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Synergistic effect of different entomopathogens with imidacloprid 600 FS insecticide against white grub, *H. consanguinea*

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Abstract
An experiment was conducted at the division of Entomology, Rajasthan Agricultural Institute Durgapura, Jaipur, SKNAU during 2018 to find out the synergistic effect of various entomopathogens with imidacloprid 600FS against white grub, *H. consanguinea.* The data revealed that the treatment *B. bassiana* + imidacloprid 600FS was significantly superior over other treatments and recorded maximum mean per cent mortality, *i.e*. 76.67, followed by treatment *M. anisopliae* + imidacloprid 600FS recorded 73.33 mean per cent mortality.

Keywords: Synergistic, entomopathogens, 600 FS, *H. consanguinea*

Introduction
Scarabaeidae is the second largest family within Coleoptera. The creature of white grub exceeds 30,000 species (Mittal, 2000) [1]. In India, mostly the white grubs from genera *Holotrichia*, *Brahmina*, *Leucopholis* and *Lepidiota* are frequently recorded to be the key pests of crops (Kumar, 2015) [2]. Due to ineffective control and deleterious effects on the environment, there is a need for the enlargement of alternate ecofriendly and economically realistic strategy for the control of white grub for this, biological control may be promising in the management of white grub. Several macro organisms have been identified on white grubs but their unsuitability to manipulation has led to the exploitation of entomopathogens which posses have great potential. Several isolates of fungi, *Beauveria bassiana*, *Beauveria brongniartii*, *Metarhizium anisopliae*, *Paecilomyces fumusoroseus* and *Verticillium lecanii* have been applied in a number of countries [4]. The entomopathogens against white grub, *H. serrata*, *Leucopholis lepidophora* and *Phyllognathus dionysius* have been reported to cause high infection rates in the grub population (Rathour *et al*., 2015) [3]. The use of nematodes as biological pest control agents has increased exponentially over the past few decades. Nematodes that parasitize insects have been described from 27 nematode families but the members of the families, *Heterorhabditidae* and *Steinernematidae* (also called as entomopathogenic nematodes) have received the most attention because of their potential as inundatively applied biological control agents (Kaya and Gaugler, 1993) [4].

Materials and Methods
Details of treatments are as follows: 7 treatments

T1	:	Imidacloprid 600FS + *Metarhizium anisopliae*
Dose	=	(0.5 ml + 0.5 g @1× 10^{12} CFU/ ml) per lit
T2	:	Imidacloprid 600FS + *Beauveria bassiana*
Dose	=	(0.5 ml + 0.5 g @ 1× 10^{12} CFU/ ml) per lit
T3	:	Imidacloprid 600FS + *Heterorhabditis indica* galleria
Dose	=	(0.5 ml + 1 galleria) per lit
T4	:	Imidacloprid 600FS + *Heterorhabditis indica* powder
Dose	=	(0.5 ml + 0.5 g) per lit.
T5	:	Imidacloprid 600FS + *Steinernema glaseri* galleria
Dose	=	(0.5 ml + 1 galleria) per lit
T6	:	Imidacloprid 600FS + *Steinernema glaseri* powder
Dose	=	(0.5 ml + 0.5 g) per lit
T7	:	Control

Inoculation of bioagents

The experiment was carried out in plastic jars for testing of entomopathogenic nematodes and fungi with combination of imidacloprid 600 FS against *H. consanguinea*. Each jar was filled with 100 g well sieved air dried sandy loam soil to which 8 ml water was added and thoroughly mixed. Then soil was inoculated with imidacloprid 600 FS and added required nematode. Efficacy of fungi was conducted by dipping the larvae in the fungal suspension for the five seconds than transferred these larvae into jars which are already treated by imidacloprid insecticide. Only one larva was put into each jar to avoid cannibalism and potato pieces or pearl millet roots were added to each jar as a diet. A set of ten larvae with three replications of each treatment and a control treated with distilled water was maintained and experiment was carried as completely randomized design.

Observation recorded

Observation on grub mortality was recorded 3, 7, 10 days after treatment. To workout per cent grub mortality the dead larvae counted and transferred to a new petri plate containing moist filter paper and observing the symptoms.

Data on per cent mortality were corrected by Abbott's formula as follows.

$$\% \text{ Corrected mortality} = 1 - \frac{\text{n in T after treatment}}{\text{n in C after treatment}} \text{ X } 100$$

Where

n= Insect population

T = Treated

C = Control

Data on infected grubs in laboratory experiment was subjected to arcsine transformations; these transformed data were subjected to analysis of variance.

Results and Discussion

At 3 days after treatment, the grub mortality ranged from 30.00 to 56.67 per cent. The treatment, Imidacloprid 600 FS + *B. bassiana* was found most effective and statistically superior over the other treatments and recorded 56.67 per cent grub mortality. Imidacloprid 600 FS + *M. anisopliae* treatment with 50.00 per cent grub mortality was recorded as the next effective treatment. No mortality was observed in the control. (Table 1 and Fig. 1).

At 7 DAT, Imidacloprid 600 FS + *B. bassiana* recorded 83.33 per cent grub mortality which was statistically superior over the remaining treatments and the minimum mortality of grubs (60.00%) was observed in treatment Imidacloprid 600 FS + *S. glaseri* powder and Imidacloprid 600 FS + *S. glaseri* galleria.

