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EFFICACY OF VERMIWASH-SMEARED MULBERRY LEAVES ON COCOON CHARACTERS OF MULTIVOLTINE HYBRID MULBERRY SILKWORM *BOMBYX MORI* L: KOLAR GOLD (K.G) RACE

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A B S T R A C T

The effect of vermiwash and vermicompost in augmenting the growth process in a variety of plants is amply documented. Biological role of feed supplements like semi-synthetic diets and mulberry grown through vermicompost administration on the growth and cocoon characters of silkworms is also equally well known. In the present investigation, the effect of fresh and two week old vermiwash of two epigeic earthworms Eudrilus eugeniae and Perionyx sp. on the cocoon characters of the mulberry silkworm, multivoltine hybrid Kolar Gold race was studied. Mulberry leaves were collected from a field where different treatments were given to the existing three year old mulberry crop. The treatments to mulberry plants included spot application of 1 and 2kg. Vermicompost, 30g NPK (300N: 120P: 120K) and Farm yard Manure (1kg) respectively. One set of the plants were sprayed with vermicompost extract (1kg. fresh vermicompost suspended in ten litres of fresh water and left for 72h. before decanting to use as spray), one more set of plants received vermicompost brew (1kg. vermicompost was treated with water at 100^{0}C and slowly filtered through a fine gauze to get the brew to use as spray to plants) and finally spraying of water to third set served as control. The leaves collected from these treatments were used as feed to different batches of silkworms of fourth instar immediately after the third molt. The silkworms were divided into two groups and one was fed with the leaves collected from the plants exposed to different treatments smeared with vermiwash [1kg. earthworms were immersed in one liter luke warm water for 30 sec. in a tray and later transferred to another tray containing water at room temperature (26 to 28^{0}C) before releasing them back in to bins. The fluid in both the trays were mixed and this served as vermiwash] and the other group was fed on the leaves without smearing with vermiwash (untreated leaves). The parameters recorded included weights of larvae, silk glands, cocoons, shell and floss. Vermiwash- smeared mulberry leaves grown with vermicompost and sprayed with brew showed significant influence on the cocoon characters when compared to other treatments. The data is analyzed using SAS programme to show the levels of

INTRODUCTION

Success in sericulture, an agro-based cottage industry, largely depends on several parameters, like the nutrient status of the mulberry leaves and genetic constitution of the silkworm race. It also depends on the best practices employed in the rearing of silkworms and finally in the reeling of silk. The nutritive status of the mulberry leaves can be enhanced by upgrading the nutrient level of the soil through organic amendments or inorganic nutrients.

Edwards (1998) reported significant influence of vermicompost on the growth and productivity of

plants. Murarkar et al. (1998) showed that vermicompost and NPK influence the leaf yield per branch, height of the plant, and number of leaves in mulberry plant. Reddy et al. (2003) observed enhanced growth of mulberry varieties (V1, S13, S30, S36) in response to vermicompost application. Jadhav et al. (2000) and Washimkar et al. (2005) reported the growth promoting effect of vermicompost on the growth and yield of mulberry. Ingham (2005) expressed that soluble mineral nutrients in the vermicompost influence plant growth.

Effect of foliar sprays of vermicompost extracts on fruit quality and late blight suppression on field grown tomatoes has been reported (Zaller, 2006). Use of vermicompost leachate as a biofertilizer in agriculture was demonstrated by Gutirrez-Miceli et al. (2008). Vermiwash, the extracted body fluid of earthworms, is rich in nutrients and plant growth hormones (Ismail, 1997). Karuna et al. (1999) reported the positive effects of vermiwash as a spray to the tissue cultured crinkle red variety of Anthurium andreanum.. Thangavel et al. (2003) reported the influence of vermiwash on increasing the level of soil nutrients as well as yield of paddy.

Correlation between the nutrient content of mulberry on growth and development in the silkworm B. mori L. is also amply documented. Good growth of larvae, good quality of cocoons and equally good yield of silk depends on the nutritional content of mulberry (Legay, 1958 ; Seki and Oshikane , 1959). The larvae of silkworms need both essential and non essential amino acids for their growth (Ito and Arai, 1964). Vitamins and mineral salts have been found to play an important role in the nutrition of silkworm (Akhtar and Asghar, 1972). Effects of nutrient - supplemented mulberry on commercial value of cocoons have been reported by Kumararaj et al. (1972). Ito (1978), showed that, vitamins present in the mulberry leaves satisfied the minimum needs of the silkworms, their amounts depending to a great extent on the conditions of the environment, use of fertilizers, the mulberry variety and field practices employed. He has also shown that riboflavin, and sprays of choline and its derivatives, enhanced the production of silk and reduced uric acid excretion.

In the present investigation, effects of fresh and two week old vermiwash of two epigeic earthworm species *E. eugeniae* and *P. excavatus* on larval growth parameters, as indicated by larval and silk gland weights and cocoon characters including wet weights of cocoons, floss weight, wet weight of deflossed cocoons, dry weight of deflossed cocoons and shell ratio percent, of the mulberry silkworm *B. mori* L. belonging to Kolar Gold race have been studied.

MATERIALS AND METHODS

Field work was carried out during 2007 – 2010 at Ajith sericulture farm, near Bannerughatta, Bangalore. Three year old *Morus Alba* (Victory 1) plants were selected for experimentation. This is the most popular cultivar in Karnataka state because of its high yielding potential. The soil of the experimental field was identified as Red clay soil, [Mapping unit No. 4 (NBSS, 1998)]. The plants faced East- west direction and received abundant sunlight. Plants received vermicompost as spot applications. One and two Kg of vermicompost was added into pits 45 and 75 cm deep respectively. Farm yard manure was collected from Ajith sericulture farm and certified NPK was collected from the trader. Mulberry plants were rooted in eight rows at a distance of 75cms. The plants in these rows were variously treated as shown in the (Table 1).

