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Bioefficacy and compatibility of *Metarhizium anisopliae* and new generation insecticide against *Helicoverpa armigera* infesting chickpea

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Abstract
The field experiments were carried out during the year 2013-2014 at the experimental field of JNKVV, Jabalpur to evaluate the efficacy and compatibility of *Metarhizium anisopliae* and new generation insecticide alone and in combination against *Helicoverpa armigera* infesting chickpea. On the basis of the effectiveness of different treatments against pod borer and the grain yield obtained, it can be said that emamectin benzoate 5 SG, flubendiamide 20 SG and rynaxypyr 20 SC proved to be the most effective treatments, not only in reducing the damage due to pod borer complex but also recorded higher grain yields.
Taking in account the cost of plant protection inputs, the cost benefit ratio value of sole chemicals and combination treatments were close to each other. *i.e.* 1:8.58 and 1:8.04 for emamectin benzoate and *M. anisopliae* + rynaxypyr, respectively. By decreasing the dose of chemicals and incorporating biopesticides as combination treatments in pest management programme can give the farmer the advantage of environmental friendly farming and higher economic returns.

Keywords: Chickpea, efficacy, *M. anisopliae, H. armigera,* new generation insecticides

Introduction
The gram pod borer is the major constraint in chickpea production inflicting considerable economic losses. Gram pod borer, *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae) is also known as monophagous pest. The attack of this dreaded pest starts right from the vegetative stage and continues upto crop maturity [1].
Synthetic chemical pesticides remained the mainstream of pest eradication. However, insecticide resistance, pest resurgence, safety risks for humans and domestic animals, contamination of ground water, decrease in biodiversity, and other ecological conditions safe strategies for pest control including exploring the use of biopesticides [2] . This thing has encouraged researchers for the development of environmentally opportunities. Entopathogenic fungi are ideal for Integrated Pest Management (IPM) programs because they are relatively safe to use and have a narrow spectrum of activity than chemical insecticides [3-4]. The integration of microbial pesticides with chemical pest management practices requires compatible data would enable farmers to select appropriate compounds. The ready availability of the mycoinsecticides unlike chemical insecticides is a challenging factor in testing the pathogenecity of the fungal pathogens against target insect hosts.
Keeping the fact in background the present investigation are undertaken under field condition on bioefficacy and compatibility of *Metarhizium anisopliae* with new generation insecticides against *Helicoverpa armigera* infesting chickpea.

Material and Methods
Field experiment were conducted at the experimental field of Department of Entomology, Adhartal, JNKVV, Jabalpur (M.P.) during *Rabi* 2013-14, under randomized block design. Chickpea variety JG-12 was sown on 12th December, 2013 in a plot size of 10 x 3.3 m^2 with a spacing of 30 x 10 cm. Other agronomic practices were followed as per local recommendation. There were eight treatments comprising of *Metarhizium anisopliae* ($1x10^8$ spores/ml) and new generation insecticides (Rynaxypyr, Flubendamide, Emamectin benzoate) alone and combination of *M. anisopliae* with neem derivatives including control (Table 1). Insecticides were purchased from local market. Treatment wise application of biochemical’s were made at

pod formation stage (90 DAS) of crop at ETL (*i.e.* ≥ 2 larvae/mrl) level of *H. armigera.* Observation were recorded on *H. armigera* larvae on randomly selected 10 sites (1 meter row length/site) on 1,3,7,10 days after application (DAA). Larval count was also taken at 24 hrs before initiation of treatments. Pods of ten plants per plot were counted and per cent pod damage were calculated based on healthy and bored pods. Grain yield/plot was also assessed after harvesting and C:B ratio was calculated based on cost of application, market price of biopesticides and chickpea.

Table 1: Treatment details on compatibility of *M. anisopliae* and new generation insecticides (*in vivo*)

Tr. Code	Treatments	Doses
T1	*Metarhizium anisopliae*	1X10^8 spores/ml
T2	Rynaxypyr 20 SC	18 g *a.i.*/ha
T3	Flubendamide20 EC	60 g *a.i.*/ha
T4	Emamectin benzoate 5 SG	11 g *a.i.*/ha
T5	*M. anisopliae* + Rynaxypyr 20 EC	1 X 10^4 spores /ml + 9 g *a.i.*/ha
T6	*M. anisopliae* + Flubendamide20 EC	1 X 10^4 spores /ml+ 30 g *a.i.*/ha
T7	*M. anisopliae* + Emamectin benzoate 5 SG	1 X 10^4 spores /ml+5.5 g *a.i.*/ha
T8	Control	---

All the data were subjected to statistical analysis after appropriate transformation as suggested by [8].

