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Efficacy of newer insecticides against hadda beetle (*Epilachna vigintioctopunctata* Fab.) in spine gourd (*Momordica dioica* Roxb.)

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Abstract
Field investigation were laid out to test the efficacy of newer insecticides against hadda beetle on spine gourd during kharif 2019-20, result revealed that emamectin benzoate + thiamethoxam 3.0% + 12.0%WG proved to be the best effective treatment with maximum reduction of (0.64 beetle/plant) pest population followed by spinosad 45%SC, emamectin benzoate 5%SG and chlorantraniliprole 18.5%SC with 0.76, 0.81 and 0.94 beetle/plant respectively, being statistically at par with each other, but significantly superior to rest of the treatments. The next level effective treatments novaluron + indoxacarb 0.25% + 4.5%SC (1.11 beetle/plant) and flubendamide 20%WG (1.24 beetle/plant) were being statistically at par with each other, but significantly superior over control (3.07 beetle/plant).

Keywords: Efficacy, hadda beetle, insecticides, spine gourd

Introduction
Spine gourd (*Momordica dioica* Roxb.) is a potential vegetable crop, which belongs to family Cucurbitaceae (Trivedi and Roy, 1972) [11]. It is a wild perennial dioecious climber with tuberous root and its fruit is less bitter than bitter gourd (*Momordica charantia* L.). Spine gourd is commercially and economically important crop mostly cultivated for its green fruits as well as young twigs and leaves, which is used as vegetable or cooked as a vegetable (Tiwari and Tigga, 2015) [10]. It is commonly known by various names *viz.*, Kheksi/Kheksa (in Chhattisgarhi) Kankoda, Teasel gourd, Spine gourd, Meetha karela and Kantola (Yadav, 2018) [9]. Spine gourd gets affected by various insect pests *viz.*, fruit fly, green stink bug, epilachna beetle, fruit borer, fruit skin feeder, red pumpkin beetle and leaf miner etc. that cause varying degrees of damage, limiting the sustainable production and productivity of the crop (Shaw *et al.* 1998; Deshmukh *et al.* 2012; Sandilya *et al.* 2018) [8, 2, 7]. Among the various insect-pests, hadda beetle (*Epilachna vigintioctopunctata*) belongs to family Coccinelidae is a very important and destructive pest of this vegetable crop (Anant and Painkra, 2019) [7], and may cause significant damage up to 80% of the host plants depending on location and season (Rajagopal and Trivedi, 1989) [6]. The pest is also called epilachna beetle, spotted ladybird beetle or spotted leaf-eating beetle (Kumar and Kumar, 1998) [5].

Hadda beetle is also called a leaf scrapping coccinellid beetle due to its feeding reference to epidermal tissues of the leaves by scrapping, resulting in drying up and falling of the leaves (Imura and Ninomiya, 1978) [3]. To our knowledge, there are no reports available in the field efficacy on new insecticide molecules against hadda beetle especially on spine gourd in Chhattisgarh. Hence, present study was taken up to evaluate the efficacy of some newer insecticides against hadda beetle, infesting spine gourd field conditions.

Materials and Methods
The present research work was conducted at the area of Research-cum-Instructional Farm of R.M.D College of Agriculture and Research Station, Ambikapur (C.G.) during *kharif* season 2019-20. The trials were laid in Randomized Block Design (RBD) with the three replications. The crop was transplanted in the main field having 4 x 4 m^2 plot size. The population of hadda beetles was recorded from randomly selected three plants in each treatment. The total number of beetles was counted on each leaf from top, middle and bottom of canopy of the selected plants. First count was taken one day before first spray and post treatment counts were recorded at one, three, seven and fourteen days after each spray.

The second spray was done at 15 days interval after first spray. The data on surviving population was recorded on per plant basis. The obtained data were transformed to square root values (√n+0.5) to correct heterogeneous variances and the transformed data were subjected to statistical analyses.

