Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; Sp 9(4): 86-90
Received: 18-05-2020
Accepted: 20-06-2020

Raghavendra SM
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Mirgund, Srinagar, Jammu and Kashmir, India

KA Sahaf
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Mirgund, Srinagar, Jammu and Kashmir, India

NA Ganaie
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Mirgund, Srinagar, Jammu and Kashmir, India

Somagaini Pavankumar
Division of Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu and Kashmir, India

Prithiv Raj V
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Nayeema Jan
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Mirgund, Srinagar, Jammu and Kashmir, India

Corresponding Author:
Raghavendra SM
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Mirgund, Srinagar, Jammu and Kashmir, India

Assessing the impact of nuclear polyhedrosis virus (Grasserie) on economic traits of bivoltine silkworm (*Bombyx mori* L.) breeds under temperate climatic conditions

Raghavendra SM, KA Sahaf, NA Ganaie, Somagaini Pavankumar, Prithiv Raj V and Nayeema Jan

Abstract
The present investigation was carried out to assess the impact of nuclear polyhedrosis virus (Grasserie) on economic traits of bivoltine silkworm (*Bombyx mori* L.) breeds under temperate climatic conditions. Ten mature larval weight was recorded (40.9g) in case of SANISH8 and it was minimum (35.6g) in APS4. Among the cocoon traits SH_6 recorded the maximum cocoon weight of 1.49g, NB_4D_2 recorded highest shell weight of 0.30g and shell ratio of 20.12 per cent. However in susceptible breed cocoon traits found minimum cocoon weight of 1.38 g (CSR_4), shell weight of 0.26 g (APS_4) and shell ratio of 18.56 per cent (APS_4). Breeds which were less susceptible to BmNPV *viz*., NB_4D_2 and APS_8 yields more cocoons by weight. Among the improved breeds of silkworm the average filament length, filament size and raw silk were found significantly in BmNPV inoculated. However, the maximum average filament length of 816 m (DUN-6), filament size of 2.61 (DUN-22) and raw silk of 29.17% (DUN-6) was noticed. However, in susceptible breeds average filament length of 709 m (APS_4), filament size of 2.28 (APS_4) and raw silk of 24.58% (CSR_2). Genotypes APS_8 and NB_4D_2 has showing better economic characters as compared to other silkworm genotypes.

Keywords: BmNPV, *Bombyx mori* L., Grasserie and Nuclear Polyhedrosis virus

Introduction
Sericulture is one of the oldest agro-based industries in the world. It is commonly rural based on-farm and off-farm activity and has huge employment generation potential. Sericulture has been perceived as one of the most suitable avenue for socio-economic development especially in a developing nation like India particularly for farmers with little land possessions as well as to other weaker section of the society. Sericulture in India has ended up being an exceptionally profitable money crop which gives alluring returns consistently. India ranks second in respect of mulberry raw silk production being next only to china. Mulberry silk accounts for 70.1 per cent (21,273 MT), tasar silk 10.8 per cent (3,268 MT), eri silk 18.6 per cent (5,637 MT) and muga silk 0.56 per cent (170 MT) of the total raw silk production of 30,348 MT (Anonymous, 2017) [1]. Sericulture occupies a unique position in Indian economy and assumes more importance in alleviating the problems of the rural people. Since it is practiced from days of hore, it has now become the most significant rural industry due to its low investment, maximum employment generation and quick turn over. Jammu and Kashmir is the traditional sericulture state of India and is practiced in 20 districts. The cocoon and the raw silk production in J&K during 2016-2017 have been 973 MT and 145 MT respectively (Anonymous, 2017) [1]. Presently, about 30,000 rural families are directly or indirectly associated with the silk industry.