Results

Effect of new generation insecticides on larval population of *H. armigera*

The data on efficacy of *M. anisopliae* with some new generation insecticides against *H.armigera* under field conditions are presented in Table 2 and depicted in figures 1 and 2.

(i) *H. armigera* larval population

Pre- treatment:

Differences in the *Helicoverpa armigera* mean larval population per metre row length among different treatments were not significant, indicating more or less uniform distribution of the pest in the experimental field.

One day after spray

At one day after spray, the differences in the mean larval population among different treatments were significant. Among the treatments, emamectin benzoate 5 SG @ 11 *a.i.* /ha was found to be most effective as it recorded lowest larval population (0.10 larvae/mrl). This was followed by *Metarhizium anisopliae* + emamectin benzoate 5 SG @ 1×10^4 spores/ml + 5.5g *a.i.* /ha (0.17 larvae/mrl), but it did not differ significantly from. The next effective treatment was flubendiamide 20 SC @ 60g *a.i.* /ha (0.20 larvae/mrl) followed by *M. anisopliae* +flubendiamide @ 1×10^4 spores/ml + 30g *a.i.* /ha (0.23 larvae/mrl), rynaxypyr 20 SC @ 18g *a.i.* /ha (0.27 larvae/mrl) and *M. anisopliae* +rynaxypyr @ 1×10^4 spores/ml + 9g *a.i.* /ha (0.27 larvae/mrl), but all were at par with each other. The next treatment was *M. anisopliae* @ 1×10^8 spores/ml (2.43 larvae / mrl) and it differed significantly from control which recorded highest larval population (2.57 larvae/mrl).

Three days after spray

At three days after spray, the differences in the mean larval population among different treatments were significant. Among the treatments, emamectin benzoate 5 SG @ 11 *a.i.* /ha was found to be most effective as it recorded lowest larval population (0.15 larvae/mrl), this was followed by *M. anisopliae* + emamectin benzoate 5 SG @ 1×10^4 spores/ml + 5.5g *a.i.* /ha (0.17 larvae/mrl), flubendiamide 20 SC @ 60g *a.i.* /ha (0.17 larvae/mrl), rynaxypyr 20 SC @ 18g *a.i.* /ha (0.18 larvae/mrl), *M. anisopliae* + flubendiamide @ 1×10^4 spores/ml + 30g *a.i.* /ha (0.25 larvae/mrl), *M. anisopliae* +rynaxypyr @ 1×10^4 spores/ml + 9g *a.i.* /ha (0.28 larvae/mrl), but all were at par with each other. The next treatment was *M. anisopliae* @ 1×10^8 spores/ml (2.43 larvae / mrl) and it differed significantly from control which recorded highest larval population (2.77 larvae / mrl).

Seven days after spray

At seven days after treatment, the differences in the mean larval population among different treatments were significant. Among the treatments, emamectin benzoate 5 SG @ 11 *a.i.* /ha was found to be most effective as it recorded lowest larval population (0.10 larvae/mrl). This was followed by flubendiamide 20 SC @ 60g *a.i.* /ha (0.12 larvae/mrl), rynaxypyr 20 SC @ 18g *a.i.* /ha (0.13 larvae/mrl) and *M. anisopliae* + emamectin benzoate 5 SG 1×10^4 spores/ml + 5.5 g *a.i.* /ha (0.18 larvae/mrl), but they did not differ significantly from each other. The next effective treatment was *M. anisopliae* + flubendiamide @ 1×10^4 spores/ml + 30g *a.i.* /ha (0.23 larvae/mrl) and *M. anisopliae* +rynaxypyr @ 1×10^4 spores/ml + 9g *a.i.* /ha (0.27 larvae/mrl), but both were at par with each other. The next treatment was *M. anisopliae* @ 1×10^8 spores/ml (0.43 larvae / mrl) and it differed significantly from control which recorded highest larval population (4.13 larvae/mrl).