Table 1

Various treatments on Mulberry

Row	Treatment per plant
1	1Kg Vermicompost (VC)
2	2Kg Vermicompost (VC)
3	1Kg V.C. + 1L of Vermicompost.extract once in15days
4	2Kg V.C. +1L of Vermicompost extract once in15days
5	1Kg V.C. +1L of Vermicomopst brew once in15days
6	2Kg V.C. +1L of Vermicomopst brew once in15days
7	1Kg of FYM (Control)
8	30g of NPK (300:120 :120 t/ha)

Preparation of vermicompost, vermicompost extract, vermicompost brew and vermiwash*:*

Vermicompost of heterogenous organic waste was prepared using two species of epigeic earthworms, *E. eugeniae* and *P.excavatus*. Vermicompost extract was prepared by suspending 1 kg of fresh vermicompost in 10 L of fresh water for 72 h, decanted and used as spray. The three year old mulberry plants were sprayed with one liter of this preparation, per plant, once in every fifteen days. Vermicompost brew was prepared by suspending 1 kg of vermicompost in 10 L of water at 1000C for 72 h. This was slowly filtered through a gauze and used as spray. The three year old mulberry plants were sprayed with one liter of this preparation per plant once in every fifteen days.

Vermiwash: Clitellate earthworms of genus E. eugeniae and P. excavatus weighing one kilogram each were separately placed in dry enamel trays for 15-20 mins to clear out the casts released during handling. Subsequently, they were separately suspended in glass beakers containing 500ml of

lukewarm distilled water (37°-40°C), mildly agitated for 30sec , removed, and again suspended into beakers containing 500ml of cold distilled water at room temperature (25° -27°C), rinsed thoroughly to separate out the exudates adhering to their body wall before releasing them back to the culture bins. The contents in the two beakers were mixed and used as spray. The syrupy exudate thus collected, is called the vermiwash (Kale, 2006).

The vermiwash so prepared was stored in two dark bottles to avoid exposure to sunlight and used for experimentation. Fresh vermiwash was prepared just before the commencement of treatment and stored in a refrigerator where as, old vermiwash was prepared two weeks in advance before the commencement of treatment and kept at room temperature. The vermiwash so prepared was used to smear the Victory -1 mulberry leaves just 2h before feeding. Vermiwash (0.5 ml.) was used to smear every 5 g of mulberry leaves and air dried before giving them as feed to the silkworms.. The three types of vermiwash used as smear were designated as EVW (E. eugeniae vermiwash), PVW (P. excavatus vermiwash) and MVW (Mixed vermiwash), prepared by mixing the EVW and PVW in equal proportions.

Silkworms

B. mori L. Kolar Gold race is a multivoltine hybrid (Pure Mysore x CSR). The cocoons are yellowish in color. Third moult silkworm larvae were collected from Kirangeri chawki centre located near Kanakapura, Bangalore and reared in Ajith sericulture farm under controlled conditions (Temp. 22°-28°C, Humidity 65-75%). Rearing of silkworms was done as per the Centre Silk Board, Bangalore; guide lines (CSB. 2003). Larvae divided into fifteen groups, each with 100 larvae, maintained in triplicates, were fed with fresh and two week old EVW, PVW and MVW smeared mulberry leaves of plants grown on 1 and 2 kg vermicompost sprayed with vermicompost extract, 1 and 2 kg vermicompost sprayed with vermicompost brew, and on 30 g of NPK, thrice a day. (Table 2). Four more silkworm groups maintained and fed on mulberry leaves plucked from four categories of plants grown on 1kg vermicompost, 2 kg vermicompost, 30 g of NPK (300N:120P: 120K) and 1 kg Farm Yard Manure respectively, without vermiwash treatment were considered as untreated groups (Table.2).

Weights of randomly picked five larvae were recorded at maturity, just before they stopped feeding and the mean noted. Weights of the silk glands of a sample of five were also recorded and the mean noted. Mature silkworm larvae were picked and mounted on specifically fabricated mountages, locally called ‘Chandrikes’. Fully formed cocoons were collected from the mountage on the fifth day. Weights of five randomly picked cocoons were noted , and styphled to facilitate convenient study of

the other cocoon parameters. Data were analyzed through SAS program.

Table 2

Experimental Design

Column	Treatment Code	Silkworm groups fed on Vermiwash-smeared mulberry
1	T2 a1 (EVW)	Leaves of 1Kg VC +VC extract + E. eugeniae Vermiwash(EVW)
2	T2 a2 (PVW)	Leaves of 1Kg VC +VC extract + P. excavates Vermiwash(PVW)
3	T2a3 (MVW)	Leaves of 1Kg VC +VC extract + (EVW+PVW)Mixed vermiwash
4	T2 b1 (EVW)	Leaves of 2Kg VC +VC extract + E.eugeniae Vermiwash
5	T2 b2 (PVW)	Leaves of 2Kg VC +VC extract + P. excavatus. Vermiwash
6	T2 b3 (MVW)	Leaves of 2 Kg VC +VC extract + (EVW+PVW)Mixed vermiwash
7	T3a1 (EVW)	Leaves of 1Kg VC +VC brew + E.eugeniae Vermiwash
8	T3a2 (PVW)	Leaves of 1Kg VC +VC brew + P. excavatus. Vermiwash
9	T3a3	(MVW) Leaves of 1Kg VC +VC brew+ (EVW+PVW)Mixed vermiwash
10	T3b1 (EVW)	Leaves of 2Kg VC +VC brew + E.eugeniae Vermiwash
11	T3b2 (PVW)	Leaves of 2Kg VC +VC brew + P. excavatus. Vermiwash
12	T3b3 (MVW)	Leaves of 2Kg VC +VC brew + ((EVW+PVW)Mixed vermiwash
13	T4 b (EVW)	Leaves of 30g NPK + E.eugeniae Vermiwash
14	T4 c (PVW)	Leaves of 30g NPK + P. excavatus. Vermiwash
15	T4 d (MVW)	Leaves of 30g NPK +(EVW+PVW) Mixed vermiwash
Silkworm groups fed on mulberry without vermiwash treatment (Untreated)		
16	T1 a	Leaves of 1Kg VC
17	T2 b	Leaves of 2 Kg of VC
18	T4	Leaves of 30g of NPK
19	C	Leaves of 1Kg of FYM (control)

RESULTS

In a study that formed a part of our preliminary investigations, a definite positive effect of vermicompost in combination with spraying of vermicompost extract and vermicompost brew, once in fifteen days, on the growth of three year old mulberry plants has been recorded. The combined effect of vermicompost and vermicompost brew has been observed to be the best significant at 0.05 level (Rawgol et al., 2010).

