INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 7, Issue - 9, Sept – 2021
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 05/09/2021 Acceptance Date: 19/09/2021 Publication Date: 30/09/2021

INFLUENCE OF HOST PLANTS ON THE EFFICACY OF NUCLEOPOLYHEDROVIRUS OF MAJOR POLYPHAGOUS PEST *SPODOPTERA LITURA*(F.) (LEPIDOPTERA: NOCTUIDAE)

Dr. B. S. RAVISHANKAR
Assistant Professor,
Department of Zoology
BLDE Associations S B Arts and KCP Science College, Vijayapur – 586103, Karnataka,
Email - ravishankarbsmscphd@gmail.com

Abstract: *The antibiosis effect of gallic acid on Spodoptera litura F. (Lepidoptera: Noctuidae) and its parasitoid evaluated by means of feeding six days vintage larvae on synthetic weight-reduction plan integrated with exclusive concentrations (five ppm, 25 ppm, a hundred twenty five ppm, 625 ppm, 3125 ppm) of the phenolic compound revealed better attention (LC50) of gallic acid had a poor impact at the survival and physiology of S. litura and its parasitoid Bracon hebetor (Say) (Hymenoptera:Braconidae). The mortality of S. litura larvae became expanded while adult emergence declined with growing attention of gallic acid. The developmental duration was behind schedule substantially and all of the dietary indices had been reduced considerably with boom in attention. better attention (LC50) of gallic acid adversely affected egg hatching, larval mortality, adult emergence and general development duration of B. hebetor. At lower attention (LC30) the impact on B. hebetor adults and larvae became non-vast with appreciate to govern. Gene expression for the enzymes viz., Superoxide dismutase, Glutathione peroxidase, Peroxidase, Esterases and Glutathione S transferases accelerated whilst the overall hemocyte remember of S. litura larvae reduced with remedy. Our findings suggest that gallic acid even at decrease concentration (LC30) can impair the boom of S. litura larvae without inflicting any full-size harm to its parasitoid B. hebetor and has big capability to be used as biopesticides.*

Key Words: *Spodoptera litura , geographically, insecticides, application, degradation.*

1. INTRODUCTION:

Spodoptera litura is commonly known as tobacco caterpillar in India is a major polyphagous pest attacks variety of economically important crops such as cotton, groundnut, rice, tomato, tobacco, citrus, cocoa, potato, rubber, castor, millets, sorghum, maize and many vegetable crops (Hill 1993). Caterpillars of the pest defoliate the crops. The pest occurs in India, Pakistan, Bangladesh, Sri Lanka, S. E. Asia, China, Korea, Japan, Philippines, Indonesia, Australia, Pacific islands, Hawaii and Fiji (Hill 1993).

In various species of lepidopteran pest management, increasing failures of chemical pesticides and the problems posed by their indiscriminate use have created the right impetus to the development of environment friendly methods of pest control. Microbial pesticides are becoming increasingly attractive as an alternative pesticide. In particular, a family of insect-specific viruses, the Baculoviridae has long been recognized as an environmentally safe and potential alternative to chemical pesticides as the viruses are highly host specific, non-pathogenic to beneficial insects and other non-target organisms, including mammals. Thus, making them attractive candidates for integrated pest management (IPM). Other advantages of baculoviruses for pest control include lack of toxic residues, allowing growers to treat their crops even shortly before harvest and unlikelihood development of stable resistance.(reference)

Baculoviruses, among other insect viruses, are regarded as safe and selective bio-insecticides, restricted to insects only. They have been used worldwide against many insect pests. These viruses with specificity potential that can suppress insect pests of economic importance in agricultural crops, have been indicated their application as microbial pesticides.The concept of microbial control originated over a hundred years ago (Steinhaus 1956). By late 1800s and 1900s, many attempts were made to control insect pests with pathogens with some attempts were successful and some failure. The early unpredictable results with insect pathogens in field applications and the subsequent development and successful use of broad spectrum pesticides to reduce pest populations slowed down the development and successful use of microbial pesticides (Tanada and Kaya 1993). The entomogenous viruses are of immense utility (Ignoffo and Couch 1981). Owing to their often pronounced host specificity and their high virulence to susceptible insect hosts, baculoviruses are considered to be one of the most efficient biocontrol agents for insects. The virions are occluded in Polyhedral Occlusion Bodies (POBs) and are protected against environmental conditions for years. Today, at least 1300 insect viruses are known to infect insects (Moscardi 1999). Among these,

