EFFICACY OF BIOCONTROL AGENTS COMBINED WITH INSECTICIDE AGAINST THE LARGER GRAIN BORER *PROSTEPHANUS TRUNCATES* (HORN.) (BOSTRICHIDAE: COLEOPTERA)

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ABSTRACT

The biological agents, the predator *Teretrosoma negrescens* (Lewis) and the entomogenous fungus *Beauveria bassiana* (Bol.) can successfully suppress population of the larger grain borer, *Prostephanus truncates* (Horn.) (Bostrichidae: Coleoptera). The insecticide pirimiphos-methyl produced 100 % mortality of adult *P. truncates* and 96.81 % mortality of the predator *T. nigrescens*. *P. truncates* was more susceptible to the insecticide than was the predator. A concentration of 1.611×10^6 spores / ml of *B. bassiana* killed 50 % of a mixed population of the larger grain borer populations. A dose 10^6 spore / ml of the fungus *B. bassiana* was used in these experiments. The use of the entomogenous fungus isolate No. 274 and release of the predator *T. negrescens* for the control of *P. truncates* would be beneficial wherever insecticides are used too frequently.

Key words: *Beauveria bassiana, Prostephanus truncates*, biopesticide, Insecticide, control, predator

INTRODUCTION

The use of biological control agents as biopesticides has wide scope in Integrated Pest Management (IPM). Their use has resulted in environmentally sound pest control methods with little danger of the development of resistance, and no lethal effect on non-target organisms.

Fumigants and residual insecticides have been used to control stored grain pests. The use of chemical insecticides has the more obvious approach of hygiene and cleanliness (Adane *et al*., 1996). The use of chemical insecticides against crop pests and stored product pests has resulted in environmental damage, lethal effects on beneficial organisms and also the problem of chemical residues remaining in the food. Dick (1988) pointed out that alternative methods to chemical control were needed including the use of biological control agents.

Recent development in the microbial control of insect pests has indicated that the entomogenous fungi have great potential for the control of a variety of insect pests (Robert and Yendol, 1971; Ferron 1978, 1981; Burges, 1981). Currently 20 microbial pest control agents are registered with the Environmental Protection Agency (USA) (Starnes *et al.*, 1993). Little comparable work relating to stored product pests has been done (Searle and Doberski, 1984). Khan and Selman (1984, 1987, 1988) examined the effect of *Nosema whitei* alone or in combination with insecticides on *Tribolium castaneum*. Rodrigues and Pratissoli (1990) worked with *Metarhizium anisopliae* (Mots) and *Beauveria brongniarti* (Sacc) against the maize weevil.

Recently there has been interest in using *B. bassiana* against stored product pests. This is partly because it can be applied in the same way as chemical pesticides with similar quick acting results. The results show that *B. bassiana* has great potential for the control of the larger grain borer. The studies showed that all stages of the predator *T. nigrescens* were more resistant to *B. bassiana* than the larger grain borer, *P. truncates*.

Predators are used as biocontrol agents to reduce pest damage to tolerable levels over long periods. The results show that both the larvae and adults of the predator *T. nigrescens* are effective predators of *P. truncates*. After successfully determining the biology and functional response to the predator *T. nigrescens* against its prey, the larger grain borer, it is necessary to compare the losses of maize grain caused by *P. truncates* treated with fungus and the predator, and to compare the numbers of progeny produced by both prey and predator.

The contact chemical insecticide pirimiphos methyl has been widely used to control *P. truncates* in Africa (Peter *et al.*, 1990; Dales and Golob, 1997). If *T.*

nigrescens is to be used as a biocontrol agent for *P. truncatus*, it is necessary to consider the pathogenic effects of both the fungus *B. bassiana* and the chemical insecticide pirimiphos-methyl to the predator *T. nigrescens*.

The objectives of the present studies were to evaluate the efficacy of the biological control agents *B. bassiana* and *T. nigrescens* against *P. truncates* and also *T. nigrescens* when combined with the insecticide pirimiphos-methyl.

MATERIALS AND METHODS

Adults of *P. truncates* and *T. nigrescens* were collected from rearing cultures at 30 °C and 70 % R.H. 5 - 10 day old beetles of both the prey and predator were used in the experiments. Fifty grams of French maize ex pigeon feed grain were used for each treatment to feed *P. truncates* in 500 gram capacity jars. The maize grains were checked for previous damage before use in the experiments. In each treatment either the fungus *B. bassiana* or the insecticide pirimiphos-methyl was used against the larger grain borer with or without the predator *T. nigrescens* and the results compared to *P. truncates* alone or controlled solely using *T. nigrescens*. Details of the treatments are given in Table 1.

