest legumes, the legume pod borer, *Maruca vitrata* (Geyer) is one of the most serious insect pests during flowering and pod formation stage inflicting huge losses (Pappu *et al.,* 2010). Due to its destructiveness at critical stages of crop growth *viz,* flowering and pod development stages especially to the economic plant parts such as flower buds, flowers and pods, it became a significant constraint to attain the maximum productivity from grain legumes. In India, *M. vitrata* damage has been found to range between 9 to 51 per cent in pigeonpea (Bhagwat *et al.*, 1998) 35 to

40 per cent in mungbean (Bindra, 1968) 9 to 84 per cent in blackgram (Manjunath and Mallapur, 2015) and 20-80 per cent in cowpea (Singh *et al.*, 1990). In this context, use of microbial control agents which are environmentally safer to manage insect pests are being investigated, which have a significant role in regulation of natural insect pest populations (Steinkraus, 2002) naturally.

MATERIAL AND METHODS

The experiment was conducted during *rabi* 2020-21 at Agricultural College Farm, Bapatla. Native *Bt* isolates 16, 49, 51, 52, 55, 493, HD1, Dipel, *M. anisopliae* and spinosad 45% SC along with an untreated control were tested against spotted pod borer *Maruca vitrata* on a blackgram cv. PU31. There were three replications in a randomized block design (RBD). Sowing was done manually and two to three seeds were sown per hill with a spacing of 30 cm row to row and 10 cm plant to plant. Thinning was done at 15 DAS to maintain intra row spacing. Gaps were filled wherever necessary to maintain the optimum plant population. Normal agronomic practices were followed for raising the crop (Basal fertilizer N: P: K: 20:50: 0 kg/ha). Six lepidopteran specific native *Bacillus thuringiensis* isolates that were present in the repository of Insect Pathology Lab, Department of Entomology, at Agricultural College, Bapatla.

Formulation of *B. thuringiensis* Isolates for Field Sprays:

A concentrated two g wettable powder formulation was prepared by mixing the required *Bt* powder with $1x10^{10}$ CFU g^{-1} concentration and 0.26 g boric acid and talc of 1.5 g were mixed thoroughly with the help of mortar and pestle under aseptic conditions. About 10 mg of sucrose, 60 ìl of Tween-80 and 40 ìl of Triton X-100 and finally 15 mg of silica gel were added and mixed thoroughly with the help of mortar and pestle. Thus, the prepared formulations were stored at 4 ^{0}C and used for field sprays.

For each spray 4g/l was used. Three sprays were applied at 10 days interval starting from bud initiation with high volume knapsack sprayer so, as to give uniform coverage on plant. Ten plants were randomly selected per replication in each treatment. Two border rows in each plot were excluded from observations. The data collected and calculated per cent bud damage, per cent flower damage, per cent pod damage and total number of larval count per plant per plot were recorded, one day before spray as pre-treatment data and 3, 5, 7 and 10 days after each spray as post-treatment data.

Per cent bud damage =

$$\frac{\text{Number of damaged buds}}{\text{Total number of buds}} \times 100$$

Per cent flower damage =

$$\frac{\text{Number of infested flowers}}{\text{Total number of flowers}} \times 100$$

Per cent pod damage =

$$\frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

ICB Ratio =

$$\frac{\text{Extra benefit of enhanced yield}}{\text{Extra cost incurred for each treatment}} \times 100$$

RESULTS AND DISCUSSION

Spinosad treated plots (4.97 larvae per plant) were recorded with the least larval population out of all the treatments and the highest population was recorded in untreated control (8.83 larvae per plant). The treatments that were on par with spinosad were

Dipel (5.15 larvae per plant), followed by treatment where isolate-HD1 (5.36 larvae per plant) *M. anisopliae* (5.37 larvae per plant), *Bt* isolate-493 (5.68 larvae per plant) were sprayed. The mean larval population reduction over the control after third spray indicated that the highest reduction was achieved in spinosad treatment plots (43.30%) which was statistically superior over Dipel (33.35%) treated plot. The next effective treatments were isolate-HD1 (30.02%), *M. anisopliae* (28.51%), *Bt* isolate 493 (24.77%), *Bt* isolate 16 (23.21%) and these were statistically on par with isolate 51 (21.78%), isolate 55 (20.55%).