The successful cocoon crops are highly dependent on several factors *viz*., nutritional status, silkworm breed, rearing technology employed, environmental factors during rearing, the latter contributing considerably to the cocoon crop. The major problems faced by the silk industry are frequent disease outbreaks since most of the commercially reared silkworm species, including *Bombyx mori*, are highly susceptible to the diseases like pebrine, flacherie, grasserie and muscardine. In India approximately 40 percent crop losses are attributed to these diseases (Sheebarajakumari *et al.*, 2007; Subha Rao *et al.*, 1991) [9, 12]. Among the diseases, viral diseases are most commonly occurring diseases (Samson *et al*., 1990) [7]. The virus formerly known as *Borrelina bombycis* is presently termed as *Bombyx mori* L. nuclear polyhedrosis virus (BmNPV). This disease is caused by an occluded baculovirus. The nuclear polyhedrosis of silkworm is commonly known as 'Grasserie' disease (French).

The names indicate either the yellowish colour of diseased insect or its swollen fat like appearance. Infection with grasserie, the worms show the symptoms of shiny body, aimless crawling, inter-segmental swelling, white fluid coming out after skin rupture and dead worms hanging from the rearing stands and trays.

Grasserie disease usually affects fourth and fifth instars silkworms under natural conditions (Chitra *et al.*, 1975) [2]. If the infection is noticed during early instars, worms fail to spin cocoons and die, but worms can spin the cocoons and die inside producing melted cocoons, if infection occurs during later instars. *Bombyx mori* nuclear polyhedrosis virus (BmNPV) is prevalent during all the rearing seasons. The silkworms infected by BmNPV show symptoms at the advanced stage of development and by that time the larvae have almost completed the feeding period, consuming the entire quantum of leaves and dies within a day or two. In India the loss due to BmNPV has been accounted for to the extent of 20-50 per cent in commercial sericulture (Samson *et al.*, 1990) [7]. Rearing of bivoltine breeds and hybrids increase both quantity and quality of raw silk production however, these silkworm breeds are more susceptible to Grasserie as compared to multivoltine breeds (Sivaprakasam and Rabindra, 1995; Liushixian, 1984) [11, 5]. Obviously this causes a big constraint for the successful adoption of bivoltine sericulture in a tropical country like India. Need was felt to identify silkworm breeds tolerant to BmNPV before taking up any breeding programme, specifically for evolving BmNPV tolerant breeds. Therefore, it would be essential to assess the susceptibility status of the available silkworm breeds against BmNPV. Hence, keeping in view the economic importance of silkworm breeds and magnitude of impact caused by nuclear polyhedrosis virus, the present study was proposed.

Materials and Methods

Investigations were made during spring, 2017 to assess the impact of nuclear polyhedrosis virus (Grasserie) on economic traits of bivoltine silkworm (*Bombyx mori* L.) breeds in College of Temperate Sericulture, SKUAST-Kashmir, Mirgund. The experiment comprised of ten treatments (10 silkworm genotypes) (Table-1) and design of the experiment was completely randomized design (CRD) with each treatment replicated thrice. The DFL's of breeds were surface sterilized and eggs are incubated at 25±1ºC and 75±5% relative humidity. After hatching, the larvae of all breeds were reared up to third instar by following standard rearing practices and then separated into replications of 200 worms each for imposing the treatments. After preparation of BmNPV inoculum, the inoculation was carried out per orally by feeding silkworm with virus suspension on leaf.

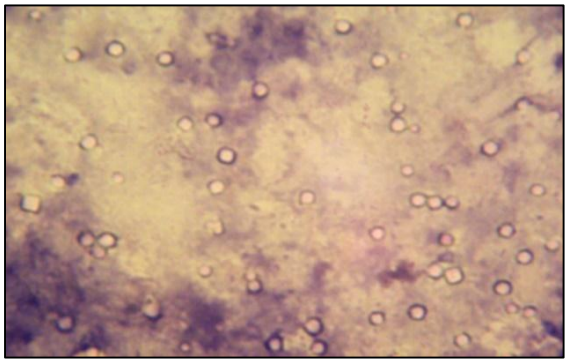

Fig 1.

