IJIE Int. J. Indust. Entomol. 40(2) 41-50 (2020)
ISSN 1598-3579, http://dx.doi.org/10.7852/ijie.2020.40.2.41

ISSN 1598-3579 (Print)
ISSN 2586-4785 (Online)

Improving productivity of mulberry trees and silkworm, *Bombyx mori* L., using vermicompost application

Usama M. Ghazy*, Tahia A. Fouad, and Ghada M. Ahmed

Sericulture Research Department, Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt.

Abstract

Vermicompost, manure, compost and organic fertilization are ecofriendly. Nowadays, many products resulted from sericulture consumed by humans such as mulberry leaves, fruits, mulberry tea, silk and natural silk cosmetics. Soil applications of three treatments with vermicompost (0.5, 1 and 2 tons per 0.42 hectare) and recommended rate of mineral fertilizers of nitrogen phosphorus potassium were used for investigation. Impact of fertilization on mulberry plant traits of moisture, number of shoots/tree, total shoots length/tree, number of leaves/shoot, number of leaves/ (100g), leaf yield/tree and leaf yield of fadden/season were recorded. In addition the effect of fertilization on larval and cocoon characters of young instar duration, fifth instar duration, total larval duration, larval mortality percentage, weight of third instar larvae, weight of fourth instar larvae, weight of fifth instar larvae, fresh cocoon weight, fresh shell weight, pupae weight, cocoon shell ratio, silk productivity, cocooning percentage, pupation ratio, number of cocoons/ liter, crop cocoons by number, crop cocoons by weight, fecundity and fertility. Using vermicompost treatment was enhancing plant characters. Treatments of V_3, V_2 and V_1 were shortage young, fifth and larvae durations. Mostly feeding silkworm during the whole larval duration on treated mulberry leaves with vermicompost improving the traits average. Using vermicompost for fertilization by rate of V_3 and V_2 is better than others for cocoon characters for females and males.V_3 and V_2 of vermicompost per 0.42 hectare is recommended for rearing mulberry silkworm instead of mineral fertilization.

Int. J. Indust. Entomol. 40(2), 41-50 (2020)

Received : 16 Apr 2020
Revised : 6 May 2020
Accepted : 18 Jun 2020

Keywords:
Vermicompost,
NPK,
Fertilizer,
Silkworm *Bombyx mori* L.,
Morus alba var Kokuso-27

Introduction

Sericulture activities mainly are depending on mulberry plants. Mulberry silkworm, *Bombyx mori* L., is monophagous insect fed on some mulberry varieties. Insufficient nutrients decrease the silk production (Wani *et al*., 2017). Benefits of mulberry plants are wide, mulberry leaves used for feeding cattle as well as humans because a lot of benefits discovered especially in the south Asia. Mulberry leaf, fruits, larvae and pupae of silkworm, silk filament are consumed by humans. Many products of sericulture activities are used for reduced high pressures, diabetes, triglycerides, cholesterol, heart attack, cancers, etc. Also, there are many products are used for cosmetics.

Nowadays, scientists intended to use vermicompost because it eco-friendly to environment and favorite soil conditioner, vermicompost have additional attributes of providing enzymes and hormones which stimulate plant growth (Abbasi and Ramasamy, 1999). Vermicompost improves growth, quality and yield of

***Corresponding author.**
Usama M. Ghazy
Sericulture Research Department, Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt.
Tel: +20-100-846-4773
E-mail: Usama.ghazy@arc.sci.eg

different field crops, flower, tomato, Capsicum annum and fruit crops (Azarmi *et al*., 2008, Rasool et *al*., 2008; Rekha *et al*., 2018).

Vermicomposting contributes to recycling of nitrogen and augments soil physico-chemical as well as biological properties also, rich in nitrogen, phosphorus, and potassium, also hygienically safe as pathogens (Vasanthi *et al*., 2013). The procedures of vermicompost is expedited the microbial-mediate mineralization in waste and subsequently enriches the end product with more available forms of nutrients of agronomic magnitude. The utilization of vermicompost results in several benefits to farmers, industries, environment and overall national economy.