The mean bud damage after first spray at 3, 5, 7 and 10 DAS were recorded in the range of 5.43 to 8.93 per cent. The minimum bud damage was recorded in spinosad treatment plots (5.43%), which was on par with Dipel (5.95%), *Bt* isolate HD 1 (6.08%), *M. anisopliae* (6.08%) and native *Bt* isolates16, 49, 51, 52, 55 and 493 and the respective treated plots were recorded with 6.45, 7.48, 6.72, 7.26, 6.90 and 6.31 per cent bud damage per plant. The mean bud damage reduction over control (Table1 and Fig.2) after first spray ranged from 14.29 to 38.25 per cent.

The maximum reduction was observed in spinosad (38.25%) which was statistically on par with Dipel (29.99%), followed by *M. anisopliae* (28.31%), *Bt* isolate-HD1 (28.94%), *Bt* isolate 493 (25.93%) and native *Bt* isolates 16, 51 and 55 were on par with each other recording 23.87, 22.21 and 21.30 percentage reduction over control in respective treated plots.

Over all, the mean per cent flower damage after second spray recorded at 3, 5, 7, 10 DAS ranged from 8.06 to 11.60 per cent. The minimum flower damage was recorded in spinosad plots (8.06%), Dipel (8.58%), *M. anisopliae* (8.69%) and *Bt* isolate HD1 (8.59%). The next effective treatments were *Bt* isolate16 (9.07%), *Bt* isolate 493 (8.90%) and *Bt* isolate 55 (9.55%) treated plots which were on par with *Bt* isolate 51 treated plot (9.33%).

Maximum mean flower damage reduction over control (Fig.3) after second spray was recorded in spinosad treated plots (31.65%) which was significantly superior over other plots, followed by Dipel (24.92%), HD-1 (23.34%) and *M. anisopliae* (22.95%) and all these treatments were on par with each other. The native *Bt* isolate 493 treated plots recorded (21.10%) in per cent flower damage reduction over control of which was on par with *Bt* isolates16 (19.54%) and 51 treated plots (18.20%).

The mean per cent pod damage after third spray collected at 3, 5, 7, 10 DAS was in the range of 7.85 to 11.98 per cent. The most effective treatment was spinosad which was on par with Dipel (8.07%), *Bt* isolate-HD1 (8.49%), and *M. anisopliae* (8.63%), *Bt* isolate 493 (8.94), 16 (8.97) and 51 (9.37) treated plots were on par with spinosad. Mean per cent pod damage reduction over control (Table 1 and Fig.4) after third spray was in the range of 15.61 to 37.56 per cent. Spinosad recorded with the maximum reduction in pod damage over control and was followed by Dipel (30.96%), *Bt* isolate-HD1 (27.77%), *M. anisopliae* (27.67%) and *Bt* isolate 493 (23.74%). The reduction over control in pod damage with native *Bt* isolates 16 and 51 treated plots were recorded with pod damage of 22.29 and 20.65%, respectively.

Among all the treatmental plots, spinosad @ 0.3 ml l^{-1} application resulted in the highest yield (412 kg ha^{-1}) accounting to 166 kg ha^{-1} increase over control, which was significantly superior over remaining treatments, this was followed by Dipel treated plots (392 kg ha^{-1}) that accounted to 146 kg ha^{-1} increase over control.The yields recorded in plots treated with *Bt* isolate HD1(375 kg ha^{-1}) and *M. anisopliae* (362 kg ha^{-1}) were on par with each other