NuclearPolyhedrosis Viruses (NPVs) are the most suitable and effective pest control agents due to their desirable attributes like infectivity, lethality, storage stability and environmental safety (Cunningham 1999). They are particularly attractive as bioinsecticides because of two factors. They are safe for vertebrates and other non-target fauna and they are generally highly pathogenic, host death being the most likely outcome of an infection. Today, several baculoviruses have been commercialized all over the world and used as possible alternative for toxic, environmentally disruptive chemicals. As the selection of virulent strain of NPV is a key to the development of effective bio insecticides, local strains are always preferred for sustainability, adaptability and efficacy under a given set of agro-ecosystem and hold an ample scope for their wide spread multiplication and commercial use as novel biopesticides in a particular region (Gupta e*t al.* 2007). Among the alternatives that are currently available is use of insect viruses remain the most promising, considering the fact that they can be used in a manner similar to the familiar chemical pesticides. Unlike other natural enemies, insect viruses can be produced and stored and made available to the farmers at a short notice due to their longer shelf life. Of the various insect viruses, nucleopolyhedroviruses are more successful in pest management (Roberts *et al.* 1991).

2. REVIEW OF LITERATURE:

Literature related to *Spodoptera litura* and its pathogenic nucleopolyhedrovirus collected from the journals, e-journals, CAB PEST ROM and biological abstracts has been reviewed.

2.1 Pest Status:

The tobacco caterpillar, *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) is a polyphagous pest and widely distributed throughout India. Its biology and feeding response on different hosts has been studied (Ratanlal and Nayak 1963; Bhalani and Talati 1984; and Patel *et al*. 1987). However, the degree of host plant suitability is a function of several factors, including nutritional composition (Thorsteinson 1960; Yamamoto and Fraenkel 1960).

Widespread development of resistance to chemical insecticides including the widely used pyrethroids has been reported in *S. litura* (Ahmad *et al*. 2007). In recent years the problem of resistance to chemicals has worsened, resulting in 20-30% crop loss due to pests in India (Bhargava *et al*. 2008). *Spodoptera litura* also enjoys a wide distribution and besides India, it is reported from Thailand, Philippines, China, Japan, Vietnam, Indonesia, Australia, Korea, Iran, Egypt, Bahrain, Fiji and Formosa (Singh and Jalali 1997). It is reported to feed on 112 species of plants and the outbreak of this pest occurs under rainfall condition after a long dry spell (Moussa *et al*. 1960). Further, the pest has developed resistance to several insecticides like malathion, pyrethrum, lindane and endosulfan (Ramakrishnan *et al*. 1984). The wild soybean (Glycine soja Sieb. Zucc.) has been reported to be relatively resistant to *S. litura* (Ying *et al*. 2011). The genetics of insecticide resistance has been extensively studied in several insect pests, but there is a lack of information on *S. litura* (Xiang 2011).

In India, the tobacco caterpillar infests most of the Rabi crops like gram, linseed, sunflower, etc. every year. The third and fourth instar *S. litura* larvae feed on geminating seeds. At times, its severity necessitates resowing. Many workers have reported *S. litura* as a folivore pest (Jack 1915; Lever 1943; Singh and Bichoo 1971; Patel *et al*. 1973; Gangrade 1974; Rathi 1984). It has a cosmopolitan behaviour (Commonwealth Institute of Entomology 1967). The insect causes economic damage ranging from 25.8- 100% (Dhir *et al*. 1992; Higuchi *et al*. 1994; Trivedi 1988).

2.2 Biology:

The biology and food preference of *S. litura* on five different hosts (soybean, gram, wheat, sunflower and linseed) was studied (Sharma 1994). Vaish and Agarwal (1978) conducted lab tests on the feeding preference of larvae of *S. litura* for their development on eight food plants. Sunflower was the most preferred food plant followed by cowpea (Vigna unguiculata L.), radish (Raphanus sativus L.), green gram (Vigna radiate L.), blackgram (Vigna munga L.), rose petal (Rosa L.), rose leaf and tur (Cajanus cajan L.) in the order of preference.

