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Cross infectivity and safety of nuclear polyhedrosis virus, *Bacillus thuringiensis* subsp. *kurstaki* Berliner and *Beauveria bassiana* (Balsamo) Vuille to pests of groundnut (*Arachis hypogea* Linn.) and their natural enemies

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ABSTRACT : The nuclear polyhedrosis virus (NPV) of *Spodoptera litura* (Fabricius) was not cross infective to other groundnut pests tested, *viz., Heliothis armigera* (Hub.), *Aproaerema modicella* (Deventer), *Empoasca kerri* Pruthi and *Aphis craccivora* Koch. and safer to their predators, *viz., Coccinella septumpunctata* Linn., *Menochilus sexmaculatus* Fab. and *Chrysoperla carnea* (Steph.) and parasitoids *Bracon gelichae* Ashm. and *Tetrastichus* sp. tested. *Bacillus thuringiensis* subsp. *kurstaki* Berliner (*B.t.*) was highly effective against the larvae of lepidopterous pests tested but not against homopteran insects. *B.t.* was also safe to coccinellid predators and larval parasitoids of *A.modicella* except for adults of *C.carnea. Beauveria bassiana* (Balsamo) Vuille. was infective to groundnut pests and coccinellid predators tested. Nevertheless, its safety was proved against the larval parasitoids of *A. modicella.*

The development of alternative methods of controlling insects has become indispensable in view of harmful effects of chemical insecticides to mankind. One such development in this direction is microbial control of insect pests using insect pathogens like virus, bacteria and fungi, which are effective, safe, and acceptable. Among them, nuclear polyhedrosis virus (NPV), *Bacillus thuringiensis* Berliner (*B.t.*) and *Beauveria bassiana*(Balsamo) Vuille. are greatly exploited. Further, their broad host range and compatibility with insecticides has an added significance in integrated pest management systems involving multifaceted pest suppression strategies. In view of these considerations, investigations on cross infectivity and safety of these microbial agents to groundnut pests and their natural enemies, were undertaken.

MATERIALS AND METHODS

The NPV inoculum obtained from the Department of Entomology, S.V. Agricultural College, Tirupathi, was multiplied by feeding third and fourth instar larvae of *S.litura* with virus contaminated groundnut leaves. The purified, concentrated suspension of poly-

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hedra isolated from the dead, diseased larvae of *S.litura* was used as infective material as described by Backwad and Pawar (1981).

'Dipel'a wettable powder formulation of *B.t.*subsp. *kurstaki* was multiplied by feeding bacteria contaminated groundnut leaves to third and fourth instar larvae of *S.litura*. The bacteria was isolated from the diseased *S.litura* larvae and pure culture was prepared from it as described by Kiraly *et al.* (1974a). Ten ml distilled water was added to each agar slant and growth was harvested. The bacterial suspension so obtained was used as stock suspension.

The fungus inoculum obtained from the white muscardine silkworm cadavars from the Department of Sericulture, University of Agricultural Sciences, GKVK, Bangalore, was isolated and multiplied as per Kiraly *et al.* (1974b). Then the spores were transferred in to a conical flask containing sterile distilled water and thoroughly shaken for 10 minutes. The suspension was strained through a double layer sterile cheese cloth and filtrate was used as stock suspension. A standard haemocytometer (Neubaur's improved double ruling, Germany) was used for counting the polyhedra and spores of *B.t.* and *B.bassiana* under meopta phase contrast microscope.

The studies were carried out at S.V. Agricultural College, Tirupati, during *rabi,* 1991. Cross infectivity to groundnut pests was examined by feeding them for 24 hours on groundnut leaves contaminated with highly concentrated NPV (1×10^9 PIBs ml^{-1}), *B.t.* (1×10^9 spores ml^{-1}), and *B.bassiana* (1×10^9 spores ml^{-1}) suspensions along with 0.1 per cent teepol. Second instar larvae of *Heliothis armigera* (Hubner) (Noctuidae), *Aproaerema modicella* (Deventer) Gelechiidae), adults of *Aphis craccivora* Koch. (Aphididae), and *Empoasca kerri* Pruthi (Cicadellidae) were used. The experiment was conducted with 3 replications consisting of 60 larvae in the case of lepidopterous pests and 60 adults in the case of homopteran insects. The second instar larvae of *S.litura* served as control and as check on the viral, bacterial and fungal activity. Observations were recorded on the larval mortality till pupation.

Common predators of groundnut aphid and parasitoids of *A.modicella* were used for safety tests. Adults of aphid predators, *viz., Coccinella septumpunctata* Linn. (Coccinellidae), *Menochilus sexmaculatus* Fab. (Coccinellidae), *Chrysoperla carnea* (Steph.) (*Chrysopa carnea*) (Chrysopidae) were fed with aphids dipped in viral, bacterial and fungal suspensions for 24 hours and healthy aphids were provided thereafter. Adult predators of the same age group provided with healthy aphids constituted untreated control and served as a check on the NPV, *B.t.* and *B.bassiana* activity.

Parasitoids, *viz., Bracon gelichae* Ashm. (Braconidae) and *Tetrastichus* sp. (Eulophidae) were provided with viral, bacterial and fungal infected larvae of *A.modicella* as host material. The parasitoids provided with healthy larvae of *A.modicella* served as control. Observations were made on general behaviour and mortality of predators and parasitoids. In both these cases, the host insects, *viz., A.craccivora* and *A.modicella* were treated with highly concentrated NPV (1×10^9 PIBs ml^{-1}), *B.t.* (1×10^9 spores ml^{-1}) and *B.bassiana* (1×10^9 spores ml^{-1}) suspensions along with 0.1 per cent teepol.