Table 1: Details of the insecticides used for the experiment

S. No.	Name of Pesticide	Trade name & formulations	Dose/ ha	Chemical groups	Manufacture company	Mode of Action
T_1	Spinosad	Tracer 45%SC	150ml	Spinosyn	Dow Agro Sciences India Pvt. Ltd. Mumbai	Acetylcholine neurotransmission disruptor
T_2	Flubendiamide	Fame 39.35%SC	150ml	Phthalic acid diamide	Bayer Crop Science, Mumbai	Muscle stimulation
T_3	Novaluron + Indoxacarb	Plathora 5.25% + 4.5% SC	875ml	Benzoylphenyl urea + oxadiazine	Adama India Pvt. Ltd. Hyderabad	Chitin synthesis inhibitor + Sodium channel blocker
T_4	Emamectin benzoate	Xplode 5%SG	200g	Avermectine	Insecticides (India) Ltd, Rajasthan	Glutamate receptor stimulation
T_5	Chlorantraniliprole	Coragen 18.5%SC	150ml	Ryanoid/ Anthranilic diamide	Ayushi crop science Pvt. Ltd. Gujrat	Ryanodine receptor
T_6	Emamectin benzoate + thiamethoxam	Encounter 3.0% + 12.0%WG	150g	Avermectine + neonicotinoids	Insecticides (India) Ltd. Rajasthan	Glutamate receptor stimulation + Acetylcholine receptor
T_7	Control	-	-	-	-	-

The required quantity of spray solution was calibrated and spraying done by knapsack sprayer. The first sprays of insecticides were done at the initiation of pest infestation and second sprays were done at 15 days interval after first spray.

Results and Discussions

The data obtained in the present investigation efficacy of newer insecticides against the hadda beetle on spine gourd are documented in Table 2 which revealed that the pre-treatment observation of pest populations were recorded as no significant difference within the treatments. However, significant reduction in population of the pest was recorded after application of insecticides during kharif season 2019-20.

First Spray

Pre-treatment observation

During 2019-20, persual of data presented in Table 2 and Fig 1 revealed that the population of hadda beetle was non-significant difference within the treatments including control, ranged with 2.67 to 6.11 beetle/plant at before application of insecticides.

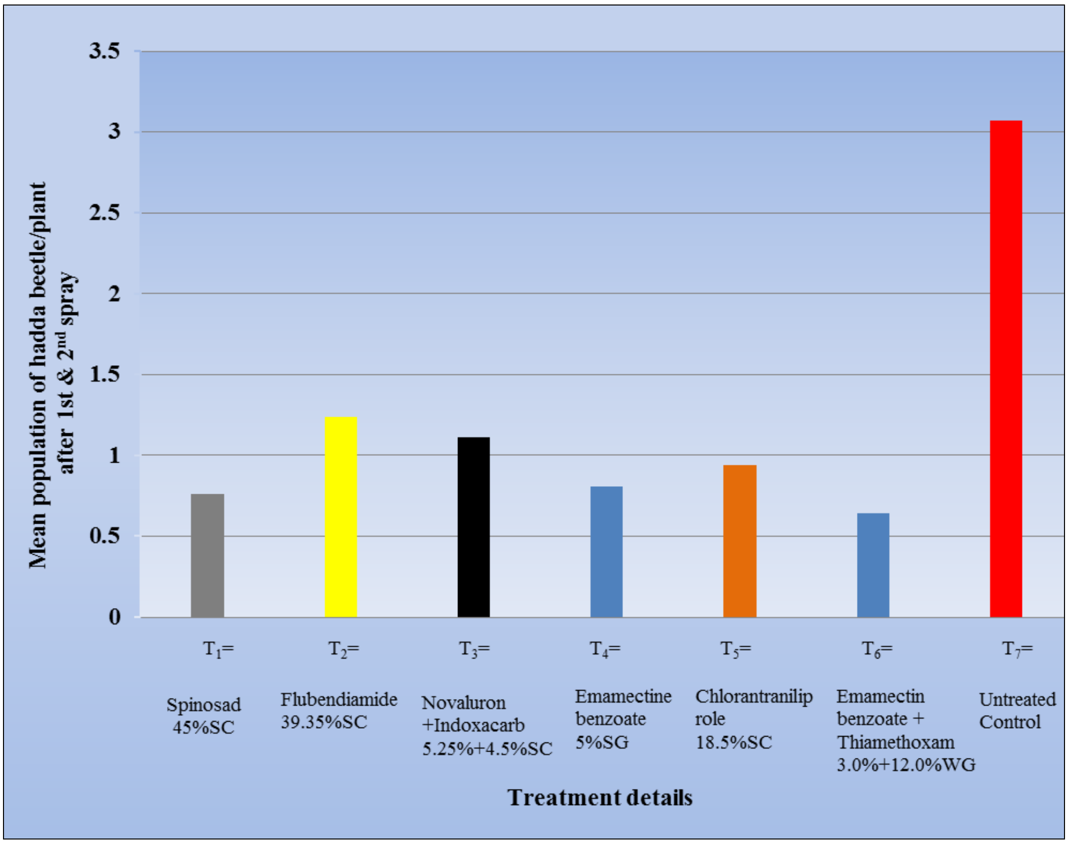

Fig 1: Efficacy of newer insecticides against hadda beetle in spine gourd during kharif season 2019-20.