Ten days after spray

At ten days after treatment, the differences in the mean larval population among different treatments were significant. Among the treatments, emamectin benzoate 5 SG @ 11 *a.i.* /ha was found to be most effective as it recorded lowest larval population (0.07 larvae/mrl). This was followed by rynaxypyr 20 SC @ 18g *a.i.* /ha (0.10 larvae/mrl), flubendiamide 20 SC @ 60g *a.i.* /ha (0.13), *M. anisopliae* + emamectin benzoate 5 SG @ 1×10^4 spores/ml + 5.5g *a.i.* /ha (0.13 larvae/mrl) and *M. anisopliae* + rynaxypyr @ 1×10^4 spores/ml + 9g *a.i.* /ha (0.20 larvae/mrl), but all were at par with each other. The next effective treatment was *M. anisopliae* + flubendiamide @ 1×10^4 spores/ml + 30g *a.i.* /ha (0.23 larvae/mrl) followed by *M. anisopliae* @ 1×10^8 spores/ml (0.50 larvae/mrl), but both of them did not differ significantly from each other. The highest larval population was recorded in control (2.20 larvae / mrl).

Overall mean

On the basis of overall mean, the differences in the mean larval population among different treatments were significant. Among the treatments, emamectin benzoate 5 SG @ 11 *a.i.*

/ha was found to be most effective as it recorded lowest larval population (0.10 larvae/mrl). This was followed by flubendiamide 20 SC @ 60g *a.i.* /ha (0.15 larvae/mrl), rynaxypyr 20 SC @ 18g *a.i.* /ha (0.17 larvae/mrl) and *M. anisopliae* + emamectin benzoate 5 SG @ 1×10^4 spores/ml + 5.5g *a.i.* /ha (0.18 larvae/mrl) but all were at par with each other. The next effective treatment was *M. anisopliae* + flubendiamide @ 1×10^4 spores/ml + 30g *a.i.* /ha (0.22 larvae/mrl) and *M. anisopliae* + rynaxypyr @ 1×10^4 spores/ml + 9g *a.i.* /ha (0.25 larvae/mrl) but they did not differ significantly from each other. The next treatment was *M. anisopliae* @ 1×10^8 spores/ml (1.45 larvae / mrl) and it differed significantly from control which recorded highest larval population (2.92 larvae/mrl).

Table 2: Bioefficacy of *Metarhizium anisopliae* and new insecticides alone and their combinations on *Helicoverpa armigera* and chickpea grain'

Treatment Code	Treatments	Dose	Mean *H.armigera* larval population/mrl*						Pod damage (%)**	Grain yield (kg/ha)
			Pre treatment	Days after spraying						
				1	3	7	10	Mean		
T_1	*Metarhizium anisopliae*	1×10^8 spores / ml	2.23	2.43	2.43	0.43	0.50	1.45	12.26	768.52
			(1.49)	(1.71)	(1.56)	(0.66)	(1.00)	(1.20)	(20.47)	
T_2	Rynaxypyr 20 SC	18 g *a.i.*/ ha	2.23	0.27	0.18	0.13	0.10	0.17	4.03	1034.26
			(1.49)	(0.88)	(0.42)	(0.36)	(0.77)	(0.41)	(11.49)	
T_3	Flubendamide 20 EC	60 g *a.i.*/ ha	2.40	0.20	0.17	0.12	0.13	0.15	3.44	1111.11
			(1.55)	(0.84)	(0.40)	(0.34)	(0.80)	(0.39)	(10.60)	
T_4	Emamectin benzoate 5 SG	11 g *a.i.*/ ha	2.20L	0.10L	0.15L	0.10L	0.07L	0.10L	1.89 L	1171.30H
			(1.48)	(0.77)	(0.38)	(0.32)	(0.75)	(0.32)	(7.72)	
T_5	*M. anisopliae* + Rynaxypyr 20 EC	10^4 spores / ml + 9 g *a.i.*/ ha	2.20	0.27	0.28	0.27	0.20	0.25	6.31	904.63
			(1.48)	(0.88)	(0.53)	(0.51)	(0.84)	(0.50)	(14.46)	
T_6	*M. anisopliae* + Flubendamide 20 EC	10^4 spores / ml + 30 g *a.i.* / ha	2.43	0.23	0.17	0.23	0.23	0.22	5.01	1006.48
			(1.56)	(0.86)	(0.39)	(0.48)	(0.85)	(0.46)	(12.92)	
T_7	*M. anisopliae* + Emamectin benzoate 5 SG	10^4 spores / ml + 5.5 g *a.i.*/ ha	2.37	0.17	0.25	0.18	0.13	0.18	4.69	1012.96
			(1.54)	(0.82)	(0.50)	(0.43)	(0.79)	(0.43)	(12.48)	
T_8	Control		2.33	2.57H	2.77H	4.13H	2.20H	2.92H	26.20H	550.93L
			(1.53)	(1.75)	(1.66)	(2.03)	(1.64)	(1.71)	(30.78)	
	SEm ±		0.02	0.03	0.04	0.04	0.04	0.04	0.39	5.40
	CD at 5%		NS	0.08	0.13	0.11	0.13	0.11	1.17	16.37