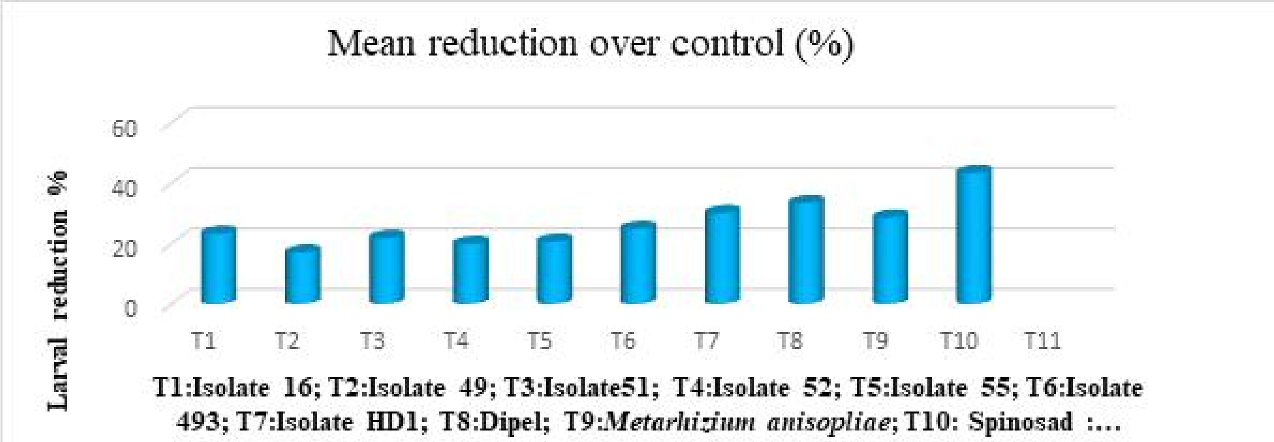

Fig.1. Efficacy of native and commercial *Bt* formulations against larval reduction of *M. vitrata* on blackgram after third spray during *rabi* 2020-21.

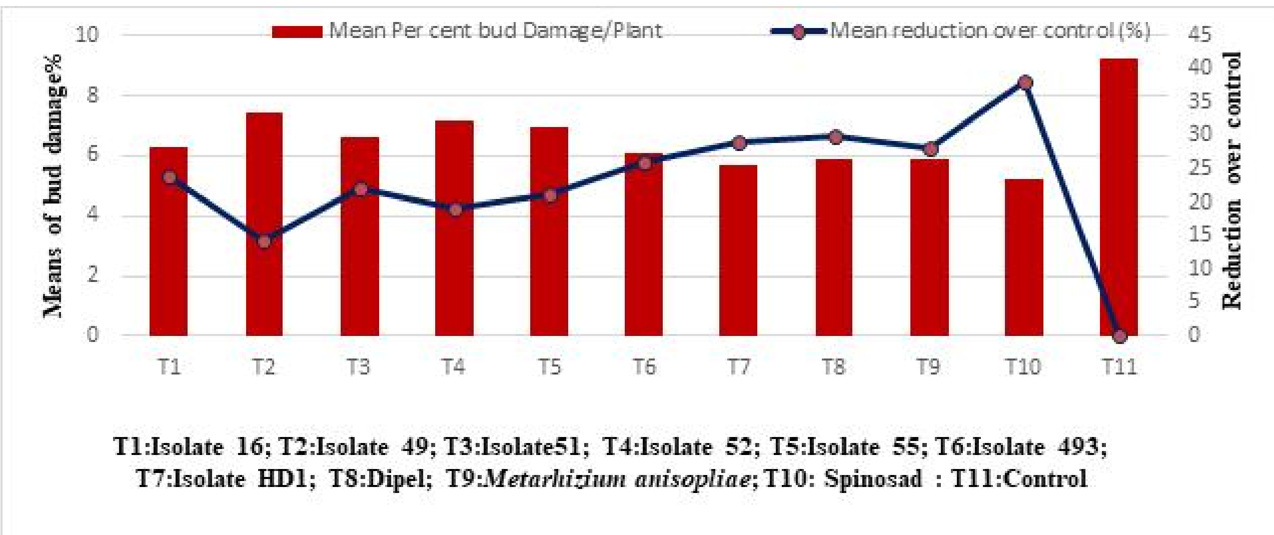

Fig 2. Mean efficacy of native and commercial *Bt* formulations against per cent bud damage by *M. vitrata* on blackgram after first spray during *rabi* 2020-21.