Table 2: Efficacy of newer insecticides against hadda beetle in spine gourd during kharif season 2019-20

S. N	Treatment	Dose/ha	Mean population of hadda beetle/plant (Days after 1st spray)					Mean	Mean population of hadda beetle/plant (Days after 2nd spray)					Mean	Pooled mean
			1DBS	1th DAS	3th DAS	7th DAS	14th DAS		1DBS	1th DAS	3th DAS	7th DAS	14th DAS		
T1	Spinosad (45%SC)	150 ml	5.00 (2.44)*	1.00 (1.41)	0.89 (1.37)	0.78 (1.33)	1.00 (1.41)	0.92 (1.38)	1.55 (1.60)	0.67 (1.29)	0.55 (1.24)	0.44 (1.20	0.78 (1.33)	0.61 (1.27)	**0.76** (1.32)
T2	Flubendiamide (39.35%SC)	150 ml	3.78 (2.18)	1.78 (1.67)	1.45 (1.56)	1.22 (1.49)	1.89 (1.70)	1.58 (1.60)	2.00 (1.71)	1.00 (1.41)	0.89 (1.37)	0.78 (1.33	0.89 (1.37)	0.89 (1.37)	1.24 (1.49)
T3	Novaluron + Indoxacarb (5.25% + 4.5% SC)	875 ml	4.22 (2.25)	1.67 (1.63)	1.33 (1.53)	1.00 (1.41)	1.67 (1.63)	1.42 (1.55)	1.89 (1.70)	0.89 (1.37)	0.78 (1.33)	0.67 (1.29	0.89 (1.37)	0.81 (1.34)	1.11 (1.45)
T4	Emamectin benzoate (5%SG)	200g	4.56 (2.35)	1.11 (1.45)	0.78 (1.33)	0.67 (1.29)	1.22 (1.49)	0.94 (1.39)	1.67 (1.63)	0.78 (1.33)	0.67 (1.29)	0.55 (1.24	0.67 (1.29)	0.67 (1.29)	0.81 (1.34)
T5	Chlorantraniliprole (18.5%SC)	150 ml	4.33 (2.30)	1.22 (1.49)	1.11 (1.45)	0.89 (1.37)	1.78 (1.67)	1.25 (1.50)	1.89 (1.70)	0.78 (1.32)	0.55 (1.24)	0.44 (1.20	0.78 (1.33)	0.64 (1.27)	0.94 (1.39)
T6	Emamectin benzoate + Thiamethoxam (3.0% + 12.0%WG)	150g	6.11 (2.66)	0.89 (1.37)	0.78 (1.33)	0.56 (1.25)	1.00 (1.41)	0.81 (1.34)	1.33 (1.52)	0.56 (1.25)	0.44 (1.20)	0.33 (1.15	0.56 (1.25)	0.47 (1.21)	0.64* (1.28)
T7	Control		2.67 (1.91)	2.00 (1.73)	2.22 (1.79)	3.22 (2.05)	3.56 (2.13)	2.75 (1.93)	3.00 (2.00)	3.11 (2.03)	3.78 (2.19)	4.00 (2.44)	4.45 (2.33)	3.84 (2.25)	3.07 (2.01)
	S.Em±		-	0.03	0.04	0.03	0.06	-	-	0.04	0.04	0.04	0.05	-	-
	C.D. (0.05)		N/S	0.09	0.13	0.09	0.14	-	N/S	0.10	0.13	0.13	0.15	-	-
	CV%		-	3.25	4.71	3.46	4.66	-	-	4.71	4.96	5.25	5.73	-	-

Note: * Figure in parenthesis are √x+0.5 transformed value; DBS = Day before spray; DAS = Day after spray

One day after 1st spray

Data revealed that there was a significant difference among treatments including control at one day after 1st spray of insecticides. The lowest grub and adult population (0.89 beetle/plant) was recorded for Emamectin benzoate + thiamethoxam 3.0% + 12.0%WG which differed significantly from spinosad 45%SC (1.00 beetle/plant), emamectin benzoate 5%SG (1.11 beetle/plant) and chlorantranilprole 18.5%SC (1.22 beetle/plant) followed by treatment novaluron + indoxacarb 5.25% + 4.5%SC (1.67 beetle/plant) and flubendiamide 39.35%SC (1.78 beetle/plant) which were found to be statistically at par with each other. The highest pest population was observed in untreated control (2.00 beetle/plants).