mrl =meter row length

*= Figures in parentheses are $(\sqrt{x + 0.5})$ square root transformed values

**= Figures in parentheses are arcsin transformed values

NS=Non significant L=Lowest H=Highest

Max. temp. 31.9 ±4.2 °C; Min. temp.13.9 ± 4.8 °C; Morning RH(%) 79 ± 18.5 ; Evening RH(%) 34 ± 17

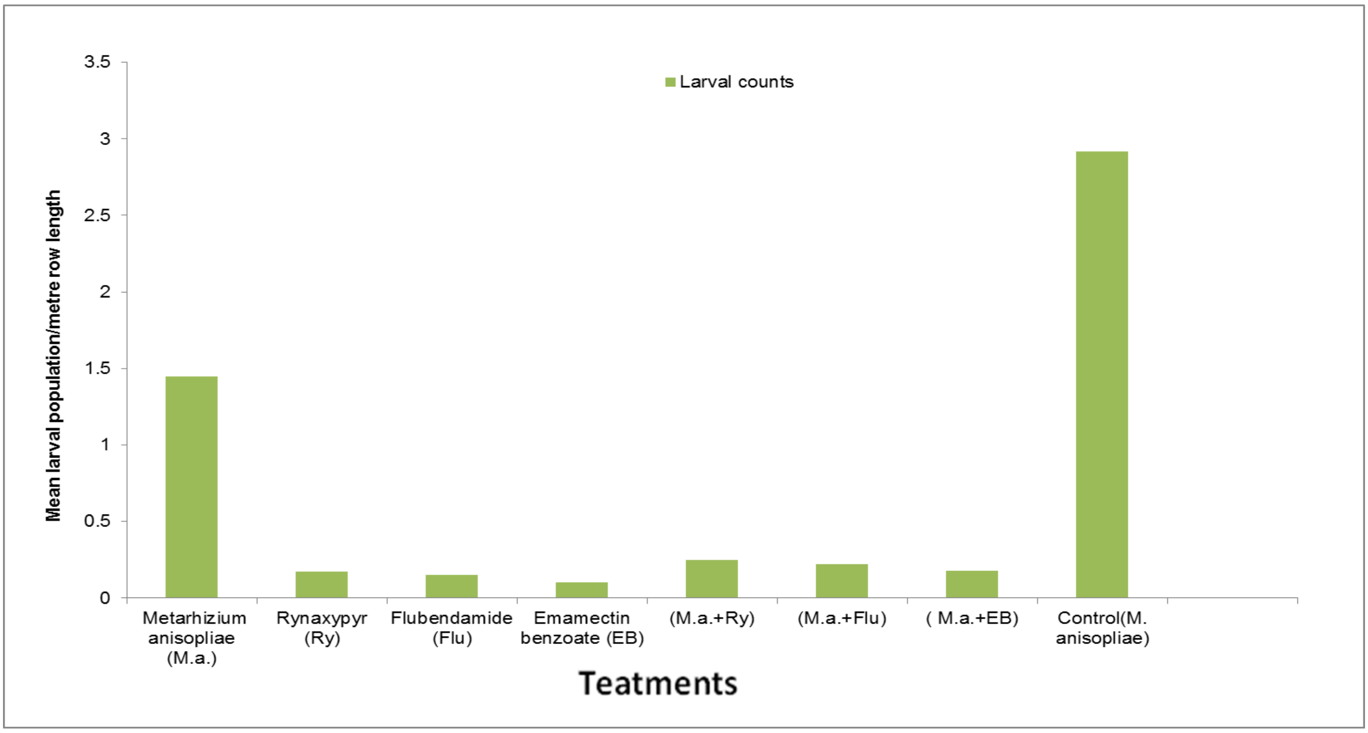

Fig 1: Bioefficacy of *M. anisopliae* and insecticides alone and their combinations on gram pod borer larvae infesting chickpea

(ii) Pod damage

All the treatments significantly reduced the pod damage by gram pod borer as compared to control (26.20%). Among the treatments, significantly lowest pod damage was recorded in emamectin benzoate 5 SG @ 11 *a.i.* /ha (1.89%). This was followed by flubendiamide 20 SC @ 60g *a.i.* /ha (3.44%) and rynaxypyr 20 SC @ 18g *a.i.* /ha (4.03%) but both were at par with each other. The next treatment was *M. anisopliae* + emamectin benzoate 5 SG @ 1×10^4 spores/ml + 5.5g *a.i.* /ha (4.69%), *M. anisopliae* + flubendiamide @ 1×10^4 spores/ml + 30g *a.i.* /ha (5.01%), but both were at par with each other. The next treatment was *M. anisopliae* + rynaxypyr @ 1×10^4 spores/ml + 9g *a.i.* /ha (6.31%) followed by *M. anisopliae* @ 1×10^8 spores / ml (12.26%) but all were at par with each other (Table 2 and figure 2).