Polyhedral bodies causing viral disease (Grasserie) of Silkworm (*Bombyx mori*)

The larvae were allowed to feed on the treated leaves for 16 hrs and subsequently fed with untreated mulberry leaves. Survived larvae were reared till cocooning and mounted for spinning. The cocoons were harvested on 6th day of spinning and assessed on 7th day for economic parameters. All these data's were subjected to statistical analysis. The materials used and the techniques employed are presented below:

Table 1: Treatment details of economic trait assessment of different bivoltine silkworm breeds against nuclear polyhedrosis virus

Treatments	Silkworm genotype
T_1	APS-4
T_2	APS-8
T_3	CS-6
T_4	CSR-2
T_5	CSR-4
T_6	DUN-6
T_7	DUN-22
T_8	NB4D2
T_9	SH-6
T_{10}	SANISH-8

Economic trait assessment parameters

Fifth instar larval duration (hours), total larval duration (hours), average larval weight, single cocoon weight (g), single shell weight (g), shell ratio (%), ERR by number & weight, filament length, filament size and raw silk (%).

Fig 2: Larvae of different genotypes of silkworm (*Bombyx mori* L.) breeds

Result and Discussion

Larval characters

Among the inoculated lot NB_4D_2 revealed least fifth instar duration of 173 hrs which was significantly different from rest of breeds (Table-2). Longest fifth instar duration was recorded in CSR_4 (221 hrs.). The maximum per cent increase over control of 16.58 was observed in CS_6, whereas minimum per cent increase over control of 3.46 was observed in NB_4D_2. Vijay-kumari *et al*. (2001) [13] have also reported prolongation in the larval period in fifth instar. NB_4D_2 revealed least total larval duration of 653 hrs which was significantly different from rest of breeds. Longest total larval duration was recorded in CSR_4 (701 hrs.). The maximum per cent increase over control of 4.75 was observed in CS_6, whereas minimum per cent increase over control of 0.91 was observed in NB_4D_2. The reason for prolongation of larval duration in the inoculated batches can be due to loss of feeding ability because of decreased digestive enzymes activity (Gururaj *et al.*, 1999) [3] and variation in hormone titers (Mikhailov *et al.*, 1992) [6]. The average larval weight of different breeds under study ranged from 35.6 g to 40.9 g. Among the inoculated silkworm breeds, $SANISH_8$ recorded the maximum larval weight of 40.9 g, followed by CSR_4 (40.7 g) and NB_4D_2 (40.5 g); whereas minimum larval weight of 35.6g was recorded in APS_4. The maximum per cent decrease over control of 9.41 was observed in APS_4, whereas minimum per cent decrease over control of 0.48 was observed in CSR_4. Horic and Watanabe (1980) [14] has also reported that under BmNPV infection larval weight gets reduced due to the accumulation of body substances, depletion of fuel reserves such as haemolymph, trehalose, fat bodies and glycogen.

Single cocoon weight (g)

The single cocoon weight of different breeds under investigation ranged from 1.38 g to 1.50 g (Table-3). Among the inoculated silkworm breeds, SH_6 recorded the maximum single cocoon weight of 1.50 g, followed by $SANISH_8$ (1.49 g), DUN-22 (1.47 g), NB_4D_2 (1.47 g), CSR_2 (1.45 g), CS_6 (1.43 g), DUN-6 (1.43 g) APS_4 (1.42 g) and APS_8 (1.42 g), while least single cocoon weight of 1.38 g recorded in CSR_4. This reduction in cocoon weight in BmNPV infected silkworms has been attributed to diminish in total proteins at the later phase of infection (Watanbe and Kobayashi, 1969). The control batches maintained for each breed showed higher single cocoon weight (g) in contrast to the inoculated breeds. The maximum per cent decline over control of 7.38 was observed in CSR_4, while least per cent decrease over control of 0.66 was noticed in $SANISH_8$.