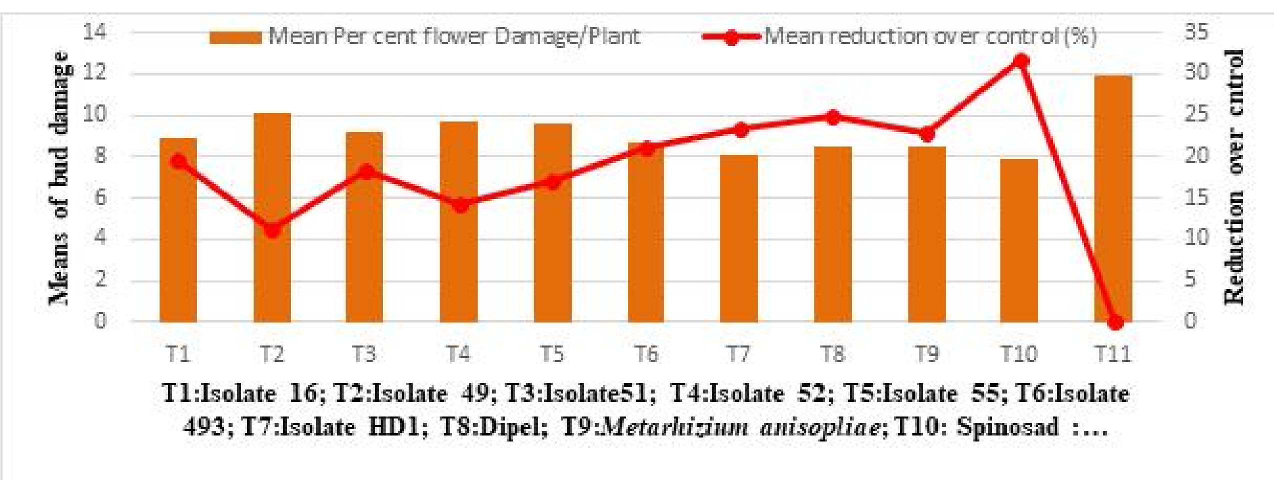

Fig 3. Mean efficacy of native and commercial *Bt* formulations against per cent flower damage by *M.vitrata* on blackgram after second spray during *rabi* 2020-21.

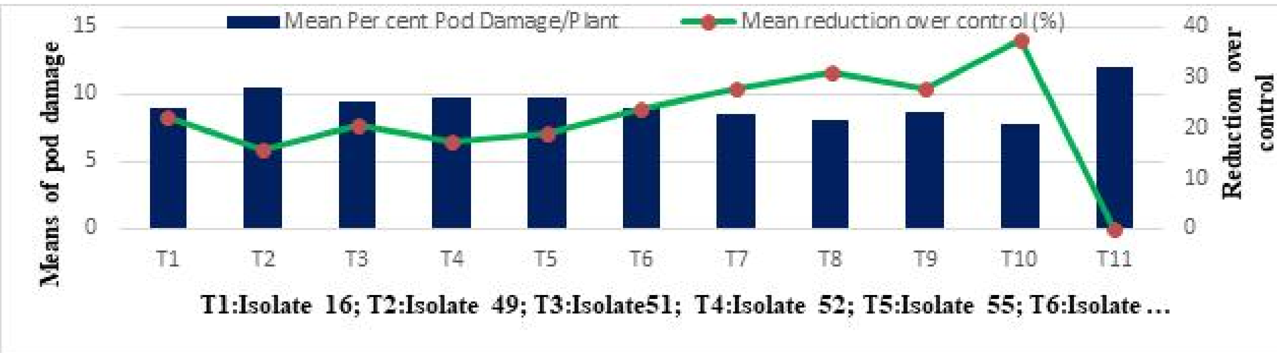

Fig.4. Mean efficacy of native and commercial *Bt* formulations against per cent pod damage by *M. vitrata* on blackgram after third spray during *rabi* 2020-21.