The consumption and utilization of nine food plants by *S. litura* was compared in the laboratory in India. On the basis of rate of food intake, growth rate, digestibility and efficiency of conversion of ingested and digested food to body biomass, the most suitable plants were castor and sunflower, while the least suitable was pigeonpea (Chibber *et al*. 1985).

Patel *et al*. (1987) studied the effects of various food plants viz., castor, *Dolichus lablab*, cabbage, lucerine and *Coccinia grandis* on the survival and development of *S. litura* larvae. The larval survival of the noctuid was highest on castor and cabbage followed by *D. lablab*, lucerine and *Coccinia grandis*. The duration of larval development was shortest on castor followed by lucerine, Cabbage, *D. lablab* and *C. grandis*.

Bhalani *et al*. (1989) reported that larvae of *S. litura* showed high growth index, pupal weight, size and less duration of development when reared on castor. The suitability of the remaining plants were in the order of cotton > groundnut > cowpea > green gram > sorghum > maize. The complexes have been screened against *S. litura* for

antifeeding and insect growth-regulating activity (Shyamala *et al*. 2010). The flight activity of *S. litura* in tethered conditions is evaluated using a computer-mediated flight-mill in the laboratory (Gou *et al*. 2010).

Studies were conducted to determine the pathogenicity of a local isolate of *Beauveria bassiana* against *S. litura* (Bhaduria *et al*. 2011). Investigations were carried out to assess the pathogenicity of some isolates of the entomopathogenic fungus, *Nomuraea rileyi*, against different instars of *S. litura* (F.) under *in vitro* conditions (Rajan and Muthukrishnan 2009). The study was conducted to determine the characteristics of *S. litura* resistant soybean lines.

Both *Microplitis prodeniae* Rao and Chandry (Hymenoptera: Bracondidae) and *Campoletis chlorideae* Uchida (Hymenoptera: Ichnumonidae) are major parasitoids of *S. litura* in tobacco. The results showed that the competition between the two species for spatial and food resources was very intense, and *C. chlorideae* was always dominant when the two species compete for spatial and food resources in different periods (Shi *et al*. 2010). Eight essential oil compounds were evaluated against the Asian armyworm, *S. litura* to determine the influence on the oviposition and feeding behavior (Singh and Rup 2010).

3. MATERIALS AND METHODS:

The materials used and the methods employed in the investigations on influence of different host plants on the virulence of *Sl*NPV, interactions between biochemical components of host plants and *Sl*NPV and field trials with *Sl*NPV against *Spodoptera* culture on different crops are described here.

3.1. Source of insect and virus:

Field collected larvae of *S. litura* on castor, *Ricinus communis* L. in Bangalore were reared on semi-synthetic diet in the laboratory following the method of Shorey & Hale (1965) at constant temperature (25±1°C), humidity (65±5%RH) and photoperiod 14L:10D (Figure 1). When these larvae were pupated, the pupae were sexed and kept in nylon cages (30x30x30cm) at 5:5 ratio (Male: Female) per cage. The emerged male and female moths were allowed to mate in the cages and females were provided with muslin cloth for egg deposition. Freshly hatched larvae were mass reared on semi-synthetic diet. The initial culture of *S. litura* nuclear polyhedrosis virus (*Sl*NPV) was obtained from Biological Control Research Laboratory, Pest Control India Pvt. Ltd., Bangalore and infected the early fourth instar larvae of *S. litura* by diet surface contamination method. The infected larvae exhibiting typical symptoms of polyhedrosis virus were collected and stored in stopper flask with 1ml of water per larva and they were left to putrefy for about 15 days enable them to release polyhedra from infected tissues. The putrefied suspension of diseased larvae was homogenized using the tissue homogenizer and left undisturbed for 2-3 days to facilitate the polyhedra to settle as a whitish layer at the bottom of flask. Then the dead tissue on the upper layer of the flask was removed gently without disturbing the polyhedra at the bottom and the remains of the polyhedra was filtered by two-layered filter cloth and was centrifuged at 6000 rpm for 1 hr. The pallets containing pure polyhedral inclusion bodies were collected and re-suspended in distilled water and stored at 4°C till further use. The concentrations of the polyhedra were estimated with the help of a double ruled improved Neubaur Haemocytometer of depth factor 0.1 mm (Weber, England) under a phase contrast microscope. Appropriate *Sl*NPV dilutions were made using stock preparation of 1×10^9 POB/ml.