Table 2: Effect of BmNPV infection on the larval characters of different breeds of silkworm, *Bombyx mori* L.

Genotypes	Fifth instar larval duration (hours)			Total larval duration (hours)			Average larval weight (g)		
	Inoculated	Control	Percent increase over control	Inoculated	Control	Percent increase over control	Inoculated	Control	Percent decrease over control
APS_4	204	191	6.37	684	671	1.90	35.6	39.3	9.41
APS_8	178	161	9.55	658	641	2.58	35.8	38.0	5.78
CS_6	193	161	16.58	673	641	4.75	38.8	40.5	4.19
CSR_2	202	194	3.96	682	674	1.17	38.7	40.5	4.44
CSR_4	221	197	10.8	701	677	3.42	40.7	40.9	0.48
DUN-6	190	181	4.73	670	661	1.34	39.3	41.0	4.14
DUN-22	202	191	5.44	682	671	1.61	39.1	40.6	3.69
NB_4D_2	173	167	3.46	653	647	0.91	40.5	41.2	1.69
SH_6	196	171	12.75	676	651	3.69	38.5	40.6	5.17
$SANISH_8$	192	169	11.9	672	649	3.42	40.9	45.8	10.06
Mean	195	178		675	657		38.9	40.8	
SEm±	4.12	1.0		3.08	1.0		0.80	0.6	
CD at 5%	12.52	2.9		9.17	2.9		2.38	1.8	

Single shell weight (g)

The single shell weight of different breeds under study ranged from 0.26 g to 0.30 g. Among the inoculated silkworm breeds, NB_4D_2 recorded the maximum single shell weight of 0.30 g, followed by DUN-6 (0.29 g), SH_6 (0.29 g), $SANISH_8$ (0.29 g), APS_8 (0.28 g), CS_6 (0.28 g), CSR_2 (0.28 g), CSR_4 (0.28 g) and DUN-22 (0.28 g), whereas minimum single shell weight of 0.26 g in (APS_4). The control batches maintained for each breed showed higher single shell weight (g) in comparison to the inoculated breeds. The maximum per cent decrease over control of 9.67 was observed in CSR_4, whereas minimum per cent decrease over control of 3.22 was observed in NB_4D_2 (Table 3).

Shell ratio (%)

The shell ratio of different silkworm breeds ranged from 18.56 to 20.12 per cent. Among the inoculated silkworm breeds NB_4D_2 recorded the maximum shell ratio of 20.12 per cent, followed by $SANISH_8$ (19.88%), CSR_4 (19.83%), SH_6 (19.78%), APS_8 (19.65%), CS_6 (19.44%), CSR_2 (19.24%), DUN-22 (19.22%) and DUN-6 (18.80%), whereas minimum shell ratio of 18.56 per cent in APS_4. The control batches maintained for each breed showed higher shell ratio in comparison to the inoculated breeds. The maximum per cent decrease over control of 6.83 was observed in DUN-6, whereas minimum per cent decrease over control of 0.31 was observed in CSR_2 (Table-3). The present findings are in corroboration with the earlier findings on the effect on shell ratio (Satish and Govindan, 1988) [8].

Cocoon yield by number per 10,000 larvae

The cocoon yield by number per 10,000 larvae of different breeds ranged from 3733 to 7267 (Table-4). Among the inoculated silkworm breeds, APS_8 recorded the maximum cocoon yield by number per 10,000 larvae of (7267), followed by NB_4D_2 (6767), SH_6 (6167), CS_6 (5867), $SANISH_8$ (5433), DUN-6 (5333), DUN-22 (4633), APS_4 (4500) and CSR_2 (4067), while least cocoon yield by number per 10,000 larvae of 3733 in CSR_4. The control batches maintained for each breed showed higher cocoon yield by number per 10,000 larvae in contrast to the inoculated breeds. The maximum per cent decrease over control of 53.72 was observed in CSR_4, whereas minimum per cent decrease over control of 22.13 was observed in APS_8. Sidhu and Singh, (1968) [10] reported that multivoltine breeds yield more number of cocoons than bivoltine breeds at moderate levels of BmNPV infections.