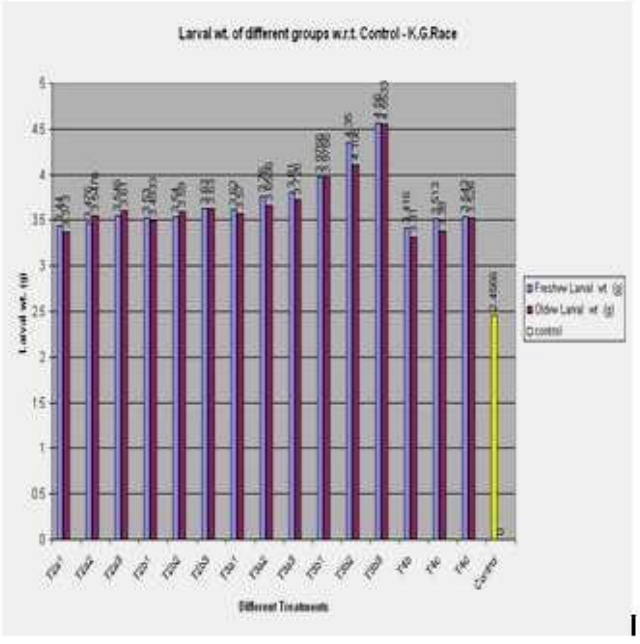
Weight of Larvae

The mean weights of larvae fed with fresh and old vermiwash (VW) smeared mulberry, were 4.56g and 4.55g respectively, while that of the control group larvae was 2.45g. T3b3 performed better than control and other groups and was found to be significant at 0.05 levels (Fig.1.). The ranking sequence in performance is as follows:

Fresh VW - T3b3 > T3b2 > T3b1 > T3a3> T3a2 > (T3a1= T2b3) > T2b2 > T2b1> T4 d > T4 c > T2b2 > T2a1> T4 b> C

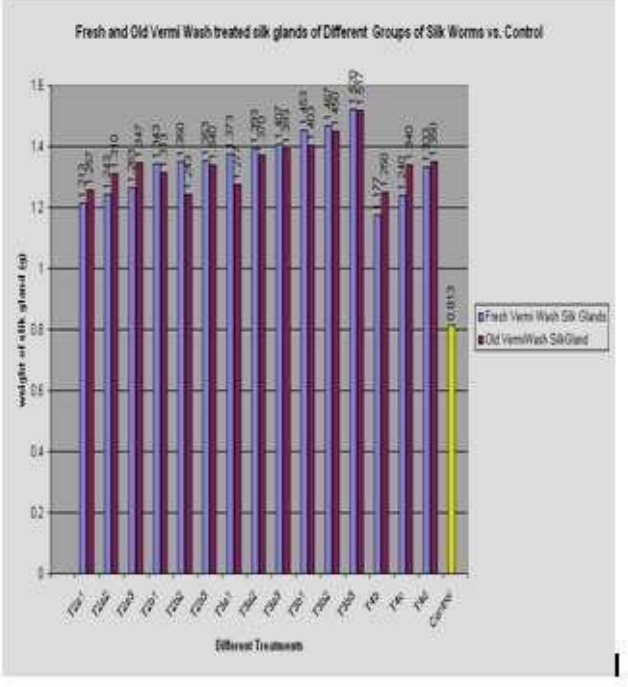
Old VW - T3b3> T3b2 > T3b1 > T3a3 >T3a2 > T3a1 >T2a2 > T2b3 > T2a3 > T2b2 > T4 d >T2a3 > T2b1 >T4 c > T2a1 > C

Fig. 1 Larval weighs of Treated Silkworm groups with respect to Control



Weights of Silk gland

Fig. 2. Silk gland weights of Treated silkworm groups with respect to Control



The mean weights of silk glands of larvae fed with fresh and old vermiwash smeared mulberry were

1.520g and 1.5 179g respectively, while that of control group larvae was 0.8 13g. T3b3 performed better than control and other groups and was found to be significant at 0.05 level (Fig. 2.). The ranking sequence in performance is as follows:

Fresh VW - T3b3 > T3b2 > T3b1 > T3a3>T3a2> T3a1 > T2b3> T2b2> T2b1 > T2a3> T4 d > T2a2 > T4 C > T2 a1 > T4 b> C

Old VW- T3b3> T3b2 >> T3b1 >> T3a3 > T3a2 >T4d >T2a3> (T2b3 =T4c)>T2a2 > T2 b1 > T3a1 > T2b2 > T2a1>T4 b >C

Cocoon characters

The mean weights of fresh wet cocoons of larvae fed with fresh and old vermiwash smeared mulberry, were 2.562g and 2.506g respectively, while that of the control group larvae was 1.4720g. T3b3 performed better than control and other groups and was significant at 0.05 level (Table 3). The ranking sequence in performance is as follows:

Fresh VW - T3b3 > T3b2 > T3b1 > T3a1>T3a2> T3a1 > T2b3 > T2b2> T2b1 > T4 d >T2a3 > T2a1 > T2 a2 > T4 C > T4 b> C

Old VW -T3b3> T3b2 > T4d > T3b1 > T3a3 > T3a2 > T3a1>T2b3 >T4c >T2b2 > T2b1 > T4 b > T2 a3 > T2a2 > T2a1 >C

The mean weight of the floss of cocoons of larvae fed with fresh and old vermiwash smeared mulberry was 0.01g, while that of the control group was 0.104g. Most of the vermiwash treated groups performed better than control on floss weights and was significant at 0.05 level (Table 3). The ranking sequence in performance is as follows:

Fresh VW - (T3b3 = T3b2 = T3b1 = T3a1=T3a2= T3a1 = T2b3= T2b2= T2b1 = T2a3 = T2a2=T2 a1 = T4 b=T4 c = T4 d)< C

Old VW - (T3b3 = T3b2 = T3b1 = T3a1=T3a2= T3a1 = T2b3= T2b2= T2b1 = T2a3 = T2a2=T2 a1 = T4 b=T4 c = T4 d) < C