Table 1. Semi-synthetic diet composition for rearing of *Spodoptera liturra* (Shorely and Hale, 1965)

Diet composition	
Part A	**Quantity**
Base ingredient *	100.00 gms
Ascorbic acid	03.00 gms
Yeast tablets	30.00 gms
Water	400.00 ml
Part B	
Agar-Agar	13.00 gms
Water	400.00 ml
Part C	
Wesson salt	07.00 gms
Sorbic acid	01.00 gms
Methyl parahydroxy benzonate	02.00 gms
Streptomycin sulphate	00.25 gms
Vitamin	04.00 ml
Bavistin	02.00 gms

Formaldehyde 10% in water	02.00 ml
Alcohol	02.00 ml

***Base ingredient:** Kabuligram

3.1.4 Enumeration of polyhedral occlusion bodies (POB):

Use of appropriate dose of NPV is important for successful biological control of pests. It is therefore, very essential to ascertain the strength of the NPV in the suspension before it is applied. The concentrations of the polyhedra were estimated with the help of a double ruled improved Neubauer haemocytometer of depth factor 0.1 mm (Weber, England) under a phase contrast microscope.

POB counting:

A. Serial dilution:

The suspensions of different samples were made to a standard volume. 10 µl of the suspension was transferred to a sterile microfuge tube and the volume made up to 100 µl with distilled water. Serial dilution was repeated twice and enumeration and calculation of the number of POBs were performed thrice as described by Rabindra *et al.* (2001).

B. Enumeration:

- Cleaned the cover slip and the haemocytometer by wiping with tissue paper dipped in 70% ethanol.
- Placed the cover slip on top of the slide exactly over the depression in the counting chamber.
- Sample was thoroughly mixed in a vortex.
- Using a digital pipette, introduced 10 µl of sample into the counting chamber directly so that the chamber is filled completely. Avoided over flooding of the suspension.
- Firmly but carefully pressed down on the sides of the cover slip to ensure that the chamber is of the correct depth.
- Left the haemocytometer undisturbed for 2-3 minutes so that the POB in the suspension settles down and Brownian movement is reduced.
- Observed the haemocytometer under a 40 x objective and using phase contrast microscope (Phase 2), polyhedral are focused.
- The central squares are divided into 5x5 squares equally. Each of these 1/25 squares is further sub divided into 16 smaller squares. Totally there are 400 smaller squares. The polyhedral body was counted systematically in sequence across the grid. By doing so one will be able to count the polyhedra in 160 small squares. The polyhedra within each smaller square and those touching the top and left hand sides alone were counted.
- The counts were taken in three replicates and average was worked out.

C. Calculation:

The number of polyhedra/ml was calculated by following formula:

$$\frac{D \times X}{N \times K}$$

Where:

D = dilution factor

X = total number of polyhedra counted (Mean of 3 counting)

N = number of squares counted (160 small square)

K = volume above one small square in cm^3 (i.e., 2.5×10^{-7})

Explanation for K

a. Area of each smaller (1/400) square is $0.0025mm^2$
b. Depth of the chamber is 0.1 mm
c. The volume of the liquid above the smaller (1/400) square is $0.0025mm^2$
d. To convert to cm^3 multiply by 1/1000
e. The volume of suspension (K) will be $2.5x10^{-7}$

3.1.2 Host plants

Five species of host plants *viz.*, groundnut (*Arachis hypogaea* L.), cabbage (*Brassica oleracea* L.), cotton (*Gossypium hirsutum* L.), rose (*Rosa indica* L.) and potato (*Solanum tuberosum* L.) were selected for the virus-host

plant interaction studies. The host plants were grown separately in pots filled with red earth and peat-lite mix soil mixture in the greenhouse at BCRL, Bangalore. Plants were watered daily.

