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EFFECT OF BOTANICAL TREATMENT TO *BM* NPV POLYHEDRAL BODIES ON COCOON PARAMETERS OF SILKWORM *B.MORI* (PM x CSR_2)

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ABSTRACT
The study on the "Effect of medicinal plant extract treatment on *Bm*NPV polyhedra was undertaken in the Department of Sericulture UAS, GKVK, Bangalore-65. The treated polyhedral bodies with aqueous extracts of different medicinal plants *viz*., *Adathoda vasica, Bougainvillea spectabilis, Phyllanthus niruri, Terminalia arjuna* and *Pongamia glabra* administered to silkworm through mulberry leaves once during fourth and fifth instar larvae of PMxCSR_2 revealed positive response on cocoon weight, shell weight, shell percentage and silk productivity. However *P. niruri* recorded higher cocoon, shell weights (1.59 and 1.65; 0.264 and 0.284) compare to control. The higher shell percentage of 16.51 and 17.20 %; were observed in *P. niruri* administered lots (10^{-3}) and lowest of 14.45 and 15.95 %; was recorded for *P. glabra* (0 h). The shell percentage and silk productivity of PMxCSR_2 administered with different hours of botanical treatment to *Bm*NPV resulted significant change. However, maximum shell percentage and silk productivity of 17.36and 17.69 per cent; 3.08 and 3.27 cg/day and minimum of 14.99 and 16.03 per cent; 2.27and 2.78 cg/day were encountered for *P. niruri* and *P. glabra* at 7 h treated lots of fourth and fifth instar respectively followed by, *B. spectabilis*, *T. arjuna*, and *A. vasica*.

Key words: Botanical extracts, *Bm* NPV, Cocoon parameters and Silk productivity

INTRODUCTION

Sericulture is an important agro based cottage industry contributing more to the small and marginal farmers giving regular income throughout the year. However, due to continuous rearing of mulberry silkworms, become highly susceptible to various diseases which accounts for 30-40 per cent loss in the cocoon yield (Chandrasekharan *et al.,* 2006). Among diseases grasserie, a viral disease caused by nuclear polyhedrosis virus (*Bm*NPV) is considered as the most serious disease in tropical countries due to its prevalence throughout the year (Sivaprakasam, 1999). Management of silkworm diseases is one of the vital components of successful silkworm rearing for obtaining higher cocoon yield and quality. Among the various methods, use of bed disinfectants in silkworm rearing leaving residual effect in the rearing house and environment. This will intern alter the physiology of silkworm to minimize this residual effect, use of plant molecules is an appropriate means of minimizing residual effect and the spread of the disease which are contagious like *Bm*NPV. The biomolecules present in botanicals have both antimicrobial and antiviral properties which can be exploited through application in silkworm rearing. They also act as growth promoting factors indirectly help in reducing further spread of *Bm*NPV. Several botanicals experimented on *Bm*NPV revealed that, they have both the properties on silkworm rearing and disease management. (Gangadhar Murthy, 2004; Shubha, 2005; Sridevi, 2003; Rajasekhar Gouda, 1991; Manimegalai and Chandramohan, 2006). Further use of botanicals in silkworm rearing have antimicrobial property, non-toxic, biodegradable and non-pollutant, and serve as an alternate strategy to control diseases of silkworm. Keeping the above facts in view, an attempt was made to explore the possibility of using botanical extracts as an effective and preventive measure for grasserie disease of silkworm.