The mean wet weights of deflossed cocoons of larvae fed on fresh and old vermiwash smeared mulberry were 1.802g and 1.176g respectively while that of the control group larvae was 0.65g. Most of the vermiwash treated groups performed better than the control showing significance at 0.05 level (Table 3) The ranking sequence in performance is as follows:

Fresh VW - T4 d >T3b3 > T4 b >T3b2 >T4 C> T3b1>T2b3 >T2b1 > T3a3> T2a3 >T3a1> T3a2 > T2a1> T2 a2 > T2b2 > C

Old VW - T2b2 >T3b1 > T3b3 >T2a1> T3b2 >T2b3 >T3a3 > T4 C > T4 d > T3a2> T3a1> T2b1 > T2a2 > T2a3 > T4 b > C

Table 3

Statistical analysis of Cocoon characters of Treated Silkworm groups with respect to Control

Groups	Variables	Mean	Std.Dev	Co.eff of Variation.	Min	Max	Std. error	Lower 95% of CL for mean	Upper95% of CL for mean
T2a1	Fresh VW- wet wt. of Cocoon	2.086	0.0288097	1.3810988	2.05	2.11	0.0128841	2.050228	2.121772
	Old VW- wet wt. of Cocoon	1.658	0.0420714	2.537477	1.59	1.70	0.0188149	1.6057615	1.7102385
	Fresh VW- Floss wt. of Cocoon	0.018	0.0083666	46.481113	0.01	0.03	0.0037417	0.0076115	0.0283885

	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.030	0.1473092	14.301864	0.86	1.24	0.0658787	0.8470915	1.2129085
	Old VW- wet wt. of deflossed Cocoon	1.418	0.051672	3.6440087	1.35	1.47	0.0231084	1.3538407	1.4821593
	Fresh VW- Dry wt. of deflossed Cocoon	2.068	0.0311448	1.5060359	2.03	2.10	0.0139284	2.0293286	2.1066714
	Old VW- Dry wt. of deflossed Cocoon	1.648	0.0420714	2.5528743	1.58	1.69	0.0188149	1.5957615	1.7002385
T2a2	Fresh VW- wet wt. of Cocoon	1.954	0.0568331	2.9085511	1.86	2.01	0.0254165	1.8834324	2.0245676
	Old VW- wet wt. of Cocoon	1.74	0.045607	2.6120857	1.68	1.79	0.0203961	1.6893714	1.8026286
	Fresh VW- Floss wt. of Cocoon	0.014	0.0054772	39.12304	0.01	0.02	0.0024495	0.0071991	0.0208009
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	0.944	0.1848783	19.58457	0.79	1.23	0.0826801	0.7144432	1.1735568
	Old VW- wet wt. of deflossed Cocoon	1.154	0.0779744	6.7568765	1.04	1.23	0.0348712	1.0571821	1.2508179
	Fresh VW- Dry wt. of deflossed Cocoon	1.940	0.0565685	2.9159043	1.85	2.00	0.0252982	1.8697609	2.0102391
	Old VW- Dry wt. of deflossed Cocoon	1.736	0.045607	2.6271323	1.67	1.78	0.0203961	1.6793714	1.7926286
T2a3	Fresh VW- wet wt. of Cocoon	2.056	0.0114018	0.55456	2.04	2.07	0.005099	2.0418429	2.0701571
	Old VW- wet wt. of Cocoon	1.826	0.0304959	1.6700932	1.79	1.86	0.0136382	1.7881343	1.8638657
	Fresh VW- Floss wt. of Cocoon	0.014	0.0054772	39.12304	0.01	0.02	0.0024495	0.0071991	0.0208009
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.162	0.1003494	8.6359199	1.03	1.26	0.0448776	1.0373998	1.2866002
	Old VW- wet wt. of deflossed Cocoon	1.050	0.0707107	6.7343503	0.96	1.12	0.0316228	0.9622011	1.1377989
	Fresh VW- Dry wt.	2.042	0.0083666	0.4097258	2.03	2.05	0.0037417	2.0316115	2.0523885

	of deflossed Cocoon								
	Old VW- Dry wt. of deflossed Cocoon	1.816	0.0304959	1.6792897	1.78	1.85	0.0136382	1.7781343	1.8538657
T2b1	Fresh VW- wet wt. of Cocoon	2.126	0.0194936	0.9169139	2.10	2.15	0.0087178	2.1017955	2.1502045
	Old VW- wet wt. of Cocoon	1.904	0.0304959	1.6016755	1.86	1.94	0.0136382	1.8661343	1.9418657
	Fresh VW- Floss wt. of Cocoon	0.012	0.0044721	37.2678	0.01	0.02	0.002	0.0064471	0.0175529
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.244	0.1477498	11.876993	1.07	1.44	0.0660757	1.0605444	1.4274556
	Old VW- wet wt. of deflossed Cocoon	1.160	0.0751665	6.4798691	1.10	1.29	0.0336155	1.0666685	1.2533315
	Fresh VW- Dry wt. of deflossed Cocoon	2.114	0.0207364	0.9809102	2.09	2.14	0.0092736	2.0882523	2.1397477
	Old VW- Dry wt. of deflossed Cocoon	1.894	0.0304959	1.6101321	1.85	1.93	0.0136382	1.8561343	1.9318657
T2b2	Fresh VW- wet wt. of Cocoon	2.238	0.0370135	1.6538656	2.19	2.28	0.0165529	2.1920417	2.2839583
	Old VW- wet wt. of Cocoon	2.196	0.0151658	0.690608	2.18	2.22	0.0067823	2.1771692	2.2148308
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	0.930	0.1467992	15.784858	0.83	1.19	0.0656506	0.7477247	1.1122753
	Old VW- wet wt. of deflossed Cocoon	1.760	0.0406202	2.3079655	1.73	1.83	0.0181659	1.7095634	1.8104366
	Fresh VW- Dry wt. of deflossed Cocoon	2.228	0.0370135	1.6612886	2.18	2.27	0.0165529	2.1820417	2.2739583
	Old VW- Dry wt. of deflossed Cocoon	2.186	0.0151658	0.6937672	2.17	2.21	0.0067823	2.1671692	2.2048308
T2b3	Fresh VW- wet wt. of Cocoon	2.276	0.0350714	1.5409207	2.23	2.32	0.0156844	2.2324532	2.3195468
	Old VW- wet wt. of Cocoon	2.268	0.0414729	1.8286103	2.21	2.32	0.0185472	2.2165046	2.3194954
	Fresh VW- Floss	0.010	0	0	0.01	0.01	0	-	-