4. RESULTS:

4.1. Effect of host plants on *Sl*NPV without direct contact:

In the case of *S. litura* larvae reared on different host plants and subsequently fed with *Sl*NPV treated semi-synthetic diet, LC_{50} with respect to different host plants ranged from 0.11 to 0.67 POB/mm^2. The highest LC_{50} was recorded in rose (0.67) and the lowest in groundnut (0.11). However, the lowest LC_{50} was recorded in control of all the treatments. (Table 1). The range of LT_{50} at different concentrations on different host plants in the ascending order was as follows: groundnut 4.579-6.557, cabbage 4.877-7.382, potato 5.455-7.806, cotton 5.623-8.606 and rose 5.800-9.032. The lowest LT_{50} was recorded in groundnut and the highest in rose within the same concentration. However, the lowest LT_{50} was recorded in control of all the treatments (Table 2).

4.2. Effect of host plants on *Sl*NPV by direct contact

Spodoptera litura larvae reared on semi-synthetic diet and assayed on different host plants, LC_{50} with respect to different host plants ranged from 0.15 to 1.06 POB/mm^2. The highest LC_{50} was recorded in rose (1.06) and the lowest in groundnut (0.15). However, the lowest LC_{50} was recorded in control (Table 3).

The range of LT_{50} at different concentrations against *S. litura* larvae reared on semi-synthetic diet and subsequently fed with *Sl*NPV treated leaf discs of various host plants in the ascending order was as follows: groundnut 4.757-7.156, cabbage 4.933-7.954, potato 5.584-9.164, cotton 6.135-9.394 and rose 6.312-9.816. The lowest LT_{50} was recorded in groundnut and the highest in rose within the same concentration. However, the lowest LT_{50} was recorded in control of all the treatments (Table 4).

Table 1. LC_{50} of *Sl*NPV against *Spodoptera litura* fed on different host plants and assayed on semi-synthetic diet

Host plants	LC_{50} (POB/mm^2)	Fiducial limits		Slope	Intercept	χ^{2**} (n-2)
		Lower	Upper			
Groundnut	0.11	0.03	0.26	0.53	0.51	1.24
Cabbage	0.17	0.05	0.38	0.51	0.39	0.84
Potato	0.26	0.09	0.65	0.50	0.28	0.60
Cotton	0.42	0.15	1.07	0.49	0.18	0.46
Rose	0.67	0.25	1.76	0.49	0.08	0.36
Semi-synthetic diet*	0.07	0.02	0.17	0.57	0.64	1.98

*Control, ** All lines are significantly a good fit at P<0.05.

Table 2. LT_{50} of *Sl*NPV against *Spodoptera litura* fed on different host plants and assayed on semi-synthetic diet

Concentration (POBs/ml)	Host plants	LT_{50}	95% limit		Slope	Intercept	χ^{2**}
			Lower	Upper			
1×10^6	Groundnut	4.579	4.043	5.071	7.618	-5.034	14.117
	Cabbage	4.877	4.597	5.151	7.071	-4.866	9.210
	Potato	5.455	5.131	5.801	6.132	-4.518	7.539
	Cotton	5.623	5.295	5.979	6.247	-4.685	6.931
	Rose	5.800	5.427	6.230	5.410	-4.130	8.722
	Semi-synthetic diet*	4.323	3.876	4.833	9.132	-5.860	15.416
2×10^5	Groundnut	4.824	4.242	5.387	6.613	-4.519	13.892
	Cabbage	5.215	4.674	5.784	6.265	-4.494	11.043
	Potato	5.606	5.268	5.975	5.951	-4.455	8.645
	Cotton	5.951	5.598	6.358	6.057	-4.692	5.957
	Rose	6.134	5.728	6.632	5.304	-4.178	7.041
	Semi-synthetic diet*	4.652	4.049	5.214	6.885	-4.597	15.596