Table 1. Treatments used for the control of the larger grain borer *P. truncates*

Treatments (T)	Prey with	predator treated	with fungus or	insecticide
	Prey (50)	Predator (10)	Fungus	Insecticide
T1	*P. truncates*	-	-	-
T2	*P. truncates*	*T. nigrescens*	-	-
T3	*P. truncates*	-	*B. bassiana*	-
T4	*P. truncates*	*T. nigrescens*	*B. bassiana*	-
T5	*P. truncates*	-	-	Pirimiphos-methyl
T6	*P. truncates*	*T. nigrescens*	-	Pirimiphos-methyl

A conidial suspension of *B. bassiana* of a dose (1.611×10^6, spore^{-1}) was sprayed onto adults of *P. truncates* or *T. nigrescens* with a perfume sprayer. Pirimiphos-methyl was sprayed onto maize at a dose of 0.05 grams per 50 grams of maize grain (Golob, 1988). The treated grain was shaken thoroughly to ensure that the insecticide was distributed evenly throughout the grain. There were six replicates for each treatment. The surviving populations of *P. truncates* and *T. nigrescens* were recorded 65 days after treatment. The grain loss was assessed by weighing the flour and maize debris. The losses were compared with biological agents or insecticide (pirimiphos-methyl) and an untreated control.

RESULTS AND DISCUSSION

The populations of the larger grain borer *Prostephanus truncates* and its predator *T. nigrescens* are shown in Table 2. The total number of *P. truncates* recorded from each treatment in the progeny bioassay included the 50 parent beetles initially introduced and also the 10 *T. nigrescens* when these predators were part of the treatment. In a comparison of the effects of the biological agents *B. bassiana* and *T. nigrescens* on populations of the larger grain borer, the fungus *B. bassiana* allowed the production of more adults and larvae of *P. truncates* than did the predator *T. nigrescens*. The results showed that the predator was a more efficient agent to control populations of *P. truncates* than the fungus *B. bassiana* (Table 2).

The for weight loss of maize grains in different treatments are presented in Fig. 1. There was a highly statistical significant difference ($P<0.001$) between the control, the bio-control agents and the insecticide (Table 3). When using the predator, or the fungus alone or a combination of the bio-agents there was no statistical significant difference between them. All treatments significantly reduced the damage percentage as compared to the control ($F=158.4$, $P<0.001$).

Undamaged grain in the treatments were 100 %, 86.72 %, 84.17 % and 63.06 % after treatment with insecticide, predator, fungus and the control, respectively (Table 4). The surviving populations of the progeny of the predator *T. nigrescens* are shown in the Fig 2. Very high numbers of adult *T. nigrescens* were counted in the fungus treatments and low numbers in the insecticide treatments. There was a highly significant difference between the fungus, insecticide and control treatments (Table 5).

Teretrosoma nigrescens was much more susceptible to the insecticide pirimiphos-methyl than to the fungus *B. bassiana*. Peter *et al*. (1990) observed *T. nigrescens* to be susceptible to insecticides. However, the predator was more resistant to pirimiphos-methyl than was the larger grain borer. Pirimiphos-methl is a compound which has been specifically recommended for the control of *P. truncates* (Dales and Golob, 1997).

All treatments reduced the losses of grain and the number of progeny of the larger grain borer, *P. truncates*. *P. truncates* was significantly more susceptible to the insecticide pirimiphos-methyl than was the predator, *T. nigrescens*. The adults and larvae of *P. truncates* survived better with the fungus treatment than with the predator. A 100 % mortality of *P. truncates* was recorded in the insecticide only application. There was no statistical difference in the loss of maize grain caused by *P. truncates* between the predator only and the fungus only treatments. However, the predator was more resistant to the fungus *B. bassiana* isolate 274 than was *P. truncates*.

The present investigations conclude that the biological agents *T. nigrescens* and *B. bassiana* can successfully suppress populations of the larger grain borer. The use of the entomogenous fungus *B. bassiana* isolate 274 and the release of the predator *T. nigrescens* for the control of *P. truncates* would be beneficial wherever insecticides are now used too frequently.