	wt. of Cocoon								
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.264	0.0928978	7.349509	1.18	1.42	0.0415452	1.1486522	1.3793478
	Old VW- wet wt. of deflossed Cocoon	1.390	0.2739526	19.708817	1.12	1.83	0.1225153	1.049843	1.730157
	Fresh VW- Dry wt. of deflossed Cocoon	2.266	0.03507 14	1.5477209	2.22	2.31	0.0 156844	2.2224532	2.3095468
	Old VW- Dry wt. of deflossed Cocoon	2.258	0.0414729	1.8367087	2.20	2.31	0.0185472	2.2065046	2.3094954
T3a1	Fresh VW- wet wt. of Cocoon	2.342	0.0370135	1.5804232	2.29	2.38	0.0165529	2.2960417	2.3879583
	Old VW- wet wt. of Cocoon	2.312	0.0258844	1.1195657	2.28	2.34	0.0115758	2.2798603	2.3441397
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.084	0.1096814	10.118206	0.94	1.23	0.049051	0.9478126	1.2201874
	Old VW- wet wt. of deflossed Cocoon	1.210	0.0781025	6.4547518	1.10	1.29	0.0349285	1.1130229	1.3069771
	Fresh VW- Dry wt. of deflossed Cocoon	2.332	0.0370135	1.5872003	2.28	2.37	0.0165529	2.2860417	2.3779583
	Old VW- Dry wt. of deflossed Cocoon	2.302	0.0258844	1.1244291	2.27	2.33	0.0115758	2.2698603	2.3341397
T3a2	Fresh VW- wet wt. of Cocoon	2.316	0.0559464	2.4156478	2.24	2.38	0.02502	2.2465334	2.3854666
	Old VW- wet wt. of Cocoon	2.346	0.0397492	1.6943399	2.29	2.39	0.0177764	2.2966448	2.3953552
	Fresh VW- Floss wt. of Cocoon	0.012	0.0044721	37.2678	0.01	0.02	0.002	0.0064471	0.0175529
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.108	0.0476445	4.3000467	1.05	1.18	0.0213073	1.0488415	1.1671585
	Old VW- wet wt. of deflossed Cocoon	1.288	0.0687023	5.3340261	1.21	1.37	0.0307246	1.2026949	1.3733051
	Fresh VW- Dry wt. of deflossed Cocoon	2.304	0.053 1977	2.3089299	2.23	2.36	0.0237908	2.2379463	2.3700537

	Old VW- Dry wt. of deflossed Cocoon	2.336	0.0397492	1.7015931	2.28	2.37	0.0177764	2.2866448	2.3853552
T3a3	Fresh VW- wet wt. of Cocoon	2.394	0.04219	1.7623244	2.33	2.44	0.018868	2.3416141	2.4463859
	Old VW- wet wt. of Cocoon	2.370	0.0316228	1.3342944	2.32	2.40	0.0141421	2.3307351	2.4092649
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.220	0.0681909	5.5894187	1.14	1.32	0.0304959	1.1353298	1.3046702
	Old VW- wet wt. of deflossed Cocoon	1.344	0.0450555	3.3523453	1.28	1.40	0.0201494	1.2880562	1.3999438
	Fresh VW- Dry wt. of deflossed Cocoon	2.384	0.04219	1.7697167	2.32	2.43	0.018868	2.3316141	2.4363859
	Old VW- Dry wt. of deflossed Cocoon	2.360	0.0316228	1.3399482	2.31	2.39	0.0141421	2.3207351	2.3992649
T3b1	Fresh VW- wet wt. of Cocoon	2.492	0.0327109	1.3126346	2.45	2.53	0.0146287	2.4513841	2.5326159
	Old VW- wet wt. of Cocoon	2.372	0.0414729	1.7484352	2.32	2.42	0.0185472	2.3205046	2.4234954
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.014	0.0054772	39.12304	0.01	0.02	0.0024495	0.0071991	0.0208009
	Fresh VW- wet wt. of deflossed Cocoon	1.334	0.159154	11.930586	1.18	1.53	0.0711758	1.1363842	1.5316158
	Old VW- wet wt. of deflossed Cocoon	1.526	0.2390188	15.663095	1.29	1.83	0.1068925	1.2292189	1.8227811
	Fresh VW- Dry wt. of deflossed Cocoon	2.482	0.0327109	1.3179232	2.44	2.52	0.0146287	2.4413841	2.5226159
	Old VW- Dry wt. of deflossed Cocoon	2.358	0.0370135	1.5696994	2.31	2.40	0.0165529	2.3120417	2.4039583
T3b2	Fresh VW- wet wt. of Cocoon	2.506	0.0207364	0.8274717	2.48	2.53	0.0092736	2.4802523	2.5317477
	Old VW- wet wt. of Cocoon	2.426	0.0958123	3.9493947	2.34	2.54	0.0428486	2.3070333	2.5449667
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt.	0.016	0.0089443	55.901699	0.01	0.03	0.004	0.0048942	0.0271058