Three days after 1st spray

At three days after 1st spray, all the treatments showed significant superior over control. The least population (0.78 beetle/plant) was encountered for emamectin benzoate + thiamethoxam 3.0% + 12.0%WG and emamectin benzoate 5%SG respectively, which were statistically at par with spinosad 45%SC (0.89 beetle/plant), but which were significantly superior and statistically different from other treatments including chlorantraniliprole 18.5% SC (1.11 beetle/plant), novaluran + indoxacarb 5.25% + 4.5%SC (1.33 beetle/plant) and flubendiamide 39.35%SC (1.45 beetle/plant) which were proved next effective treatments. The maximum population (2.22 beetle/plants) was found on control plot at three days after 1st spray.

Seven days after 1st spray

The observation recorded on seventh day after 1st spray revealed that all the treatments again maintained their superiority and found significant effect except untreated control. However, emamectin benzoate + thiamethoxam 3.0% + 12.0%WG, emamectin benzoate 5%SG and spinosad 45%SC proved to be the most effective treatments with highest reduction of 0.56 beetle/plant, 0.67 beetle/plant and 0.78 beetle/plant respectively, in pest population, being statistically at par with each other, but significantly superior to other treatments. The next best treatment was chlorantraniliprole 18.5%SC (0.89 beetle/plant), whereas novaluran + indoxacarb 5.25% + 4.5%SC (1.00 beetle/plants) and flubendiamide 39.35%SC (1.22 beetle/plants) were statistically at par with the chlorantraniliprole 18.5%SC. Again the maximum population of (3.22 beetle/plant) was found on control treatment.

Fourteenth days after 1st spray

On fourteenth day, all the treatment gave significantly better results over control. Emamectin benzoate + thiamethoxam 3.0% + 12.0%WG (1.00 beetle/plant) and spinosad (1.00 beetle/plant) were recorded the best treatment and were significantly superior from rest of the treatments. Flubendiamide 39.35%SC (1.89 beetle/plant) was least effective in reducing the pest population.

Overall efficacy after 1st spray

All the treatments were found effective for suppressing the pest population over control. However, Emamectin benzoate + thiamethoxam 3.0% + 12.0%WG proved to be the best effective treatment with highest mean reduction in pest population of (0.81 beetle/plant) followed by Spinosad 45%SC (0.92 beetle/plant) and emamectin benzoate 5%SG (0.94 beetle/plant), being statistically at par with each other, but significantly superior to rest of the treatments. The next level effective treatments were chlorantraniliprole 18.5%SC (1.25 beetle/plant), Novaluron + Indoxacarb 0.25 + 4.5%SC (1.42 beetle/plant) and flubendamide 20%WG (1.58 beetle/plant) being statistically at par with each other, but significantly superior over control (3.31 beetle/plant).

Second Spray

The result showed that all the treatments retained their superiority over control up to 14th days after first spray *i.e.* pre and post treatment observation in case of second spray. The perusal of data revealed that there was no-significant difference within the treatments one day before of second spray.

One day after 2nd spray

One day after 2nd spray, all the treatments were observed as significant reduction of pest population over control. The least number of pest populations were observed for the treatment of emamectin benzoate + thiamethoxam 3.0% + 12.0%WG and spinosad 45%SC with 0.56 beetle/plant and 0.67 beetle/plants respectively, which was statistically at par with each other from followed by Emamectin benzoate 5%SG (0.78 beetle/plant), chlorantranliprole 18.5%SC (0.78 beetle/plant) and novaluran + indoxacarb 5.25% + 4.5%SC (0.89 beetle/plant), which differed significantly from flubendiamide 39.35%SC (1.00 beetle/plant). The maximum of (3.11 beetle/plant) population was found on control treatment.