MATERIAL AND METHODS

Silkworm rearing

Silkworm rearing was carried out for bioassay studies in a properly disinfected ideal rearing house. Six days prior to hatching of eggs the rearing room and equipment's were cleaned, washed and properly disinfected with four per cent Formalin at the rate of 800 ml per $10m^2$ as suggested by Krishnaswami *et al.* (1973). Then the rooms were kept closed for two days for effective disinfection. Silkworm disease free layings (DFLS) were procured from Central Silk Board grainage, Madiwala. Experiments were conducted with silkworm cross breed, PM x CSR_2. They were disinfected with three per cent formalin to eliminate external contamination, then washed, shade dried and kept for incubation at 25 ± 1^0C and 75±5% RH standard black boxing treatment was given on ninth day to achieve uniform hatching of eggs. The hatched larvae were separated into two batches (one for healthy another for experimental lots). Mulberry leaves were collected from a well maintained M5 mulberry garden and fed to the worms. The standard rearing techniques were followed as recommended by Krishnaswami (1978).

Preparation of extract

The tender leaves of freshly collected plant material were washed with running water, shade dried then sterilized with 70 per cent alcohol. Extract was prepared by weight/volume basis (1:10 proportion). The crushed material was filtered through double layered cheese cloth and the filtrate was obtained and used as stock solution.

Method of application

The suitable age of leaf of 10x12 cm size leaf bits were prepared and washed in running water and sterilized by using cotton swab dipped in 70 per cent alcohol. The sterilized leaves were shade dried for five min, then 0.5ml of botanical extract was smeared on mulberry leaves on both the sides and fed to silkworms.

Schedule of treatment

To know the antiviral property of total phenols and tannins present in all the five botanicals were administered to first day of fourth and fifth instar larvae of $PMxCSR_2$. The influence of both the biomolecules was estimated based on the rearing, and cocoon parameters. 25 larvae in each replication were maintained throughout the experimentation (Shubha, 2005). During experimentation there were two batches were maintained one with botanical and another with virus

Efficacy of medicinal plant extracts on management of *Bm*NPV

Treatment details

T_1 : *Adathoda vasica* + *Bm*NPV

T_2 : *Bougainvillea spectabilis* + *Bm*NPV
T_3 : *Phyllanthus niruri* + *Bm*NPV
T_4 : *Terminalia arjuna* + *Bm*NPV
T_5 : *Pongamia glabra* + *Bm*NPV
T_6 : Water control

Design	**Factorial CRD**
No of treatments	6
No of viral dilution	2
No of replications	4
No of worms (replication)	25
Silkworm hybrid	PM x CSR_2

Each batch of larvae was introduced with botanicals along with 10^{-1} and 10^{-3} *Bm*NPV viral dilution. To know the antiviral activity of the botanicals the aqueous extract of botanical was prepared and 10^{-1} ($5.6x10^5$) and 10^{-3} ($3.6x10^7$) POBs/ml was treated at different hours *viz*., 0h, 3h, 5h and 7h. Each treated polyhedral concentration was introduced to 25 larvae of fourth and fifth instar as first feed. The remaining feeds were normal. Further as a control untreated batch was maintained.

Observations recorded

During experimentation the following cocoon parameters were recorded.

Cocoon weight (g)

Ten cocoons per replication were weighed on fifth day after cocoon formation.

shell weights (g)

Ten pupal and cocoon shells per replication were weighed and recorded.

Shell percentage (%)

Shell percentage was calculated as follows

$$\text{Shell percentage} = \frac{\text{Shell weight}}{\text{Cocoon weight}} \times 100$$

Silk productivity (cg/day)

The silk productivity was calculated using the following formula

$$\text{Silk productivity} = \frac{\text{Shell weight in centigrams}}{\text{Fifth instar larval duration in days}} \times 100$$

Statistical analysis:

The data was analyzed statistically using two factorial complete randomized designs (Sundarraj *et al*., 1972).