RESULTS AND DISCUSSION

There were no detectable symptoms of polyhedrosis on cross-infection and death did not occur due to virus in the groundnut pests (Table 1). Larval mortality due to virosis was 95.00 per cent in the control. The results indicated that NPV of *S.litura* was not cross infective to other groundnut pests tested, *viz., H.armigera, A.modicella, E.kerri* and *A.craccivora,* as no death occurred due to polyhedrosis. Thus, a high degree of host specificity of the virus was observed. Earlier, similar findings were documented with *S.litura* (Pawar and Ramakrishnan, 1971; Anuradha, 1991). Also, Smith (1967) stated that high degree of host specificity of the virus seems to be common to most of the nuclear polyhedrosis viruses.

The aphid predators, *viz., C.septumpunctata, M.sexmaculatus* and *C.carnea* and larval parasitoids of *A.modicella (B.gelichae* and *Tetrastichus* sp.) were free of virosis and death did not occur due to virus. Similar results were reported by Nageswara Rao (1990) in the case of coccinellid grubs and adults of *C.septumpunctata* and *M.sexmaculatus.*

B.t. subsp. *kurstaki* was highly effective against lepidopterous larvae (*H.armigera* and *A.modicella*) but not against homopteran insects (Table 1). The susceptibility of *H.armigera*

Table 1. Cross-infectivity and safety of NPV of *S.litura, B.t.* and *B.bassiana* on other groundnut pests and their predators and parasitoids

Test insect	No. of larvae/adults/ grubs treated for each treatment	Mortality due to			Infectivity due to		
		NPV	*B.t.*	*B. bassiana*	NPV	*B.t.*	*B. bassiana*
Other groundnut pests							
1. *Heliothis armigera* (larvae)	60	-	52 (86.67)	48 (80.00)	-ve	+ve	+ve
2. *Aproaerema modicella* (larvae)	60	-	18 (30.00)	21 (35.00)	-ve	+ve	+ve
3. *Empoasca kerri* (adults)	60	-	-	28 (46.67)	-ve	-ve	+ve
4. *Aphis craccivora* (adults)	60	-	-	33 (55.00)	-ve	-ve	+ve
Predators & Parasitoids							
5. *Coccinella septumpunctata* (adults)	60	-	-	10 (16.67)	-ve	-ve	+ve
6. *Menochilus sexmaculatus* (adults)	60	-	-	12 (20.00)	-ve	-ve	+ve
7. *Chrysoperla carnea* (adults)	60	-	2 (3.33)	5 (8.33)	-ve	+ve	+ve
8. *Bracon gelichae* (grubs)	60	-	-	-	-ve	-ve	-ve
9. *Tetrastichus* sp. (grubs)	60	-	-	-	-ve	-ve	-ve
10. *Spodoptera litura* (control) (larvae)	60	57 (95.00)	58 (96.67)	54 (90.00)	+ve	+ve	+ve

Figures in parentheses are percentage values

to *B.t.* was also reported by Rajagopal *et al.* (1988). Among two lepidopterous pests tested, *H.armigera* was found highly susceptible to *B.t.* when compared with *A.modicella.* It might be because of its concealed position within the leaf mines due to which it did not consume lethal dose of *B.t.* to get mortality.

No adult mortality was observed in the case of *C.septumpunctata* and *M.sexmaculatus* due to *B.t.* (Table 1). The present findings conform to the reports of Krieg and Lagenbruch (1981) that *B.t.* had no contact toxicity and exhibited limited insecticidal activity, outside a narrow range of foliage feeding Lepidoptera. Hassan *et al.* (1983) reported that Dipel was harmless to most of the beneficial arthropods including coccinellid predator, *C.montrouzieri* and can be recommended for use in integrated control programmes. Nevertheless, slight susceptibility of adults of *C.carnea* to *B.t.* was observed in the present study. The development and time taken for adult emergence were normal and no mortality was observed in the case of larval parasitoids of *A.modicella* developed in infected hosts. Lim *et al.* (1986) reported the selective toxicity of Dipel to *P.xylostella* but not to its braconid parasitoid, *A.plutellae.*

All the four species of groundnut pests tested were found to be equally susceptible to *B.bassiana,* suggesting its wide host range (Table 1). Also, Rao (1975) reported the effectiveness of *B.bassiana* on more than 150 insect species. Likewise, Dutky (1959) stated that with its wide undefined host range, *B.bassiana* referred as 'Magnificent pathogen'.

The aphid predators tested, *viz., C.septumpunctata, M.sexmaculatus* and *C.carnea* were susceptible to *B.bassiana.* No mortality either in *B.gelichae* or *Tetrastichus* sp. was observed when developed in fungal infected hosts (Table 1). Time taken for adult emergence was also not altered indicating its safety to larval parasitoids. This observation corroborates the findings of Sivasankaran *et al.* (1990) in the case of *Sturmia inferens,* where adult longevity and adult emergence was not altered significantly by the fungal treatment. Thus, a negative impact of *B.bassiana* was evident on aphid predators. Nevertheless, it was found to be safe enough to the larval parasitoids of *A.modicella* when developed in treated hosts.

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