Vermicompost improves soil structure, texture, aeration, and water holding capacity and prevents soil erosion. The utilization of the by-products is as important need to every agro waste industry (Sinha *et al*., 2005). Vermicompost is the excreta of earthworms, which is rich in humus and nutrients (Rathore *et al*., 2007).

Egypt has old history with sericulture. It has many villages worked in manual carpet industry. These villages distributed from Delta to Upper Egypt. It consumed 250 – 350 tons of raw silk. Productions of Egypt raw silk are ranged from 2 – 5 tons annually. Nowadays many investors are interest of sericulture to establish many mulberry fields at desert region. Recently some of them are produced many kind of silk cosmetics, tea, jam, fruits, etc, and distributed in local market.

These investigations aim to increase quality and quantity of mulberry trees production and reduction or stopping of using mineral fertilizers. Study the impact of using vermicompost fertilization on mulberry trees and silkworm traits.

Materials and Methods

Soil application of different vermicompost and mineral fertilizers were adopted during spring season, three treatments of vermicompost and recommended mineral fertilizers. Control treatment leave without any application.

Mulberry trees of *Morus alba* var. Kokuso-27 (non-fist form field planted during Spring 2005) were treated with 0.5, 1 and 2 tons per 0.42 hectare of vermicompost (where V_1= 0.5 tons, V_2= 1 tons, and V_3 = 2 tons) and mineral fertilizer of NPK (49:22:30) contains N (nitrogen), P(Phosphorus) and K(potassium) per 0.42 hectare (feddan equal 4200 square meter i.e. 0.42 hectare). Experiments were conducted at Qanater station of Sericulture Research Department Egypt. Hybrid of Giza A (F_{272} X D_{162}) eggs of mulberry silkworm *Bombyx mori* L., were reared. Rearing room temperature and humidity were registered. The average was 21.050±1.807 for temperature and 52.733±4.748 for humidity.

Three replicates were carried out for all treatments. Each replicate contains five hundred larvae fed on cutter mulberry leaves during the first instars. Whole leaves were offered during fourth and fifth instars. Silkworm larvae were divided into two groups. First group (Y) were fed on treated mulberry leaves from brushing till the end of third instar while fourth and fifth instars fed on untreated mulberry leaves. Second group (W) was fed for whole larval duration with treated mulberry leaves.

Plastic sheets and foam were applied for young instars (Ghazy, 2008). Disinfectants of larvae adopted after moulting, middle of the third instar, second day of fourth instar, second, fourth and sixth day of the fifth instar (Hosny *et al*., 2002).

Different characters of mulberry plant and silkworm were collected as follows.

A-Mulberry Plant characters:

No	character	code
1	Moisture	moist
2	Number of shoots/ tree	shoots/ tree
3	Total shoots length/tree	shoots/ length
4	Number of leaves/shoot	leaves/shoot
5	Number of leaves/(100g)	leaves/ (100g)
6	Leaf yield/tree	yield/tree
7	Leaf yield of fadden/season	Yield /season

Twenty plants were selected from each treatment. The moisture content of leaf was calculated by the following formula (Patil *et al*., 2001).

Leaf moisture (%) =

$$\frac{\text{Fresh weight of leaf (g)} - \text{Dry weight of leaf (g)}}{\text{Fresh weight of the leaf (g)}} \times 100$$

Leaf yield was converted to kilogram per 0.42 hectare and crop was calculated according to Zhen *et al.*, (1988).

The output of leaves (Kg /0.42 hectare) =

Average leaf yield per plant (Kg) X Actual number of plants/0.42 hectare.