RESULTS

Cocoon weight (g) in fourth and fifth instar inoculation

The medicinal extract treatment to *Bm*NPV resulted additive effect on different cocoon parameters of fourth and fifth instar $PMxCSR_2$. Supplementation of aqueous extracts of different plants resulted in enhancement of cocoon weight of the both instars. However, the maximum cocoon weight was recorded for 7 h of botanical treatment with *Bm*NPV viral dilution of 10^{-1} and 10^{-3}. The highest cocoon weight of 1.61 and 1.66 g recorded in *P. niruri* followed by *B. spectabilis* (1.59 and 1.65 g), *T. arjuna* (1.57 and 1.64 g) and the effect due to *A. vasica* (1.56 & 1.64 g) and *P. glabra* (1.56 & 1.61 g) found in decreasing order. Water control lot has recorded cocoon weight of 1.64 & 1.66 g which was significantly more than that of other treatments. However, except 5 hours of treatment remaining hours (0, 3 and 7 h) of treatment and their interaction effect recorded non-significant results in fourth instar. Further, 3 and 7 h of treatment to *Bm*NPV recorded non-significant results in fifth instar treated batches. Where as in fourth instar the effect on all the cocoon parameters did not show any positive effect except cocoon weight of 5 hours treated polyhedral bodies. (Table.1)

Shell weight (g) & Shell percentage (%) in fourth instar

The laboratory data on the effect of medicinal extract treatment (0 to 7 h) and *Bm*NPV infection on shell weight revealed significant results. When *Bm*NPV treated with different botanical extracts and administered to fourth instar larvae of $PMxCSR_2$ showed positive response. Significantly higher shell weight of 0.254, 0.257, 0.266 and 0.280 g was recorded for 0, 3, 5 and 7 h *P. niruri* treated batches respectively. Among dilutions 10^{-3} *Bm*NPV was recorded higher shell weight which was ranging from 0.244 to 0.264 g which were more than 10^{-1} viral dilution. It is confirmed from the experimental data that, increased hour of treatment to *Bm*NPV recorded higher shell weight (Table 2). The effect was same on shell percentage of $PMxCSR_2$. Which was ranged from 16.70 to 17.36 per cent for *P. niruri* and 14.45 to 14.99 per cent for *P. glabra,* which shared minimum (0 h) and maximum (7 h) shell percentage respectively. However, the remaining botanicals *viz*., *B. spectabilis* (16.08 to 16.77 %) *T. arjuna* (15.43 to 16.11 %) and *A. vasica* (14.80 to 15.36 %) recorded increased shell percentage from 0 to 7 h treatment and water control lots registered 18.22 % which was significantly more than that of botanical treatment (Table 2).

Shell weight (g) and shell percentage (%) on fifth instar administered

In-vivo effect of botanical treatment (0 to 7 h) to *Bm*NPV registered significant results on shell weight and shell percentage of $PMxCSR_2$. When *Bm*NPV treated with different botanical extracts and administered to fifth instar larvae showed positive response. Significantly higher shell weight and shell percentage of 0.276 g and 17.32 %; 0.280 g and 17.33 %; 0.283 g and 17.43 % and 0.293 g and

Silk productivity (cg/day)

Extrafoliation of different plant extracts registered significant results with respect to silk productivity. However, highest silk productivity was recorded in *P. niruri* 7 h treated and administered lots in both the instars (3.07 cg/day & 3.27 cg/day) followed by *B. spectabilis* (2. 91 cg/day & 3.09 cg/day), *T. arjuna* (2.72 cg/day & 3.06 cg/day) and *A. vasica* (2.35 cg/day & 2.98 cg/day) and *P. glabra* (2.27 cg/day & 2.78 cg/day). The water control lot recorded (3.30 cg/day & 3.47 cg/day). The increase hour of treatment to *Bm*NPV with botanicals has recorded increased silk productivity as it was reflected in the experimental data. The interaction effect due to hours of treatment and dilutions recorded non-significant results (Table 4).