4×10^4	Groundnut	5.233	4.477	6.100	5.326	-3.828	16.959
	Cabbage	5.754	5.128	6.559	5.245	-3.986	10.637
	Potato	6.252	5.852	6.747	5.584	-4.445	6.976
	Cotton	6.548	6.106	7.134	5.378	-4.389	6.043
	Rose	7.066	6.464	7.984	4.425	-3.758	6.871
	Semi-synthetic diet*	5.162	4.480	5.911	5.558	-3.962	14.959
8×10^3	Groundnut	5.587	4.808	6.627	4.914	-3.672	15.527
	Cabbage	6.610	6.203	7.140	6.090	-4.995	2.549
	Potato	6.803	6.327	7.464	5.371	-4.473	5.036
	Cotton	7.007	6.493	7.754	5.247	-4.436	5.080
	Rose	7.563	6.853	8.745	4.343	-3.816	5.310
	Semi-synthetic diet*	5.564	4.951	6.304	5.425	-4.044	11.148
1.6×10^3	Groundnut	5.967	5.187	7.154	4.677	-3.628	13.264
	Cabbage	6.899	6.470	7.487	6.286	-5.273	2.026
	Potato	7.122	6.611	7.873	5.525	-4.711	3.742
	Cotton	7.387	6.821	8.271	5.381	-4.674	3.843
	Rose	8.163	7.306	9.739	4.322	-3.941	4.044
	Semi-synthetic diet*	5.958	5.596	6.378	5.871	-4.551	6.657
3.2×10^2	Groundnut	6.557	5.656	8.295	4.251	-3.472	12.264
	Cabbage	7.382	6.870	8.166	6.088	-5.285	2.661
	Potato	7.806	7.151	8.916	5.350	-4.774	3.006
	Cotton	8.606	7.675	10.458	4.703	-4.397	2.254
	Rose	9.032	7.969	11.315	4.710	-4.502	2.347
	Semi-synthetic diet*	6.533	6.084	7.129	5.253	-4.282	6.527

*Control, **Non-significant, table χ^2 ($P<0.05$) at 6df = 12.592

Table 3. LC_{50} of *Sl*NPV against *Spodoptera litura* reared on semi-synthetic diet and assayed on different host plants

Host plants	LC_{50} (POB/mm2)	Fiducial limits		Slope	Intercept	χ^{2**} (n-2)
		Lower	Upper			
Groundnut	0.15	0.04	0.38	0.49	0.40	1.29
Cabbage	0.23	0.07	0.61	0.48	0.29	1.00
Potato	0.38	0.12	1.00	0.47	0.19	0.81
Cotton	0.61	0.22	1.69	0.46	0.09	0.67
Rose	1.06	0.42	2.95	0.49	0.01	0.31
Semi-synthetic diet*	0.07	0.02	0.17	0.57	0.64	1.98

*Control, ** All lines are significantly a good fit at $P<0.05$.

5. DISCUSSION:

5.1. Screening of *Sl*NPV in the laboratory

The present study was conducted to understand the influence of host plants on the virulence of *Sl*NPV both in the laboratory and field. Results of all the three experiments viz., a) without direct contact between host plants and *Sl*NPV b) with direct contact between host plants and *Sl*NPV and c) with direct contact between host plants and *Sl*NPV as well as host plants influence through the host insect.

The highest LC_{50} in rose was due to very less larval mortality compared to all other host plants and alkaline nature of the rose leaf surface. It is known that the leaf exudates from glandular hairs of the cotton plants inactivate the NPV of *Heliothis* spp. (Falcon 1971 and Young and Yearian 1974). The difference in mortalities may largely be

attributed to differences in feeding rates. Since the leaves have the highest density of the glandular hairs there is a higher degree of inactivation. The leaf exudates from glandular hairs might have affected *Sl*NPV as both the virus i.e., *Ha*NPV and *Sl*NPV are having same mode of action on insects. The lowest LC_{50} in groundnut indicates that larvae reared are more susceptible to *SI*NPV than on rose. Hence the larvae reared on rose required higher concentration of inoculum. Similar results were also reported in previous studies (Kulkarni and Hugar 2000).

Furthermore, it was reported that the host plant plays an important role in the mediating the susceptibility of lepidopteran larvae to baculoviruses (Fuxa 1982; Fuxa and Geaghan 1983; Keating and Yendol 1987; Richter *et al.* 1987; Duffey *et al.* 1995; Hoover *et al*. 1998ab). In the gypsy moth *Lymantria dispar Ld*NPV system, shows that the host plant also plays an important role in mediating viral epizootics (Keating and Yendol 1987; Schultz and Keating 1991; Schulta *et al*. 1992; Hunter and Schultz 1993). Keating and Yendol (1987) reported as much as 3-fold variation in LC_{50} for *Ld*NPV across these host plants tested for gypsy moth larvae.

The lowest LT_{50} in groundnut and highest in rose were also observed at the same concentration of *Sl*NPV screened against *S. litura* in direct contact with different host plants (Kulkarni and Hugar, 2000). Moreover, LT_{50} values were varied in the case of fungal pathogen, *Beauveria bassiana* L. tested on *Helicoverpa armigera* (Hubner), *S. litura* and *Spilosoma obliqua,* which was reared on different host plants (Haseeb, 2007).