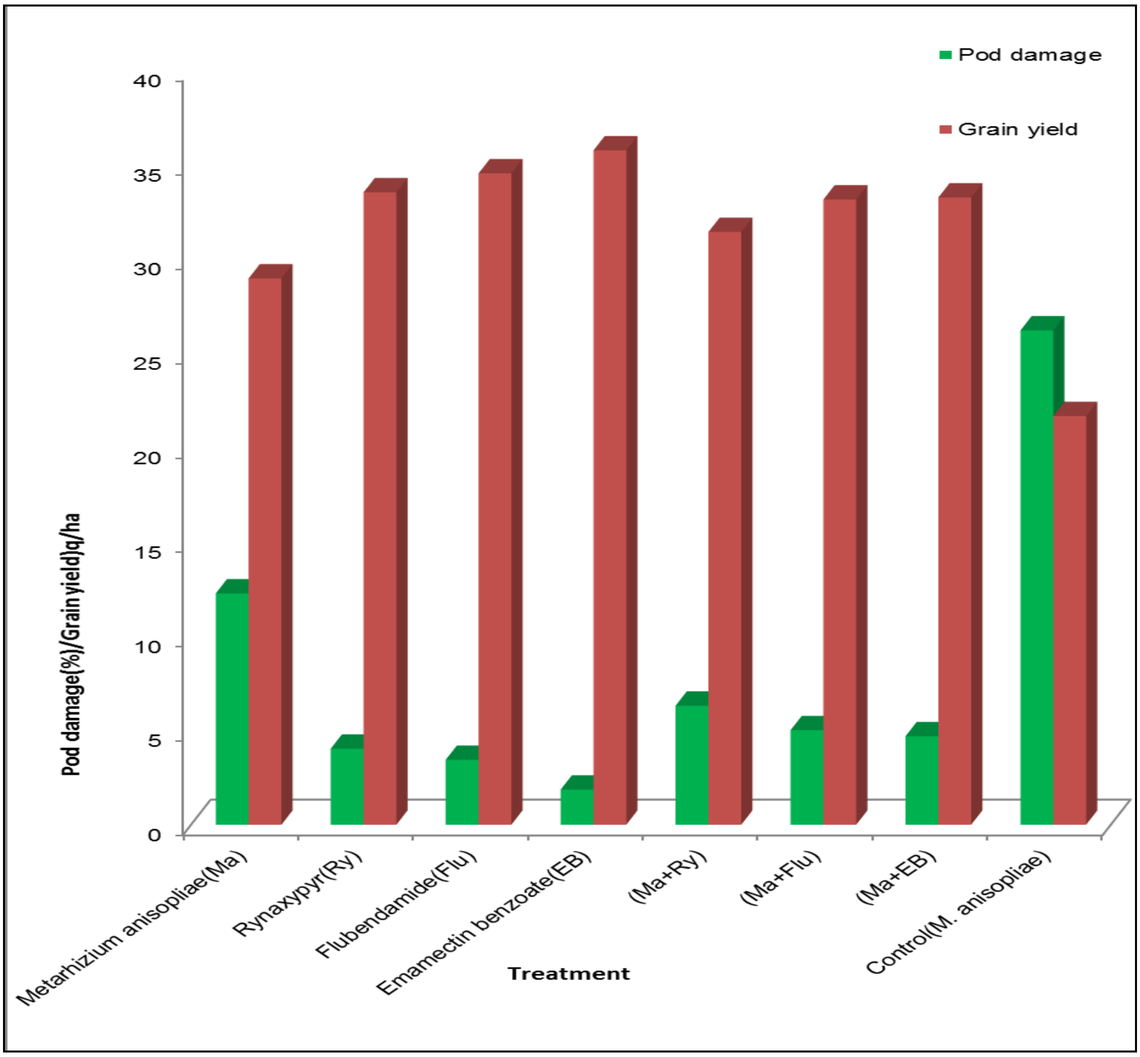

Fig 2: Bioefficacy of *M. anisopliae* and insecticides alone and their combinations on chickpea pod damage by gram pod borer and grain yield

(iii) Chickpea grain yield

The yield of net plot area of each treatment was recorded and converted into kg/ha. All the treatments registered significantly higher grain yields as compared to the control (550.93 kg/ha). The highest grain yield was recorded in emamectin benzoate 5 SG @ 11 *a.i.* /ha treated plots (1171.30 kg/ha) which was significantly superior over all the other treatments. Subsequent higher grain yield was recorded with flubendiamide 20 SC @ 60g *a.i.* /ha (1111.11 kg/ha) followed by rynaxypyr 20 SC @ 18g *a.i.* /ha (1034.26 kg/ha), but both were at par with each other. The next effective treatment was *M. anisopliae* + emamectin benzoate 5 SG @ 1×10^4 spores/ml + 5.5g *a.i.* /ha (1012.96 kg/ha) followed by *M. anisopliae* + flubendiamide @ 1×10^4 spores/ml + 30g *a.i.* /ha (1006.48kg/ha) but both were at par with each other. The next effective treatment was *M. anisopliae* + rynaxypyr @ 1×10^4 spores/ml + 9g *a.i.* /ha (904.63 kg/ha) followed by *M. anisopliae* @ 1×10^8 spores/ml (14.02%) (768.52 kg/ha) and they differed significantly from each other (Table 2 and Fig.2).

Discussion

All the insecticides and *M. anisopliae* alone and their combinations proved their superiority over control in reducing the pest population and pod damage and in increasing the grain yield. Several workers have also reported similar findings, that application of insecticides and *M. anisopliae* effectively reduced the damage due to pod borer with increased grain yield than control [9-16].

Treatment emamectin benzoate 5 SG followed by flubendiamide 20 SG and rynaxypyr 20 SG proved to be most effective treatments not only in reducing the pod borer damage, but also registered higher grain yields (1171.30 kg/ha,1111.11kg/ha, 1034.26 kg/ha, respectively). The present findings are in conformity with the findings of [12,16] and [17] also reported emamectin benzoate, flubendiamide, rynaxypyr as the most effective treatments in reducing pod borer damage and recorded higher yields.

Conclusion

All the insecticides and biopesticide proved their superiority over control in reducing the pod damage and increasing the grain yield. On the basis of the effectiveness of different treatments on pod damage by pod borer and grain yield, emamectin benzoate 5SG was the most effective treatment.

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