Table 3: Effect of BmNPV infection on the single cocoon weight, single shell weight and shell ratio of different breeds of silkworm, *Bombyx mori* L.

Genotypes	Single cocoon weight (g)			Single shell weight (g)			Shell ratio (%)		
	Inoculated	Control	Per cent decrease over control	Inoculated	Control	Per cent decrease over control	Inoculated	Control	Per cent decrease over control
APS_4	1.42	1.44	1.38	0.26	0.28	7.14	18.56 (4.42)	19.67 (4.54)	5.64
APS_8	1.42	1.48	4.05	0.28	0.30	6.66	19.65 (4.54)	20.63 (4.65)	4.75
CS_6	1.43	1.47	2.72	0.28	0.30	6.66	19.44 (4.52)	20.23 (4.68)	3.90
CSR_2	1.45	1.49	2.68	0.28	0.29	3.44	19.24 (4.50)	19.30 (4.53)	0.31
CSR_4	1.38	1.49	7.38	0.28	0.31	9.67	19.83 (4.54)	21.07 (4.69)	5.88
DUN-6	1.43	1.47	2.72	0.29	0.30	3.33	18.80 (4.44)	20.18 (4.68)	6.83
DUN-22	1.47	1.48	0.67	0.28	0.29	3.44	19.22 (4.49)	19.86 (4.56)	3.22
NB_4D_2	1.47	1.48	0.67	0.30	0.31	3.22	20.12 (4.66)	20.99 (4.68)	4.14
SH_6	1.50	1.53	1.96	0.29	0.32	9.37	19.78 (4.55)	20.70 (4.65)	4.44
$SANISH_8$	1.49	1.50	0.66	0.29	0.30	3.33	19.88 (4.44)	20.00 (4.58)	0.60
Mean	1.45	1.48		0.28	0.30		19.39	20.26	
SEm±	0.019	0.014		0.007	0.005		0.024	0.033	
CD at 5%	0.056	0.042		0.021	0.016		0.070	0.099	

Cocoon yield by weight per 10,000 larvae (kg)

The cocoon yield by weight per 10,000 larvae of different breeds under investigation ranged from 5.37 kg to 10.53 kg. Among the inoculated silkworm breeds, APS_8 recorded the maximum cocoon yield by weight per 10,000 larvae 10.53 kg, followed by SH_6 (9.70 kg), NB_4D_2 (9.61 kg), DUN-6 (9.13 kg), CS_6 (8.53 kg), $SANISH_8$ (7.88 kg), DUN-22 (6.27 kg), APS_4 (6.14 kg) and CSR_2 (5.51 kg), whereas minimum cocoon yield by weight per 10,000 larvae of 5.37 kg in CSR_4. The control batches maintained for each breed showed higher cocoon yield by weight per 10,000 larvae, in comparison to the inoculated breeds. The maximum per cent decrease over control of 55.61 was observed in CSR_4, whereas minimum per cent decrease over control of 23.91 was observed in DUN-6 (Table-4).

Table 4: Effect of BmNPV infection on the cocoon yield by number and by weight of different breeds of silkworm, *Bombyx mori* L.