Further, the increasing larval mortality was noticed from fourth to tenth day after treatment. Moreover, the lowest LT_{50} value was found at higher concentrations and visa versa. In addition, larval mortality was also increased with increasing concentrations of *Sl*NPV irrespective of the host plants. Moreover, Morris (1971) reported that LT_{50} increased with prolonged exposure of NPV to sunlight. The LT_{50} was recorded high in lower concentration. Inverse relation was noticed between concentration of inoculum dose and LT_{50}. Even the LT_{50} value varied among the host plants at the same concentration of inoculation. The mortality of *S. litura* showed that groundnut was most preferred host, which helps to complete the larval stage early at the same time the larvae feeding on it were heavier, healthier occupying high biomass, followed by cabbage, potato, cotton and rose. The other host like rose proves worst i.e., larvae has taken longer duration compare to groundnut for development. This implicates that the host plant of insect herbivores as a significant determinant in their susceptibility to disease (Hare and Andreadis 1983; Jones 1983; Schultz 1983; Noguchi and Yamaguchi 1984; Ramoska and Todd 1985; Feath and Bultman 1986; Keating and Yendol 1987; Richter *et al*. 1987; Barbosa 1988 and Shepard and Dahlman 1988). The percent larval mortality was found to be decreased with decreasing dose of inoculation. The trend of larval mortality continues to be same in all concentrations i.e., highest on groundnut followed by cabbage, potato, cotton and lowest on rose. In general the mortality of the larvae increased with increase in dose. The finding about the susceptibility of the larvae to NPV is in keeping with the findings of Ignoffo (1965a), Magnoler (1975), Narayan *et al*. 1978, Bakwad 1979 and Khare 1985. Anuradha (1991) and Kamala Jayanthi (1992) reported that larval mortality decreased with decrease in NPV concentration and with the increasing age of the larvae of *S. litura*.

Interestingly in case of potato, tomato and sunflower the infectivity of *SI*NPV was low, this may be due to the presence of trichomes or hairs on these plants. Percent larval mortality recorded on different host plants at various concentrations of *SI*NPV shows that, the larval mortality was increasing with increasing dose of inoculation. The highest mortality was recorded on groundnut at the concentration of 1×10^6 POB per ml. While the lowest on rose. It may be due to the alkaline leaf surface exudates, which inactivated the *SI*NPV, as noticed in *Heliothis* NPV (Falcon 1971; Young and Yearian 1974). The difference in mortalities may largely be attributed to differences in feeding rates.

6. SUMMARY AND CONCLUSION:

Spodoptera litura Fabricius (Lepidoptera: Noctuidae), the tobacco caterpillar is a polyphagous pest attacking 65 plant species belonging to 22 families. *S. litura* has developed resistance to several organic pesticides resulting severe crop losses. Fortunately, the pest is highly susceptible to its nucleopolyhedrovirus (NPV) of Baculoviridae and has established history of use as biopesticide due to its high virulence, high specificity, non-polluting nature and it can be applied to crops using conventional equipments designed for chemical insecticides. With growing interest in integrated approach to pest management, baculoviruses are being increasingly adopted and are currently produced on a commercial scale and applied to larger areas of different crops, and studies have shown that the virus can be used effectively as biopesticide in the field.

Literature related to *Spodoptera litura* and influence of host plants on the efficacy of nucleopolyhedrovirus of *S. litura* collected from the journals, e-journals, CAB PEST ROM and biological abstracts has been reviewed.

Spodoptera litura larvae were collected from the castor (*Ricinus communis* L.) fields in and around Rajanukunte area, Bangalore Rural district during the flush seasons, and mass reared on semi synthetic diet in the laboratory. To undertake studies on *Sl*NPV, a sufficient stock culture of NPV was maintained in the laboratory. For this purpose, the NPV of S. *litura* was propagated in early fifth instar of *S. litura* larvae. The dose of 1×10^7 POB's/ml was found optimum for the laboratory studies. Use of appropriate dose of NPV is important for successful biological

control of pests. It is therefore, very essential to ascertain the strength of the NPV in the suspension before it is applied. The concentrations of the polyhedra were estimated with the help of a double ruled improved Neubauer haemocytometer of depth factor 0.1 mm (Weber, England) under a phase contrast microscope.