	of Cocoon								
	Fresh VW- wet wt. of deflossed Cocoon	1.404	0.0568331	4.0479408	1.32	1.46	0.0254165	1.3334324	1.4745676
	Old VW- wet wt. of deflossed Cocoon	1.396	0.0350714	2.5122748	1.35	1.44	0.0156844	1.3524532	1.4395468
	Fresh VW- Dry wt. of deflossed Cocoon	2.496	0.0207364	0.8307869	2.47	2.52	0.0092736	2.4702523	2.5217477
	Old VW- Dry wt. of deflossed Cocoon	2.410	0.0880341	3.6528666	2.33	2.52	0.03937	2.3006912	2.5193088
T3b3	Fresh VW- wet wt. of Cocoon	2.562	0.0370135	1.4447116	2.52	2.54	0.0165529	2.5160417	2.6079583
	Old VW- wet wt. of Cocoon	2.506	0.0240832	0.9610211	2.48	2.61	0.0107703	2.4760968	2.5359032
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.020	0.0122474	61.237244	0.01	0.04	0.005477	0.0047928	0.0352072
	Fresh VW- wet wt. of deflossed Cocoon	1.424	0.0336155	2.3606371	1.38	1.46	0.0150333	1.3822609	1.4657391
	Old VW- wet wt. of deflossed Cocoon	1.464	0.0270185	1.8455268	1.43	1.50	0.012083	1.4304521	1.4975479
	Fresh VW- Dry wt. of deflossed Cocoon	2.552	0.0370135	1.4503727	2.51	2.60	0.0165529	2.5060417	2.5979583
	Old VW- Dry wt. of deflossed Cocoon	2.488	0.0192354	0.7731264	2.47	2.52	0.0086023	2.4641161	2.5118839
T4b	Fresh VW- wet wt. of Cocoon	1.862	0.0277489	1.4902725	1.82	1.89	0.0124097	1.8275452	1.8964548
	Old VW- wet wt. of Cocoon	1.872	0.0704982	3.7659309	1.78	1.95	0.0315278	1.7844649	1.9595351
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.014	0.0054772	39.12304	0.01	0.02	0.0024495	0.0071991	0.0208009
	Fresh VW- wet wt. of deflossed Cocoon	1408	0.0772658	5.4876261	1.29	1.48	0.0345543	1.3120619	1.5039381
	Old VW- wet wt. of deflossed Cocoon	1.050	0.1320984	12.580805	0.87	1.21	0.0590762	0.8859781	1.2140219
	Fresh VW- Dry wt. of deflossed Cocoon	1.852	0.0277489	1.4983 193	1.81	1.88	0.0 124097	1.8 175452	1.8864548
	Old VW- Dry wt. of deflossed Cocoon	1.858	0.066106	3.5579104	1.77	1.93	0.0295635	1.7759186	1.9400814

T4c	Fresh VW- wet wt. of Cocoon	1.908	0.0216795	1.1362413	1.88	1.93	0.0096954	1.8810814	1.9349186
	Old VW- wet wt. of Cocoon	2.230	0.02	0.896861	2.21	2.26	0.0089443	2.2051667	2.2548333
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Fresh VW- wet wt. of deflossed Cocoon	1.350	0.1031988	7.6443583	1.24	1.51	0.0461519	1.2218617	1.4781383
	Old VW- wet wt. of deflossed Cocoon	1.304	0.098387	7.5450146	1.18	1.42	0.044	1.1818364	1.4261636
	Fresh VW- Dry wt. of deflossed Cocoon	1.898	0.0216795	1.1422278	1.87	1.92	0.0096954	1.8710814	1.9249186
	Old VW- Dry wt. of deflossed Cocoon	2.22	0.02	0.9009009	2.20	2.25	0.0089443	2.1951667	2.2448333
T4d	Fresh VW- wet wt. of Cocoon	2.088	0.0228035	1.0921221	2.06	2.12	0.010198	2.0596857	2.1163143
	Old VW- wet wt. of Cocoon	2.398	0.0618061	2.577404	2.32	2.48	0.0276405	2.3212575	2.4747425
	Fresh VW- Floss wt. of Cocoon	0.010	0	0	0.01	0.01	0	-	-
	Old VW- Floss wt. of Cocoon	0.020	0.01	50	0.01	0.03	0.0044721	0.0075834	0.0324166
	Fresh VW- wet wt. of deflossed Cocoon	1.802	0.0653452	3.6262618	1.71	1.87	0.0292233	1.7208632	1.8831368
	Old VW- wet wt. of deflossed Cocoon	1.290	0.0308221	2.3893078	1.24	1.32	0.013784	1.2517293	1.3282707
	Fresh VW- Dry wt. of deflossed Cocoon	2.078	0.0228035	1.0973777	2.05	2.11	0.010198	2.0496857	2.1063143
	Old VW- Dry wt. of deflossed Cocoon	2.378	0.0526308	2.2132376	2.31	2.45	0.0235372	2.3126502	2.4433498
C	wet wt. of Cocoon	1.472	0.0589067	4.0018143	1.40	1.53	0.0263439	1.3988577	1.5451423
	Floss wt. of Cocoon	0.104	0.0522494	50.23981	0.04	1.53	0.0233666	0.0391238	0.1688762
	wet wt. of deflossed Cocoon	0.650	0.0689202	10.603114	0.57	0.75	0.0308221	0.5644242	0.7355758
	Dry wt. of deflossed Cocoon	1.350	0.0324037	2.4002743	1.30	1.39	0.0144914	1.3097655	1.3902345

The mean dry weights of deflossed cocoons of larvae fed with fresh and old vermiwash smeared mulberry were 2.488g and 2.552g respectively while that of the control group was 1.35g. Most of the

vermiwash treated groups performed better than the control significant at 0.05 level (Table 3).The ranking sequence in performance is as follows:

Fresh VW - T3b3 >T3b2 > T3b1 > T3a3> T3a1> T3a2 > T2b3 > T2b2>T2b1 T4 d > T2a1> T2 a3 >T4 C > T4 b > T2a2 > C

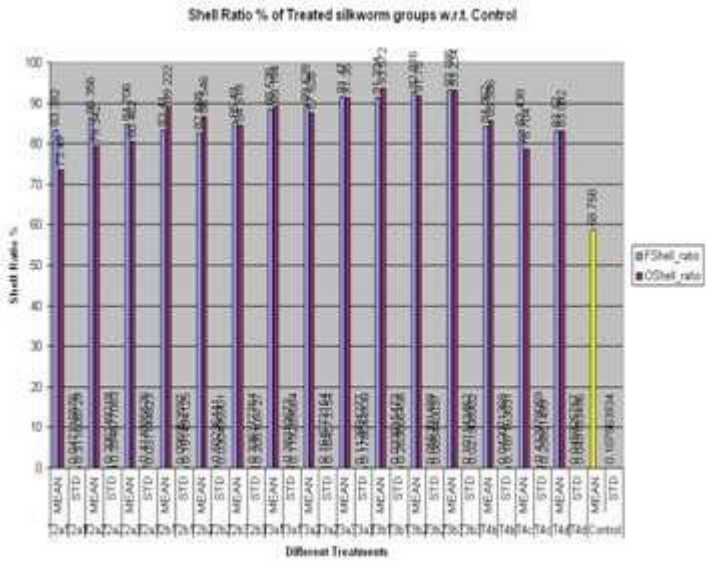
Old VW - T3b3 > T3b2 > T4 d >T3 a3 > T3 b1 > T3a2 > T3 a1 > T2b3 > T4c > T2b2 > T2b1 > T4 b > T2a3 >T2a2 > T2a1> C