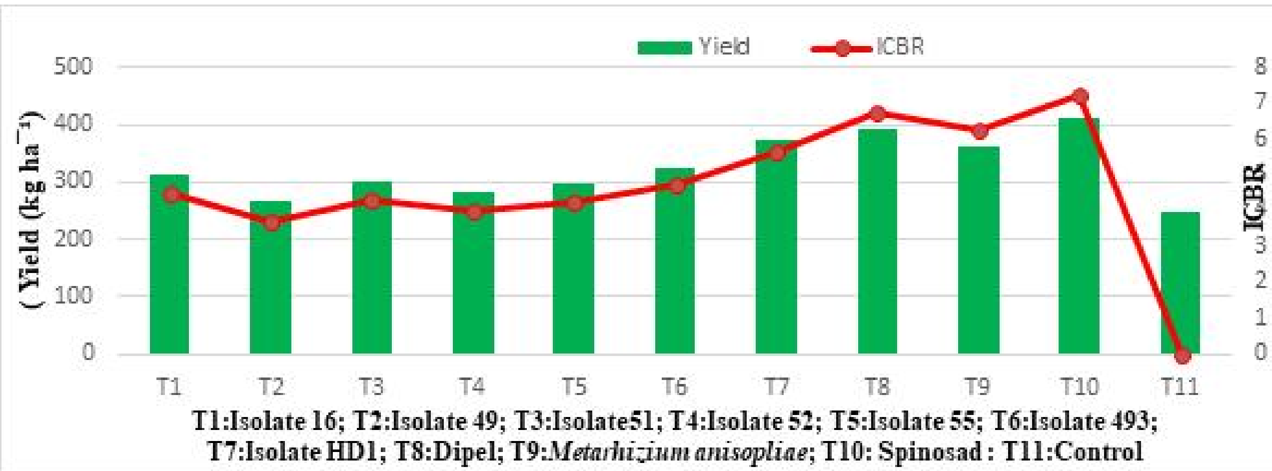

Fig 5. Influence of native *Bt* isolates on yield attributes of blackgram during *rabi* 2020-2021

showing 129 and 116 kg ha^{-1}yield increase over control. The blackgram yields in plots treated with *Bt* isolate 493 (323 kg ha^{-1}) and *Bt* isolate 16 (311 kg ha^{-1}) were statistically on par with each other, accounting to 77 and 65 kg ha^{-1} increase in yield over control. (Fig.5)

There was significant difference in incremental cost benefit ratio showed among the treatments. It ranged from 3.68 (*Bt* isolate 49) to 7.24 (spinosad). The highest ICBR was observed in the treatment where spinosad was used and was followed by Dipel (6.75), *M. anisopliae* (6.24) and HD1 (5.62). Among the native *Bt* isolates the highest ICBR was observed in *Bt* isolate 493 and was followed by *Bt* isolates 16, 51, 55, 52 and 49 which were recorded with 4.7, 4.49, 4.33, 4.22, 3.99 and 3.68 ICBR, respectively. Thilagam and Kennedy (2007) reported that *B. thuringiensis var. kurstaki* based product (Spic-Bio Reg.) was the best treatment, recording lesser *H. armigera* larval population. Prabhakara and Srinivasa (1998) reported that the *Bt* formulations caused only 58.72 per cent mortality of third instar larvae after one day of application. Mohapatra and Srivastava (2008) reported that *B. thuringiensis* provided good protection and registered significantly lesser incidence of *M. vitrata* larvae and higher yield over control. Spinosad 45 SC @ 0.3 ml l^{-1} recorded more than 30 per cent reduction in population over control, which is in confirmation with the findings of Rekha and Mallapur (2007). Spinosad was found effective against the *M. virata* at 0.005% on urdbean (Lakshmi *et al.* 2002). Chandrayudu *et al*. (2008) recorded the

Table 1. Field efficacy of native and commercial *Bt* formulations against spotted pod borer, *M. vitrata* on blackgram during *rabi* 2020-21.