Average leaf yield per plant (Kg) =

$$\frac{\text{Number of harvested leaves /plant}}{\text{Number of leaves (Kg)}}$$

B-Larval traits:

No	character	Code
1	Young instars duration	YLD
2	Fifth instar duration	FD
3	Total larval duration	TLD
4	Larval mortality Percentage	LMP
5	Weight of third instar larvae (fourth day)	Third LW
6	Weight of fourth instar larvae (fifth day)	Fourth LW
7	Weight of fifth instar larvae (seventh day)	Fifth LW

C-Cocoon traits:

No	character	code
1	Fresh cocoon weight	FCW
2	Fresh shell weight	FSW
3	Pupae weight	PW
4	Cocoon shell ratio	CSR
5	Silk Productivity	SP
6	Cocooning percentage	CP
7	Pupation ratio	PR
8	Number of cocoons / liter	C/L
9	Crop cocoons by No	Crop/No
10	Crop cocoons by weight	Crop/W
11	Fecundity	Fecund
12	Fertility	Fertilit

Double cocoon percentage and pupation ratio were calculated according to the following formulae of Lea (1996):

$$\text{Double cocoon percentage} = \frac{\text{Number of pupae made double cocoon}}{\text{Total number of pupae harvested}}$$

$$\text{Pupation ratio (\%)} = \frac{\text{Number of health pupae}}{\text{Corrected basic number of examined}} \times 100$$

$$\text{Crop cocoons by Number} = \frac{\text{Number of good cocoons (No.)}}{\text{Total No. of larvae retaind after third moult}} \times 10{,}000$$

$$\text{Crop cocoons by Weight} = \frac{\text{Weight of good cocoons harvested (Kg)}}{\text{Total No. of larvae retaind after third moult}} \times 10{,}000$$

Data were analyzed by ANOVA two ways and multi ways using SAS program (1998).

Results and Discussion

Organic fertilizers and ecofriendly fertilizers are widespread over the entire world. Specially, nowadays many products are used for human bins. There are many products are used for cosmetics. So, reducing amount of mineral fertilizers and turn using ecofriendly fertilizers are urgent.

Comparison the effect of vermicompost with mineral fertilizers and null treatment for mulberry plant, larvae and cocoon characters as follows:

A. Mulberry Plant characters:

Data in Table 1 illustrated the effect of different vermicompost treatment on mulberry plant characters.

Table 1. Effect of different treatments of vermicompost on mulberry tree characters.

Parameters / Treatment	Moist (%)	shoots/ tree (No)	shoots/length (cm)	leaves/shoot (No)	leaves / (100g) (No)	Yield / tree (kg)	Yield/season (ton)
V_1	47.222	23.333	137.670	28.333	85.000	1.208	8.458
V_2	53.334	29.667	136.000	30.333	78.000	1.433	10.033
V_3	59.333	31.000	150.000	31.000	78.000	1.457	10.197
NPK	48.889	28.333	74.000	28.000	99.667	0.880	6.160
Control	46.667	20.333	69.670	18.000	112.000	0.667	4.667
F between TRT	2.440	1.840	11.770**	35.610**	9.010**	4.740*	4.740*
LSD 0.05	-	-	35.280	2.779	21.230	0.503	3.518

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) & (*) significant at 0.05, (**) highly significant at 0.01.

Table 2. Effect of different treatments of vermicompost on larvae silkworm characters.

Character / Treatment	YLD (days)	FD (days)	WLD (days)	Third LW (g)	Fourth LW (g)	Fifth LW (g)	LMP (%)
V_1	14.250	8.167	28.417	0.152	0.684	2.141	12.967
V_2	13.250	7.900	27.150	0.158	0.710	2.351	12.583
V_3	13.083	7.733	26.817	0.161	0.728	2.447	11.850
NPK	14.083	8.500	28.000	0.145	0.691	2.204	14.947
Control	15.000	9.000	29.500	0.131	0.628	1.885	28.800
F TRT	2.940	0.350	1.290	32.950**	11.470**	28.760**	71.780**
LSD 5%	-	-	-	0.006	0.031	0.112	2.479

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) (*) significant at 0.05, (**) highly significant at 0.01.