The average shell ratio percents of cocoons of larvae fed with fresh and old vermiwash smeared mulberry were 93.186% and 93.234% respectively, while that of the control was 58.758%. Most of the vermiwash treated groups performed better than thecontrol significant at 0.05 level (Fig. 3.) The ranking sequence in performance is as follows:

Fresh VW - T3b3 >T3b2 > T3b1 > T3a3> T3a2> T3a1> T2a2 > T2b3 > T2a3 > T4b > T4c > T2b1>T2a1> T4 d > T2b2 > C

Old VW - T3b1> T3b3 > T3b2 > T3a3 > T2b1 > T3a1> T3aS2 > T2b2 > T4 b >T2b3 >T4d > T2a3> T2a2> T4 C > T2a1 > C

Fig. 3. Shell ratio percent of Treated silkworm groups with respect to Control



Untreated silkworm groups

Descriptive SAS analysis of the untreated silkworm groups revealed certain variations in cocoon characters. Generally T1b group, including larvae fed on mulberry leaves of plants grown on 2 kg vermicompost, performed better than all other groups on average weights and was significant at 0.05 level (Table 4). The ranking sequence in performance is as follows:

Wet wt. of cocoon - T1b > T1a >T4 a > C ,

Wt. of Floss - T1b< T1a < T4a < C

Wet wt. of deflossed cocoon - T1b> T1b> T4a > C

Dry wt. of deflossed cocoon -T1a > T1b > T4a > C

Shell ratio % - T1b > T1a > T4 a > C

Table 4

Statistical analysis of Cocoon characters of Untreated Silkworm groups with respect to Control

Groups	Variable	**Mean**	**Std.Dev**	**Co.eff of Variation.**	**Min**	**Max**	**Std. error**	**Lower 95% of CL for mean**	**Upper95% of CL for mean**
T1a	Wet wt of cocoon	2.086	0.023	1.104	2.05	2.11	0.010	2.0574147	2.1145853
	wt of floss	0.018	0.008	0.008	0.01	0.03	0.004	0.0076115	0.0283885
	wet wt of deflossed cocoon	2.068	0.019	0.930	2.04	2.09	0.009	2.0441161	2.0918839
	dry wt of cocoon	1.786	0.062	3.465	1.71	1.86	0.028	1.7091571	1.8628429
	Shell ratio%	80.076	0.027	0.034	80.04	80.11	0.012	80.0424521	80.1095479
T1b	Wet wt of cocoon	2.110	0.020	0.948	2.09	2.14	0.009	2.0851667	2.1348333
	wt of floss	0.022	0.013	59.265	0.01	0.04	0.006	0.0058107	0.0381893
	wet wt of deflossed cocoon	2.086	0.030	1.422	2.06	2.13	0.013	2.0491663	2.1228337
	dry wt of cocoon	1.760	0.065	3.704	1.65	1.82	0.029	1.6790534	1.8409466
	Shell ratio%	87.058	0.038	0.044	87.01	87.11	0.017	87.0103939	87.1056061
T4	Wet wt of cocoon	1.586	0.047	2.944	1.52	1.64	0.021	1.5280261	1.6439739
	wt of floss	1.042	0.022	51.618	0.01	0.07	0.010	0.0150814	0.0689186
	wet wt of deflossed cocoon	1.544	0.046	2.954	1.47	1.58	0.020	1.4873714	1.6006286
	dry wt of cocoon	1.006	0.060	5.948	0.92	1.08	0.027	0.9317074	1.0802926
	Shell ratio%	68.152	0.455	0.668	67.45	68.59	0.204	67.5868451	68.7171549
C	Wet wt of cocoon	1.472	0.059	4.002	1.4	1.53	0.026	1.3988577	1.5451423
	wt of floss	0.104	0.052	50.240	0.04	0.17	0.023	0.0391238	0.1688762
	wet wt of deflossed	1.350	0.032	2.400	1.3	1.39	0.014	1.3097655	1.3902345

	cocoon								
	dry wt of cocoon	0.650	0.069	10.603	0.57	0.75	0.031	0.5644242	0.7355758
	Shell ratio%	58.758	0.108	0.183	58.59	58.84	0.048	58.6244417	58.8915583

DISCUSSION

Good larval growth, with well developed silk glands, weighty cocoons with enhanced cocoon characters and reduced amounts of floss are attributes of healthy sericulture practices. One of the several and most important parameters that support all of these is a very nutritive mulberry feed. Regular feeding of silkworms with well grown healthy mulberry leaves, fortified with nutrient supplements is of prime importance in harvesting a rich yield of cocoons and procuring of the superior quality 'Royal Fiber', the silk yarn.

Vermicompost is not only a rich organic manure but also a very good quality soil additive. It is an aerobically degraded organic manure that has undergone chemical disintegration by the enzymic activity in the gut of earthworms and also by the enzymes of the microbial populations (Kale, 1993) . It is also rich in growth stimulators with plant hormone-like properties of Auxin and Gibberllin. Plants grow well in vermicompost supplemented soil as soil nutrients are made inoculants more readily accessible to them (Kale, 2006).

Biofertilizers are microbial capable of mobilizing important nutritional elements in the soil from non - usable to usable form. From the past one decade they are extensively used due to their eco - friendliness in enhancing soil fertility status to improve crop production through their biological activity at the rhizosphere minimizing the use of chemical fertilizers. Ram Rao et al. (2007) studied the influence of VAM fungi and bacterial biofertilizer on improving the mulberry leaf quality and cocoon characters of the silkworm hybrid Pure Mysore x NB4D2.

The vermicompost extract and vermicompost brew are obviously nutrient rich as they have a vermicompost origin. The latter is richer due to the temperature treatment given. A positive effect of vermicompost extract and vermicompost brew on the growth of the mulberry has been observed in one of our earlier studies. While there are reports of biofertilizers enhancing mulberry plant growth (Umakanth and Bhagyaraj, 1998 ; Reddy et al., 2000 ; Kashyap et al., 2004), information on the

influence of vermicompost in combination with vermicompost extract and vermicompost brew, on the growth of mulberry plant is scanty.