Three days after 2nd spray

Third day after 2nd spray of insecticides showed that all the treatments were found significantly efficient except control. The lowest population (0.44 beetle/plant) was recorded for emamectin benzoate + thiamethoxam 3.0% + 12.0%WG which was proved superior to spinosad 45%SC (0.55 beetles/plants) and chlorantrailoprole 18.5%SC (0.55 beetles/plants) followed by emamectine benzoate 5%SG (0.67 beetle/plant) and novaluron + indoxacarb 5.25% + 4.5%SC (0.78 beetle/plant). Flubendiamide 39.35%SC (0.89 beetle/plant) was recorded as least effective in reducing the population.

Seven days after 2nd spray

Seventh day after application of 2nd sprays recorded data revealed that all the treatments proved significantly superior over control. Again maintained their superiority to prove the best reduction of the pest population for emamectin benzoate + thiamethoxam 3.0% + 12.0%WG (0.33 beetle/plant) which differed significantly from spinosad 45%SC and chlorantrailoprole 18.5%SC (0.44 beetle/plant) followed by emamectine benzoate 5%SG and novaluron + indoxacarb 5.25% + 4.5%SC with 0.55 and 0.67 beetle/plant respectively. The least effective treatment was flubendiamide 39.35%SC, which recorded minimum reduction of pest population (0.78 beetle/plant).

Fourteen days after 2nd spray

On fourteenth day after 2nd spray, all the treatment gave significantly better results over control. Emamectin benzoate + thiamethoxam 3.0% + 12.0%WG (0.56 beetle/plant) was recorded the best treatment and significantly superior from rest of the treatments. The treatment of flubendiamide 39.35%SC was least (0.89 beetle/plant) effective in managing the pest population. The highest populations (4.45 beetle/plants) were recorded from untreated control at fourteenth days after 2nd spray of insecticides.

Overall efficacy after 2nd spray

All the treatments of insecticides were found effective for minimizing the pest population. However, emamectin benzoate + thiamethoxam 3.0% + 12.0%WG proved to be the best effective treatment with highest mean reduction in pest population of 0.64 beetle/plant followed by Spinosad 45%SC (0.61 beetle/plant), chlorantraniliprole 18.5%SC (0.64 beetle/plant) and emamectin benzoate 5%SG (0.67beetle/plant) respectively, being statistically at par with each other, but significantly superior to other treatments. The next level effective treatments were novaluron + indoxacarb 5.25+4.5%SC (0.81 beetle/plant) and flubendamide 39.35%SC (0.89 beetle/plant) being statistically at par with each other, but significantly superior over control (3.84 beetle/plant).

The current findings are less or more similar with the finding of Kodandaram *et al.* (2014) they reported that the emamectin benzoate 5%SG @ 10g a.i./ha and thiodicarb 75%WP @70g a.i./ha proved to be the most effective with highest reduction in pest population of 75.3 and 73.9 per cent, respectively under field conditions.

The present study is accordance with the work of Singh *et al.* (2009) [9] who evaluated the efficacy of seven insecticides in spine gourd for the control of hadda beetle, (*H. vigintioctopunctata*). They found to be the most effective treatment was methomyl @ 250g a.i./ha, followed by spinosad @100g a.i./ha, carbosulfan @ 250g a.i./ha and malathion @1000g a.i./ha, while rest of the insecticides were less effective against both the stage of the pest. But the current finding revealed the emamectin benzoate + thiamethoxam 3.0%+12.0%WG proved to be the best effective with highest reduction in pest population followed by spinosad 45%SC chlorantraniliprole 18.5%SC and emamectin benzoate 5%SG.

Pooled efficacy after 1st and 2nd sprays

Field investigation were laid out to test the efficacy of newer insecticides against hadda beetle on spine gourd revealed that after 1st and 2nd sprays the emamectin benzoate + thiamethoxam 3.0% + 12.0%WG proved to be the best effective treatment with maximum (0.64 beetle/plant) reduction of pest population followed by spinosad 45%SC (0.76 beetle/plant) emamectin benzoate 5%SG (0.81 beetle/plant) and chlorantraniliprole 18.5%SC (0.94 beetle/plant), being statistically at par with each other, but significantly superior to rest of the treatments. The next level effective treatments were novaluron + indoxacarb 0.25+4.5%SC (1.11 beetle/plant) and flubendamide 20%WG (1.24 beetle/plant) being statistically at par with each other, but significantly superior over control (3.07 beetle/plant).

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