DISCUSSION

Cocoon and shell weights (g)

The bioassay study on different hours of treatment to fourth and fifth instar inoculated with *Bm*NPV and medicinal plant extracts yielded significant results on cocoon and shell weights. However, the highest cocoon and shell weight of 1.61 and 0.280; 1.66 and 0.293 was recorded for 7 h of *P. niruri* and lowest of 1.46 and 0.211; 1.55 and 0.243 was recorded for *P. glabra* zero hour treated lots followed by *B. spectabilis*, *T. arjuna* and *A. vasica.* Among dilutions experimented, 10^{-3} was recorded higher cocoon and shell weights which was ranging from 1.52 to 1.59 and 0.244 to 0.264; 1.60 to 1.65 and 0.270 to 0.284 than 10^{-1} viral dilution (1.51 to 1.59 and 0.242 to 0.262; 1.57 to 1.64 and 0.265 to 0.282). It is confirmed from the experimental data that, increased hour of treatment to *Bm*NPV recorded higher cocoon and shell weights. The interaction effect was found non-significant. The same trend was observed even in pupal weight. This increased cocoon weight, pupal weight and shell weight in *P. niruri* might be due to the presence of biochemical constituents like tannins and phenols which have the property of phagostimulant activity.

These experimental results are in the line with the findings of Manoharan (1996) when aqueous extract of *P. coryleifolia, T. terrestris, A. sumo, C. coriaria* and Bougainvillea antiviral protein administered to $PMxNB_4D_2$ resulted increase in mean cocoon weight from 1.5 to 1.68g; shell weight from 0.28 to 0.312g compare to control (1.45 and 0.280g) this seems to be due to dual role in offering protection against *Bm*NPV as well as enhancing silk yield and quality. Further, Sivaprakasam *et al*. (1998) who documented that, when Bougainvillea antiviral protein purified from *B. spectabilis* was introduced to PMxNB4D2 cross breed resulted in offering protection against *Bm*NPV as well as enhancing silk yield and quality. Further, when *P. coryleifolia* and *Plectranthus ambionicus* were

17.69 % were recorded for 0, 3, 5 and 7 h of *P. niruri* treated batches, respectively. Among dilutions, 10^{-3} *Bm*NPV was recorded higher shell weight and shell percentage which was ranging from 0.270 to 0. 284 g and 16.86 to 17.20 % than that of 10^{-1} viral dilution (0.265 to 0.282 g and 16.78 to 17.14 %). It is confirmed from the experimental data that, increased hour of treatment to *Bm*NPV recorded higher shell weight and shell percentage of PM x CSR_2 (Table 3).

administered, they noticed an increased shell weight and shell ratio in the treated larvae than control. As reflected in the present study that, 0 to 7 h treated *Bm*NPV with *B. spectabilis* (16.08 to 16.77; 16.84 to 17.27 per cent) also revealed same trend.

Shell percentage (%) and silk productivity (cg/day)

The shell percentage and silk productivity of $PMxCSR_2$ administered with different hours of botanical treatment to *Bm*NPV resulted significant change. However, maximum shell percentage and silk productivity of 17.36 and 17.69 per cent; 3.07 and 3.26 cg/day and minimum of 14.99 and 16.03 per cent; 2.27and 2.78 cg/day were encountered for *P. niruri* and *P. glabra* 7 h treated lots of fourth and fifth instar, respectively followed by *B. spectabilis* (16.77 and 17.27 %; 2.91 and 3.09 cg/day), *T. arjuna* (16.11 and 16.94 %; 2.72 and 3.06 cg/day) and *A. vasica* (15.36 and 16.48 %; 2.35 and 2.98 cg/day). Even the trend was same in 10^{-1} (15.94 to 16.43 %; 16.78 to 17.14 cg/day) and 10^{-3} (15.95 to 16.51 %; 16.86 to 17.20 cg/day) administered lots respectively. As the duration of botanical treatment increased to *Bm*NPV there was an increase in shell percentage and silk productivity of fourth and fifth instar inoculated batches. The interaction effect of different hours of botanical treatment to *Bm*NPV did not show any change in shell percentage and silk productivity.