Vermiwash , the extracted body fluid of earthworms is also nutrient rich with componentspromoting good plant growth (Abdullah and Kumar Sukhraj, 2010 ; Murali, et al., 2010 ; Gorakh Nath , et al., 2009 ; Khaing Nwe Soe , et al., 2008). While several studies related to influence of vermiwash on plant growth are documented, studies supporting its influence on animals are rare. Studies on influence of vermiwash on growth parameters and cocoon characters of the mulberry silkworm B. mori L. are totally wanting.

Amount of food consumed by a larva, influences its growth rate, development, final body weight and probability of survival (Slansky and Sacriber, 1985). Food intake is also regulated by the physical nature of the food as well as the phagostimulants in the food (Dadd,1970). Silkworm B. mori L. reared on mulberry leaves, supplemented with minerals, oral protein supplementation, cereal flours, medicinal extracts, plant growth hormones are reported to have beneficial effects on economic parameters (Singh, 1997 ; Sunder Raj et al., 2000).

In the present investigation weights of the silkworm larvae (Fig. 1.) and their silk glands (Fig.2.) showed an increase with response to feeding on vermiwash smeared mulberry grown on vermicompost in combination with sprays of vermicompost extract and vermicompost brew. The effect of vermiwash treated leaves of the latter combination showed significant effect at 0.05 level.

An increased efficiency in digestion and assimilation of food materials, leading to increased protein synthesis will obviously result in increased overall growth of larval tissues, reflected in healthier and heavier larvae.

Intan et al. (2009) have shown that silk glands of larvae fed on thyroxin treated mulberry were heavier than control. Nutrition is an important growth regulating factor in silkworms. Vitamins of the B complex group and certain essential sugars, proteins, amino acids, minerals etc. have already been shown to be responsible for the proper growth and development of the silkworm B. mori (Horie and Ito, 1963 ; Horie et al., 1966; Senugupta et al., 1972 ; Khan and Saha, 1997a; Faruki, 1998)

Singhvi et al. (2002) found that feeding of Seriboost treated mulberry to bivoltine hybrid CSR2 X CSR4 resulted in improved commercial characters of the silkworm. Singh et al. (2005) showed that application of L. plantarum as a probiotic, enhanced the weights of larvae, pupae, cocoons, shell ratio and pupation as compared with controls of the silkworm B. mori. One of the alternate methods of improving larval feeding of B. mori is enriching the mulberry leaves with supplementary nutrients such as vitamins, as the quality and quantity of mulberry leaves changes with climatic conditions and

field practices (Kanafi et al., 2007). El-Karaksy and Idriss (2009) reported that fifth instar larvae of Bombyx mori fed on mulberry leaves treated with ascorbic acid produced heavier cocoons.

Tazima (1978) and Venkatesha Kumar et al. (2009) have shown that mulberry silkworms fed with mulberry dipped in Spirulina solutions laid a positive effect on cocoon weights, pupal weights and silk filament length. Mulberry leaf supplemented with spirulina as a feed to B. mori was found to be effective in enhancing the larval and cocoon characters (Venkataramana, 2003). Sheeba et al. (2008) showed that third instar B. mori L (L X CSR2) larvae fed with ciprofloxin, a prophylactic antibiotc smeared mulberry, killed pathogenic microbes, and enhanced food consumption by larvae, tissue growth, shell ratio and filament length. The growth promoting effect of prophylactic antibiotic treatment has been demonstrated by Barman and Pasha (1985). Shobha and Kale (2006) have shown that vermiwash (coelomic body fluid) is having antibacterial property. In the present study the antibiotic–like property of vermiwash may have likewise helped the silkworm larvae feed better resulting in heavier larvae and improved cocoon characters.

In the present investigation, cocoon parameters including the weights of cocoons, wet weights of deflossed cocoons, dry weights of deflossed cocoons, and shell ratio percent showed a significant (0.05 level) increase and floss weights showed an equally significant decrease in silkworm groups fed with vermiwash -smeared mulberry grown on vermicompost in combination with vermicompost - extract and brew as compared with control. The cocoon characters of the larvae fed with vermiwash smeared mulberry grown on NPK also showed an increase as compared with those of the controls, but the effect of the vermiwash smeared leaves of mulberry grown on vermicompost and vermicompost brew was found to be the highest (significant at 0.05 level). This suggests the effect of temperature in releasing nutrients from the vermicompost into the suspension used to spray the mulberry plants. Supplementation of such leaves with the nutrient-rich vermiwash reinforced the nutrient level of the mulberry leaves, resulting in not only heavier healthier larvae but also enhanced cocoon characters like cocoon weights ;wet weight of deflossed cocoons ; dry weight of deflossed cocoons and shell ratio percent(Fig. 3.). Floss being a wasted form of silk is a cocoon parameter which should be least in quantity to ensure maximum silk yield. Floss is minimal in the treated groups as compared with the control. Ranking sequences in the performances are clearly indicated in the results (Table 3) .A study of the cocoon parameters of the untreated groups of the silkworms revealed that those of the larvae fed with mulberry grown on 2 kg vermicompost performed the best significant at 0.05 level(Table 4).

CONCLUSION

This is a study integrating aspects of Vermiculture, Moriculture and Sericulture. The products of vermiculture, including the vermicompost,vermicompost extract, vermicompost brew and the extracted body fluid of earthworms, the vermiwash were found to significantly increase the growth parameters of the mulberry plant M. alba (Victory 1) and enhance the nutritive level of the mulberry leaves. Such leaves fed to the silkworm larvae B. mori L showed a significant positive effect on larval growth in terms of larval and silk gland weights and cocoon characters including fresh wet cocoon weights, wet weights of deflossed cocoons, dry weight of deflossed cocoons, and shell ratio percent as compared with controls. The floss weights however showed a significant decrease in the cocoons of the treated larvae as compared with controls.Vermiwash-smeared mulberry leaves of plants grown on vermicompost sprayed with vermicompost brew showed the maximum effect on the various silkworm parameters.

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