Tr. No.	Treatments	Dose (g or ml.L^{-1})	*#No. of larvae/ plant	$Mean reduction over control (%)	$Mean Per cent bud Damage/Plant	$Mean reduction over control (%)	$Mean Per cent flower Damage/Plant	$Mean reduction over control (%)	$Mean Per cent Pod Damage/Plant	$Mean reduction over control (%)	Yield (Kg ha^{-1})	ICBR
T_1	Isolate 16 (1x10^{10} CFU g^{-1})	4.0g	6.34 (2.69)^{ab}	23.21 (27.15)^{bc}	6.28 (14.14)^{ab}	23.87 (26.76)^{bc}	8.89 (16.81)^{ab}	19.54 (24.20)^{bc}	8.97 (16.71)^{ab}	22.29 (25.35)^{cd}	311.00^{cd}	4.49
T_2	Isolate 49 (1x10^{10} CFU g^{-1})	4.0g/l	6.90 (2.80)^{bc}	16.95 (23.23)^{bc}	7.43 (15.40)^{bc}	14.29 (20.69)^{cd}	10.14 (17.84)^{bc}	11.18 (18.29)^{cd}	10.49 (18.21)^{bc}	15.61 (21.07)^{cd}	265.00^{fg}	3.68
T_3	Isolate 51 (1x10^{10} CFU g^{-1})	4.0g/l	6.27 (2.69)^{ab}	21.78 (26.30)^{bc}	6.63 (14.52)^{ab}	22.21 (25.85)^{bc}	9.22 (17.03)^{ab}	18.2 (20.79)^{cd}	9.37 (16.98)^{ab}	20.65 (24.26)^{cd}	302.00^{de}	4.33
T_4	Isolate 52 (1x10^{10} CFU g^{-1})	4.0g/l	7.00 (2.82)^{bc}	19.80 (25.06)^{bc}	7.13 (15.06)^{bc}	19.16 (23.70)^{bc}	9.72 (17.41)^{bc}	14.32 (20.79)^{cd}	9.73 (17.42)^{bc}	17.23 (22.40)^{cd}	283.00^{ef}	3.99
T_5	Isolate 55 (1x10^{10} CFU g^{-1})	4.0g/l	6.16 (2.67)^{ab}	20.55 (25.54)^{bc}	6.94 (14.90)^{bc}	21.3 (25.16)^{bc}	9.58 (17.43)^{ab}	17.01 (22.43)^{bc}	9.77 (17.53)^{bc}	18.81 (23.27)^{cd}	296.00^{de}	4.22
T_6	Isolate 493 (1x10^{10} CFU g^{-1})	4.0g/l	5.68 (2.58)^{ab}	24.77 (28.07)^{bc}	6.07 (13.91)^{ab}	25.93 (27.83)^{bc}	8.65 (16.44)^{ab}	21.1 (24.94)^{bc}	8.94 (16.71)^{ab}	23.74 (26.24)^{bc}	323.00^{cd}	4.7
T_7	HD-1 (1x10^{10} CFU g^{-1})	4.0g/l	5.36 (2.52)^{ab}	30.02 (30.94)^{bc}	5.66 (13.33)^{ab}	28.94 (29.45)^{bc}	8.13 (16.00)^{ab}	23.34 (26.14)^{bc}	8.49 (16.08)^{ab}	27.77 (28.57)^{bc}	375.00^{bc}	5.62
T_8	Dipel ES (5× 10^{9} CFU ml^{-1})	4.0g/l	5.15 (2.48)^{ab}	33.35 (32.63)^{b}	5.88 (13.71)^{ab}	29.99 (30.15)^{ab}	8.51 (16.43)^{ab}	24.92 (27.37)^{b}	8.07 (15.86)^{ab}	30.96 (30.48)^{ab}	392.00^{b}	6.75
T_9	*M. anisopliae* (1×10^{8} CFU g^{-1})	2.0ml/l	5.37 (2.51)^{ab}	28.51 (30.15)^{bc}	5.88 (13.67)^{ab}	28.31 (29.14)^{bc}	8.48 (16.38)^{ab}	22.95 (26.04)^{bc}	8.63 (16.20)^{ab}	27.67 (28.58)^{bc}	362.00^{bc}	6.24
T_{10}	Spinosad 45 SC	5.0g/l	4.97 (2.45)^{a}	43.30 (37.20)^{a}	5.23 (12.78)^{a}	38.25 (34.18)^{a}	7.85 (15.77)^{a}	31.65 (30.97)^{a}	7.85 (15.48)^{a}	37.56 (34.01)^{a}	412.00^{a}	7.24
T_{11}	Untreated control	0.3ml/l	8.83 (3.09)^{bc}	----	9.24 (17.18)^{bc}	---	11.91 (19.49)^{cd}	---	11.98 (19.42)^{cd}	---	246.00^{gh}	---
	SEm±		0.12	0.77	0.67	1.59	0.55	1.7	0.55	1.73	14.57	
	CD (P=0.05)		0.31	2.27	1.98	4.7	1.62	5.01	1.62	5.1	43	
	CV (%)		6.86	5.12	8.05	11.48	5.6	13.5	5.59	12.54	7.78	