Genotypes	Cocoon yield/10,000 larvae by number			Cocoon yield/10,000 larvae by weight (kg)		
	Inoculated	Control	Per cent decrease over control	Inoculated	Control	Per cent decrease over control
APS_4	4500	8400	46.42	6.14	12.1	49.25
APS_8	7267	9333	22.13	10.53	14.5	27.37
CS_6	5867	8233	28.73	8.53	11.8	27.71
CSR_2	4067	8267	50.80	5.51	11.9	53.69
CSR_4	3733	8067	53.72	5.37	12.1	55.61
DUN-6	5333	8433	36.76	9.13	12.0	23.91
DUN-22	4633	8433	45.06	6.27	12.2	48.60
NB_4D_2	6767	9467	28.52	9.61	13.9	30.86
SH_6	6167	8467	27.16	9.70	13.2	26.51
$SANISH_8$	5433	8233	34.00	7.88	12.4	36.45
Mean	5377	8533		7.87	12.6	
SEm±	175.11	154.9		0.45	0.31	
CD at 5%	520.23	460.2		1.36	0.92	

Figures in parenthesis are arc-sine transformed values

Average filament length (m)

The average filament length of different breeds ranged from 709 m to 816 m. Among the inoculated silkworm breeds, DUN-6 recorded the maximum average filament length of 816 m, followed by $SANISH_8$ (783 m), DUN-22 (772 m), CSR_2 (768 m), SH_6 (759 m), NB_4D_2 (755 m), APS_8 (747 m), CS_6 (733 m) and CSR_4 (724 m), while least average filament length of 709 m was observed in APS_4. The control batches maintained for each breed showed higher average filament length in comparison to the inoculated breeds. The maximum per cent decrease over control of 9.79 was observed in APS_4, whereas minimum per cent decrease over control of 0.48 was observed in DUN-6 (Table-5).

Filament size (d)

The filament size of different breeds under evaluation ranged from 2.28 to 2.61 (Table-5). Among the inoculated silkworm breeds DUN-22 recorded the maximum denier of 2.61, followed by CSR_2 (2.56), CS_6 (2.54), DUN-6 (2.52), SH_6 (2.48), $SANISH_8$ (2.48), NB_4D_2 (2.34), APS_8 (2.33) and CSR_4 (2.32), whereas minimum denier of 2.28 in APS_4. The control batches maintained for each breed showed higher denier in comparison to the inoculated breeds. The maximum per cent decrease over control of 8.62 was observed in APS_8, whereas minimum per cent decrease over control of 2.24 was observed in DUN-22.

Raw silk (%)

Raw silk percentage of different breeds under study ranged from 24.58 to 29.17 per cent. Among the inoculated silkworm breeds DUN-6 recorded the maximum raw silk of 29.17 per cent, followed by CS_6 (28.82%), DUN-22 (28.53%), NB_4D_2 (28.39%), SH_6 (26.50%), $SANISH_8$ (26.39%), APS_4 (26.37%) CSR_4 (26.35%) and APS_8 (25.89%), whereas minimum raw silk percentage of 24.58 per cent in CSR_2. The control batches maintained for each breed showed significant raw silk percentage in comparison to the inoculated breeds. The maximum per cent decrease over control of 17.18 was observed in CSR_2, whereas minimum per cent decrease over control of 1.24 was observed in DUN-22 (Table-5).

Table 5: Effect of BmNPV infection on the average filament length, filament size and raw silk of different breeds of silkworm, *Bombyx mori* L.

Genotypes	Average filament length (m)			Filament size (d)			Raw silk (%)		
	Inoculated	Control	Per cent decrease over control	Inoculated	Control	Per cent decrease over control	Inoculated	Control	Per cent decrease over control
APS_4	709	786	9.79	2.28	2.43	6.17	26.37 (5.23)	29.61 (5.53)	10.94
APS_8	747	775	3.61	2.33	2.55	8.62	25.89 (5.18)	27.58 (5.34)	6.12
CS_6	733	747	1.87	2.54	2.70	5.92	28.82 (5.46)	29.39 (5.51)	1.93
CSR_2	768	773	0.64	2.56	2.62	2.29	24.58 (5.05)	29.68 (5.35)	17.18
CSR_4	724	735	1.49	2.32	2.44	4.91	26.35 (5.22)	29.17 (5.49)	9.66
DUN-6	816	820	0.48	2.52	2.58	2.32	29.17 (5.49)	30.04 (5.57)	2.89
DUN-22	772	784	1.53	2.61	2.67	2.24	28.53 (5.43)	28.89 (5.46)	1.24
NB_4D_2	755	768	1.69	2.34	2.52	7.14	28.39 (5.42)	30.08 (5.57)	5.61
SH_6	759	764	0.65	2.48	2.68	7.46	26.50 (5.24)	27.56 (5.34)	3.84
$SANISH_8$	783	805	2.73	2.48	2.67	7.11	26.39 (5.23)	29.25 (5.49)	9.77
Mean	757	782		2.45	2.59		27.10	28.93	
SEm±	1.101	1.265		0.032	0.057		0.038	0.019	
CD at 5%	3.269	3.758		0.094	0.171		0.114	0.116	