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TABLE 1: Effect of medicinal plant extracts and *Bm*NPV infection on cocoon weight (g) of PM × CSR_2

	Hours of treatment							
	cocoon weight (g)							
	Fourth instar				Fifth instar			
Dilutions/Treatments/Interactions	0 h	3 h	5 h	7 h	0 h	3 h	5 h	7 h
Dilutions								
10^{-1}	1.51	1.52	1.55	1.59	1.57	1.59	1.60	1.64
10^{-3}	1.52	1.53	1.56	1.59	1.60	1.61	1.62	1.65
F test	NS	NS	*	NS	*	NS	*	NS
SEm ±	0.006	0.005	0.002	0.002	0.007	0.008	0.005	0.005
CD at 5%	-	-	0.007	-	0.020	-	0.014	-
Treatments								
Adathoda vasica	1.48	1.50	1.52	1.56	1.56	1.58	1.59	1.64
Bougainvillea spectabilis	1.51	1.52	1.55	1.59	1.58	1.60	1.61	1.65
Phyllanthus niruri	1.52	1.53	1.57	1.61	1.59	1.62	1.62	1.66
Terminalia arjuna	1.49	1.51	1.54	1.57	1.57	1.60	1.60	1.64
Pongamia glabra	1.46	1.47	1.51	1.56	1.55	1.56	1.58	1.61
Water control	1.64	1.64	1.64	1.64	1.66	1.66	1.66	1.66
F test	*	*	*	*	*	*	*	*
SEm ±	0.011	0.008	0.004	0.003	0.012	0.015	0.009	0.009
CD at 5%	0.032	0.025	0.012	0.011	0.035	0.043	0.025	0.028
Interactions								
Av +10^{-1}	1.48	1.49	1.52	1.56	1.55	1.57	1.58	1.64
Bs+10^{-1}	1.50	1.51	1.54	1.59	1.56	1.59	1.61	1.65
Pn +10^{-1}	1.51	1.52	1.56	1.61	1.57	1.61	1.61	1.66
Ta +10^{-1}	1.48	1.50	1.54	1.58	1.55	1.58	1.58	1.64
Pg +10^{-1}	1.44	1.46	1.51	1.55	1.54	1.55	1.57	1.60
Av +10^{-3}	1.48	1.50	1.52	1.57	1.57	1.59	1.59	1.64
Bs+10^{-3}	1.52	1.53	1.56	1.59	1.59	1.62	1.62	1.65
Pn +10^{-3}	1.53	1.54	1.57	1.61	1.61	1.63	1.63	1.65
Ta +10^{-3}	1.50	1.51	1.55	1.57	1.58	1.61	1.62	1.64
Pg +10^{-3}	1.47	1.49	1.52	1.56	1.56	1.56	1.59	1.62
Water control	1.64	1.64	1.64	1.64	1.66	1.66	1.66	1.66
F test	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.016	0.012	0.006	0.005	0.017	0.021	0.012	0.014
CD at 5%	-	-	-	-	-	-	-	-

TABLE 2: Effect of medicinal plant extracts and *Bm*NPV infection on shell weight (g)and shell (%) of PM × CSR_2