*Values in parentheses are # Square root transformed, $ arc sine transformed; DBS = Day before spraying; DAS = day after spraying; NS = Non significant; In a column means followed by same letters do not differ significantly by LSD (P=0.05).

efficacy of commercial formulation of *Bt* @ 0.0025% in suppression of pod damage due to spotted pod borer in cowpea. Sunitha *et al.* (2008) reported that *Bt* @ 6.7×10^{11} and *M. anisopliae* @ 1×10^{6} were moderately effective against *M. vitrata* in pigeonpea. Sreekanth and Mahalakshmi (2012) reported that the per cent inflorescence damage due to legume pod borer was the least in spinosad 45% SC @ 73 g a.i/ ha treated plots (4.74%), followed by *Bacillus thuringiensis*-1 @ 1.5 kg/ha (10.52%) with 80.9 and 57.6 per cent reduction over control, respectively as against control (24.79%) in pigeonpea. Rao *et al.* (2014) reported that spinosad 45 SC 0.015% was highly effective treatment as it recorded 85.20% reduction in mean larval population of *M. vitrata* . The peak bud infestation (50.0%) was noticed during the 2nd week of December (Sandhyarani *et al*., 2014).

SUMMARY AND CONCLUSION

The highest larval mortality in the field was recorded in spinosad treated plots (43.30%), and the lowest larval mortality was recorded in *Bt* isolate-49 (16.95%). The highest bud, flower and pod damage reduction over control was recorded in spinosad (38.25, 31.65 and 37.56%), respectively and followed by Dipel (29.99, 24.92 and 30.96%), respectively. The lowest was recorded in *Bt* isolate-49 treated plots (14.29,11.18 and 15.6%), respectively.The highest yield was recorded in spinosad (412 kg ha^{-1}) and Dipel treated plots (392 kg ha^{-1}) with highest ICBR was recorded for spinosad (7.24) and Dipel (6.75) treatments.Thus, from the present findings it was concluded that new generation insecticide Spinosad 45%SC, biopesticides like native *Bt* isolates @ 4g/l or *M.anisolpliae* @ 5ml/lt for effective management of spotted pod borer *M.vitrata* along with an increased yield. All this native *Bt* isolates proved more than 50 per cent mortality in laboratory conditions against *M. vitrata* but in field conditons they showed least efficacy against *M. vitrata* because of this native *Bt* isolates are not properly formulated for field applications.

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Received on 23.01.2021 and revised on 31.03.2021