Similar results were documented at 10 DAT with highest (90.00%) grub mortality in treatments Imidacloprid 600 FS + *B. bassiana* recorded as well as Imidacloprid 600 FS + *M. anisopliae* which were at par with each other but statistically superior than other treatments. Least (70.00%) grub mortality was noted in treatment Imidacloprid 600 FS + *S. glaseri* powder in comparison to rest of treatments.

Similar findings were reported by Koppenhofer and Kaya, 1998; Priya, and Subramanian, 2008; Morales-Rodriguez and Peck, 2009; Shewale and Mohite, 2018; Sanjta *et al*. 2020 [6, 7, 8, 9, 10] who studied synergistic or antagonistic effect of entomopathogens with imidacloprid for control third instar white grubs and found that combinations of imidacloprid and nematodes and entomopathogenic fungi had a strong synergistic effect on mortality of grubs.

Table 1: *In vitro* evaluation of synergistic effect of recommended insecticide with different bioagents against 1st instar grub of *H. consanguinea*

S. No	Treatments	Dose per liter (ml/g)	Per cent grub mortality			
			3 DAT	7 DAT	10 DAT	Mean
1	Imidacloprid 600 FS + *M. anisopliae*	0.5 ml + 0.5 g (1× 10^{12} CFU/ ml)	50.00(45.00)	80.00(63.43)	90.00(71.57)	73.33
2	Imidacloprid 600 FS + *B. bassiana*	0.5 ml + 0.5 g (1× 10^{12} CFU/ ml)	56.67(48.85)	83.33(66.14)	90.00(71.57)	76.67
3	Imidacloprid 600 FS + *H. indica galleria*	0.5 ml + 1 galleria	50.00(45.00)	70.00(56.79)	80.00(63.43)	66.67
4	Imidacloprid 600 FS + *H. indica powder*	0.5 ml + 0.5 g	40.00(39.23)	63.33(52.78)	73.33(59.00)	58.89
5	Imidacloprid 600 FS + *S. glaseri galleria*	0.5 ml + 1 galleria	43.33(41.15)	60.00(50.77)	76.67(61.22)	60.00
6	Imidacloprid 600 FS + *S. glaseri powder*	0.5 ml + 0.5 g	30.00(33.21)	60.00(50.77)	70.00(56.79)	53.33
7	Control	-	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00
	S.Em±	-	1.03	1.27	1.18	
	CD at 5%	-	(3.15)	(3.90)	(3.62)	
	CV%	-	4.94	4.54	3.74	

DAT= Days after treatment

Figures in parentheses are angular transformed values

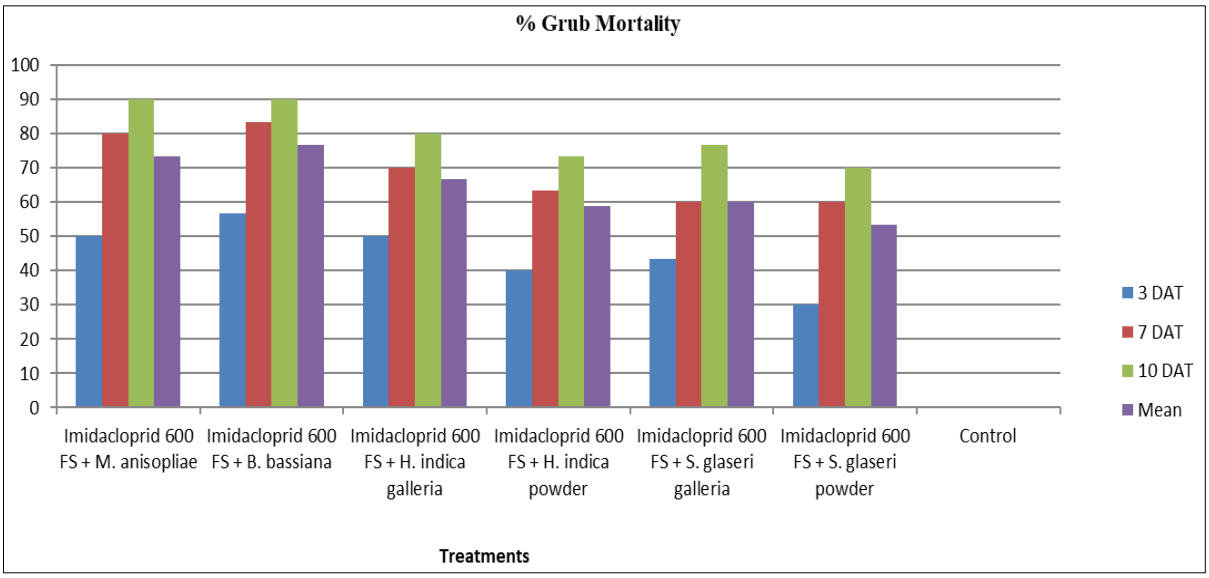

Fig 1: *In vitro* evaluation of synergistic effect of recommended insecticide with different bioagents against 1st instar grub of *H. consanguinea*

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