Figures in parenthesis are square root transformed values

References

1. Anonymous. Functioning of Central Silk Board and Performance of Indian Silk Industry. Central Silk Board, 2017, 23-27.
2. Chitra C, Karanth NG, Vasantharajan VN. Diseases of mulberry silkworm, *Bombyx mori* L. Journal of Scientific and industrial Research. 1975; 34(1):386-401.
3. Gururaju CS, Sekarappa BM, Sarangi SK. Effect of BmNPV infection on the digestive enzyme activity in the silkworm. Indian Journal of Sericulture. 1999; 38(2):102-106.
4. Horie Y, Watanabe H. Recent advances in sericulture. Annual Review of Entomology. 1980; 25:49-71.
5. Liushixian. Identification on the resistance of silkworm (*Bombyx mori* L.) race to six type of silkworm diseases. *Sericologia.* 1984; 24(3): 377-382.
6. Mikhailov VS, Zemskov FA, Abramova EB. Protein synthesis in pupae of silkworm (*Bombyx mori* L.) after infection with nuclear polyhedrosis virus: resistance to viral infection acquired during pupal period. Journal of General Virology. 1992; 73(2):3195-3202.
7. Samson MV, Baig M, Sharma SD, Balavenkatasubbaiah M, Sasidharan TO *et al*. Survey on the relative incidence of silkworm disease in Karnataka, India. Indian Journal of Sericulture. 1990; 29(2):248-254.
8. Sathish G, Govindan R. Effect of starvation and nuclear polyhedrosis virus infection in *Bombyx mori* L. on cocoon and post-cocoon stages, Indian Journal of Sericulture. 1988; 27(2):138-144.
9. Sheebarajakumari DV, Padmalata CS, Das SM, Ranjitsingh, AJA. Efficacy of probiotic and neutratical feed supplements against Flacherie disease in mulberry silkworm, *Bombyx mori* L. Indian Journal of Sericulture. 2007; 46:179-182.
10. Sidhu NS, Singh K. Studies on polyhedrosis in silkworm, *bombyx mori* L. Indian Journal of Sericulture. 1968; 7:1-5
11. Sivaprakasam N, Rabindra RJ. Incidence of Grasserie in silkworm, *Bombyx mori* L. in selected districts of Tamil Nadu. Indian Journal of Sericulture. 1995; 34(2):100-104.
12. Subha Rao G, Chandra AK, Bhattachary J. Incidence of crop loss from adopted rearers levels in west Bengal due to silkworm diseases. Indian Journal of Sericulture. 1991; 30(2):167.
13. Vijay-Kumari KM, Balavenkatasubaiah MT, Rajan RK, Himantraj MT, Nataraju B, Rekha M *et al*. Influence of temperature and relative humidity on the rearing performance and disease incidence in CSR hybrid silkworm, *Bombyx mori* L. International Journal of Industrial Entomology. 2001; 3(2):113-116.
14. Watanabe H, Kobayashi M. Effect of virus infection on the protein synthesis in the silkworm, *Bombyx mori* L. infected with nuclear and cytoplasmic polyhedrosis virus. Japanese Journal of Applied Entomology and Zoology. 1969; 15:198- 202.