Table 2. Survival and reproductive success of *P. truncates* and *T. nigrescens* in 50g maize grains when inoculated with conidiospores of the fungus *B. bassiana* isolate No. 274 and when treated with the insecticide pirimiphos-methyl (values are means of 6 replicates)

Treatment	**Population of culture**					
	Prostephanus truncates			***Teretrosoma nigrescens***		
	Adults percentage	**Larvae No. (mean±SE)**	**Pupae No. (mean±SE)**	**Adults percentage**	**Larvae No. (mean±SE)**	**Pupae No. (mean±SE)**
Control *P. truncates* alone	100.00 ± 4.398a	100.00a ± 5.338a	10.00 ± 0.671	0	0	0
With predator alone	30.13 ± 3.587b	5.66b ± 1.62b	0	100.00 ± 0.840	4.83 ± 0.477	2.00 ± 0.43
With *B. bassiana* alone	36.60 c ± 1.155	39.26c ± 2.045c	0	0	0	0
***B. bassiana* + Predator**	26.62 ± 1.500d	2.93 ± 0.764b	0	64.90 ± 0.477	2.67 ± 0.477	1.15 ± 0.21
Insecticide	0	0	0	0	0	0
Insecticide + Predator	0	0	0	3.19 ± 0.437	0	0

Values of same letter in column are not significantly different.

Fig. 1. Comparison of percentage weight losses caused by *P. truncates* to grain after different treatments using biocontrol agents and an insecticide (mean of six replications with 95 % confidence limits). Values followed by same letter are not significantly different (P<0.001)

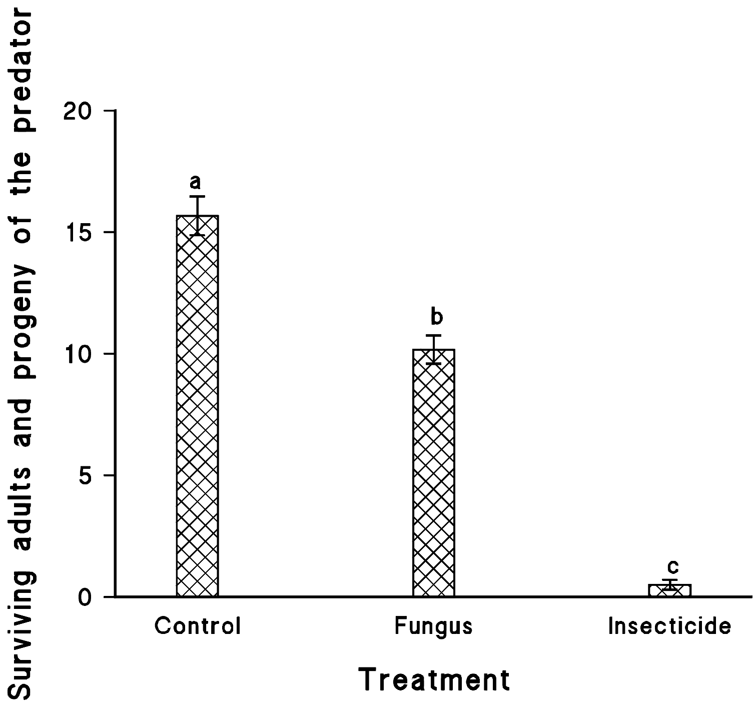

Table 3. Analysis of variance of different treatments for weight losses of grains numbers of undamaged grain and numbers of progeny of *P. truncates*

Sources	Weight loss			Undamaged grains			Progeny		
	DF	F	P	DF	F	P	DF	F	P
Treatment	5	189.54	<0.001	5	158.4	<0.001	5	265.5	<0.001
Error	30			30			30		
Total	35			35			35		

Table 4. Comparison of percentage damage caused by *P. truncates* after treatment with biocontrol agents and / or insecticide

Treatment	Percentage undamaged grain	Percentage damaged grain
Control	63.06 ± 3.807 a	36.93 ± 3.018a
Predator	86.72 ± 1.542 b	13.29 ± 0.980b
Fungus	84.17 ± 1.447 b	15.87 ± 1.366b
Fun. + Predator.	89.18 ± 1.317 c	10.82 ± 1.579 c
Insecticide	100d	0
Inse. + Predator	100d	0

Values of same letter are non-significantly different.

Table 5. Analysis of variance for the progeny of the predator *T. nigrescens* (Lewis)

Sources	DF	SS	MS	F values	P values
Treatments (control, fungus and insecticides)	2	707.44	353.72	206.72	<0.001
Error	15				
Total	17				

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