	Hours of treatment							
	Fourth instar inoculation							
	Shell weight (g)				Shell percentage (%)			
Dilutions/Treatments/ Interactions	0 h	3 h	5 h	7 h	0 h	3 h	5 h	7 h
Dilutions								
10^{-1}	0.242	0.246	0.253	0.262	15.94	16.07	16.20	16.43
10^{-3}	0.244	0.248	0.255	0.264	15.95	16.05	16.22	16.51
F test	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.001	0.001	0.001	0.008	0.058	0.060	0.070	0.048
CD at 5%	-	-	-	-	-	-	-	-
Treatments								
Adathoda vasica	0.219	0.224	0.230	0.241	14.80	14.98	15.09	15.36
Bougainvillea spectabilis	0.243	0.247	0.254	0.267	16.08	16.20	16.37	16.77
Phyllanthus niruri	0.254	0.257	0.266	0.280	16.70	16.84	16.94	17.36
Terminalia arjuna	0.231	0.234	0.244	0.254	15.43	15.51	15.78	16.11
Pongamia glabra	0.211	0.216	0.225	0.234	14.45	14.60	14.87	14.99
Water control	0.299	0.299	0.299	0.299	18.22	18.22	18.22	18.22
F test	*	*	*	*	*	*	*	*
SEm ±	0.002	0.002	0.001	0.001	0.100	0.105	0.121	0.083
CD at 5%	0.007	0.005	0.005	0.003	0.167	0.302	0.348	0.239
Interactions								
Av +10^{-1}	0.220	0.224	0.229	0.241	14.85	14.95	15.01	15.38
Bs+10^{-1}	0.242	0.245	0.253	0.266	16.11	16.21	16.34	16.72
Pn +10^{-1}	0.252	0.257	0.265	0.280	16.64	16.88	16.93	17.34
Ta +10^{-1}	0.229	0.233	0.245	0.253	15.47	15.51	15.85	16.00
Pg +10^{-1}	0.207	0.215	0.224	0.232	14.39	14.67	14.87	14.91
Av +10^{-3}	0.218	0.225	0.232	0.241	14.75	15.01	15.18	15.35
Bs+10^{-3}	0.244	0.250	0.256	0.268	16.06	16.20	16.40	16.81
Pn +10^{-3}	0.256	0.258	0.267	0.281	16.76	16.80	16.96	17.38
Ta +10^{-3}	0.232	0.236	0.244	0.255	15.38	15.52	15.71	16.21
Pg +10^{-3}	0.215	0.217	0.226	0.235	14.52	14.54	14.86	15.06
Water control	0.299	0.299	0.299	0.299	18.22	18.22	18.22	18.22
F test	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.003	0.002	0.002	0.001	0.142	0.149	0.171	0.118
CD at 5%	-	-	-	-	-	-	-	-

TABLE 3: Effect of medicinal plant extracts and *Bm*NPV infection on shell weight (g) and shell percentage (%) of PMxCSR$_2$

	Hours of treatment							
	Fifth instar inoculation							
	Shell weight (g)				Shell percentage (%)			
Dilutions/Treatments /Interactions	0 h	3 h	5 h	7 h	0 h	3 h	5 h	7 h
Dilutions								
10^{-1}	0.265	0.270	0.272	0.282	16.78	16.89	16.98	17.14
10^{-3}	0.270	0.273	0.276	0.284	16.86	16.88	16.96	17.20
F test	*	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.001	0.001	0.001	0.001	0.038	0.037	0.050	0.037
CD at 5%	0.003	-	-	-	-	-	-	-
Treatments								
Adathoda vasica	0.250	0.254	0.257	0.271	15.95	16.06	16.19	16.48
Bougainvillea spectabilis	0.266	0.271	0.275	0.286	16.84	16.87	17.01	17.27
Phyllanthus niruri	0.276	0.280	0.283	0.293	17.32	17.33	17.43	17.69
Terminalia arjuna	0.260	0.267	0.269	0.278	16.60	16.67	16.75	16.94
Pongamia glabra	0.243	0.246	0.250	0.239	15.59	15.75	15.82	16.03
Water control	0.310	0.310	0.310	0.310	18.63	18.63	18.63	18.63
F test	*	*	*	*	*	*	*	*
SEm ±	0.002	0.002	0.002	0.002	0.067	0.064	0.086	0.064
CD at 5%	0.006	0.007	0.006	0.005	0.111	0.184	0.248	0.183
Interactions								
Av +10^{-1}	0.247	0.253	0.257	0.270	15.83	16.04	16.21	16.46
Bs+10^{-1}	0.262	0.268	0.273	0.285	16.81	16.90	16.94	17.21
Pn +10^{-1}	0.272	0.280	0.283	0.293	17.28	17.37	17.51	17.66
Ta +10^{-1}	0.256	0.265	0.266	0.277	16.56	16.64	16.77	16.91
Pg +10^{-1}	0.242	0.245	0.247	0.257	15.58	15.74	15.86	16.01
Av +10^{-3}	0.252	0.256	0.258	0.272	16.07	16.08	16.17	16.51
Bs+10^{-3}	0.269	0.275	0.277	0.287	16.87	16.84	17.08	17.33
Pn +10^{-3}	0.280	0.281	0.283	0.294	17.35	17.30	17.35	17.71
Ta +10^{-3}	0.264	0.270	0.272	0.279	16.64	16.69	16.73	16.98
Pg +10^{-3}	0.244	0.246	0.254	0.261	15.60	15.76	15.78	16.05
Water control	0.310	0.310	0.310	0.310	18.63	18.63	18.63	18.63
F test	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.003	0.003	0.003	0.002	0.095	0.091	0.122	0.090
CD at 5%	-	-	-	-	-	-	-	-