REFERENCES:

1. Abbott WS (1925) A method of computing the effectiveness of an insecticide. J Econ Entomol 18:265–267
2. Ahmad JN, Mushtaq R, Ahmad SJN, Maqsood S, Ahuja I, Bones AM (2018) Molecular identification and pathological characteristics of NPV isolated from *Spodoptera litura* (Fabricius) in Pakistan. Pak J Zool 50:2229–2237
3. Ahmad M, Mehmood R (2015) Monitoring of resistance to new chemistry insecticides in *Spodoptera litura* (Lepidoptera: Noctuidae) in Pakistan. J Econ Entomol 108(3):1279–1288
4. Ali H, Hou Y, Tang B, Shi Z, Muhammad A, Sanda NB (2016) A way of reproductive manipulation and biology of *Wolbachia pipientis*. J Exp Biol Agric Sci 4(2):156–168
5. Arif M, Islam SU, Adnan M, Anwar M, Ali H, Wu Z (2018) Recent progress on gene silencing/suppression by virus-derived small interfering RNAs in rice viruses especially Rice grassy stunt virus. Microb Pathog 125:210–218
6. Arrizubieta M, Simón O, Torres-Vila LM, Figueiredo E, Mendiola J, Mexia A, Caballero P, Williams T (2016) Insecticidal efficacy and persistence of a co-occluded binary mixture of *Helicoverpa armigera* n0ucleopolyhedro virus (Hear NPV) variants in protected and field-grown tomato crops on the Iberian Peninsula. Pest Manag Sci 72(4):660–670
7. Arti P, Yogita W (2014) Field compatibility of microbial pesticide SL NPV with synthetic pesticide Roket, Cypermethrin + Profenofos] against tobacco caterpillar Spodoptera litura [Fabricus]. Res J Pharm Biol Chem Sci (2)4:767
8. Aydin MH, Gurkan MO (2006) The efficacy of Spinosad on different strains of *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae). Turkish J Biol 30:5–9
9. Ayyub MB, Nawaz A, Arif MJ, Amrao L (2019) Individual and combined impact of nuclear polyhedrosis virus and spinosad to control the tropical armyworm, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae), in cotton in Pakistan. Egypt J Biol Pest Control 29(67):1–6
10. Bala NS, Muhammad A, Ali H, Hou Y (2018) Entomopathogenic nematode *Steinernema carpocapsae* surpasses the cellular immune responses of the hispid beetle, *Octodonta nipae* (Coleoptera: Chrysomelidae). Microb Pathog 124:337–345
11. Cory JS, Myers JH (2003) The ecology and evolution of insect baculoviruses. Annu Rev Ecol Evol Syst 34:239–272
12. El-Helaly AA, El-bendary HM (2013) Impact of Spinosad and Nucleopolyhedrosis virus alone and in combination against the cotton leaf worm *Spodoptera littoralis* under laboratory. App Sci Rep 2(1):17–21
13. Gao C, Bei Y, Chen T, Gu X (2004) On factors causing outbreak of *Spodoptera litura* (Fabricius). Acta Agri Zhejiangensis 16:332–335
14. Hu Z, Chen X, Sun X (2003) Molecular Biology of Insect Viruses. A review. Adv Microb Control Insect Pests:83–107
15. Jansson RK, Peterson RF, Mookerjee PK, Halliday WR, Argentine JA, Dybas RA (1997) Development of a novel soluble granule formulation of emamectin benzoate for control of Lepidopterous pests. Flo Entomol 80:425–442
16. Ma X, Liu X, Ning X, Zhang B, Han F, Guan X, Tan Y, Zhang Q (2008) Effects of *Bacillus thuringiensis* toxin Cry1Ac and *Beauveria bassiana* on Asiatic corn borer (Lepidoptera: Crambidae). J Invert Pathol 99:123–128
17. Maqsood S, Afzal M, Haider MS, Khan HAA, Ali M, Ashfaq M, Aqueel MA, Ullah MI (2019) Effectiveness of uuclear polyhedrosis virus and *Bacillus thuringiensis* alone and in combination against *Spodoptera litura* (Fabricius). Pak J Zool 51(2):631–641