TABLE 4: Effect of medicinal plant extracts and *Bm*NPV infection on silk productivity (cg/day) of PM × CSR_2

	Hours of treatment							
	Silk productivity (cg/day)							
	Fourth instar				Fifth instar			
Dilutions/Treatments/ Interactions	0 h	3 h	5 h	7 h	0 h	3 h	5 h	7 h
Dilutions								
10^{-1}	2.33	2.38	2.48	2.77	2.83	2.88	2.95	3.09
10^{-3}	2.35	2.39	2.52	2.77	2.87	2.89	2.92	3.13
F test	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.033	0.042	0.040	0.034	0.054	0.048	0.056	0.051
CD at 5%	-	-	-	-	-	-	-	-
Treatments								
Adathoda vasica	1.94	2.01	2.17	2.35	2.67	2.64	2.68	2.98
Bougainvillea spectabilis	2.19	2.29	2.47	2.91	2.77	2.85	2.93	3.09
Phyllanthus niruri	2.66	2.65	2.81	3.07	2.97	3.04	3.06	3.27
Terminalia arjuna	2.10	2.15	2.26	2.72	2.74	2.80	2.86	3.06
Pongamia glabra	1.85	1.91	1.99	2.27	2.46	2.53	2.58	2.78
Water control	3.30	3.30	3.30	3.30	3.47	3.47	3.47	3.47
F test	*	*	*	*	*	*	*	*
SEm ±	0.057	0.073	0.070	0.059	0.093	0.084	0.097	0.089
CD at 5%	0.163	0.211	0.201	0.170	0.269	0.240	0.278	0.257
Interactions								
Av $+10^{-1}$	1.95	2.02	2.13	2.35	2.66	2.62	2.67	2.96
Bs$+10^{-1}$	2.20	2.26	2.46	2.90	2.73	2.83	2.94	3.08
Pn $+10^{-1}$	2.63	2.62	2.75	3.08	2.93	3.03	3.13	3.25
Ta $+10^{-1}$	2.11	2.18	2.27	2.71	2.72	2.80	2.86	3.05
Pg $+10^{-1}$	1.80	1.90	1.99	2.27	2.46	2.55	2.58	2.72
Av $+10^{-3}$	1.93	2.00	2.21	2.35	2.68	2.65	2.68	2.99
Bs$+10^{-3}$	2.18	2.32	2.49	2.92	2.80	2.86	2.90	3.10
Pn $+10^{-3}$	2.69	2.68	2.87	3.07	3.01	3.04	2.99	3.27
Ta $+10^{-3}$	2.09	2.13	2.26	2.72	2.74	2.81	2.86	3.08
Pg $+10^{-3}$	1.91	1.93	1.99	2.26	2.47	2.50	2.58	2.85
Water control	3.30	3.30	3.30	3.30	3.47	3.47	3.47	3.47
F test	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.080	0.104	0.099	0.083	0.132	0.118	0.137	0.126
CD at 5%	-	-	-	-	-	-	-	-