No significant differences were observed for moisture percentage and number of shoots per tree. Treatments V_3 and V_2 were highest moisture percentage. All treatments were heavier comparing control treatment. Same trend was detected for number of shoots per tree.

Highly significant differences were obtained for total shoot length per tree averages were 150.000, 137.670 and 136.000 cm for V_3, V_1, and V_2. High number of leaves per shoot was noticed for V_3, V_2, and V_1 (31.000, 30.333 and 28.333 leaf). Also number of leaves per 100 g were best for V_3 (78.000 leaf), V_2 (78.000 leaf), and V_1 (85.000 leaf), while NPK (99,667 leaf) and control (112.000 leaf). Tallest shoot length per tree trait was noticed for V_3, V_1, V_2, NPK and control treatment. There were 150.000, 137.670, 136.000, 74.000 and 69.670 cm, respectively.

Significant differences were recognized for leaf yield per tree and leaf yield per 0.42 hectare. Heaviest weight of leaves per tree discovered for V_3, V_2 and V_1 (1.457, 1.433 and 1.208 kg) comparing with NPK (0.880 kg) and control treatment (0.667 kg). Similar trend were described for leaf yield per 0.42 hectare. There were 10.197, 10.033, 8.458, 6.160 and 4.667 tons for V_3, V_2, V_1, NPK and control treatment, consequently.

From the previous results it clearly that, using vermicompost treatments improve plant characters comparing with NPK and control treatment. These results are coincidence with those found by (Karmegam *et al*., 1999; Atiyeh *et al*., 2001; Arancon *et al*., 2004, 2005; Gajalakshmi and Abbasi, 2004; Anwar *et al*., 2005; Argüello *et al.*, 2006; Lazcano *et al*., 2011) who reported that many crops growth and yield stimulated by vermicompost such as tomato, pepper, garlic, eggplant, strawberry, sweet corn and green gram as well as, some aromatic and medicinal plants. Also, vermicompost would produce similar or higher plant growth yields than inorganic fertilizers (Lazcano and Domínguez, 2011). In addition, Venugopal *et al*., (2010) stated that vermicompost raising the leaf production. Rawgol *et al*., (2011) studied 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*orus *alba* (Victory-1) and enhance the nutritive level of the mulberry leaves.

B. Larval traits:

Different vermicompost treatments effect on larvae of silkworm, *B. mori* characters were found in Table 2.

Regardless, the insignificant differences were detected for YLD, FD and WLD. Treatments of V_3, V_2 and V_1 were shortage YLD, FD and WLD comparing with NPK and control treatments.

Third, fourth and fifth larval weight and larval mortality percentage revealed highly significant differences. Heavier weights registered for V_3, V_2 and V_1 followed by NPK and control treatment. Highest larval mortality percentage (LMP) was registered for control and NPK treatments. While, V_3, V_2 and V_1 treatments were recorded lowest LMP.

These results are confirmed by those obtained by Mahesh *et al*., (2018) who recorded that treatment containing vermicompost produced higher matured larval weight, shorter fifth larval duration, good effective rate of rearing (ERR) and lower disease incidence.

Impact of using vermicompost treatments during young instars and whole larval duration was found in Table 3.

Table 3. Effect of vermicompost treatments for young instar and whole larval duration on larvae silkworm characters.

Character / Treatment	YLD (days)	FD (days)	LD (days)	Third LW (g)	Fourth LW (g)	Fifth LW (g)	LMP (%)
Young instars	14.000	8.360	28.160	0.149	0.665	1.959	16.565
Whole instars	13.867	8.160	27.793	0.150	0.712	2.452	15.893
F Instars	0.110	0.070	0.190	0.170	22.020**	187.580**	0.800
LSD 5%	-	-	-	-	0.020	0.071	-

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) (*) significant at 0.05, (**) highly significant at 0.01.

Table 4. Effect of interactions between different vermicompost treatments and different groups of tested instars duration on silkworm characters.

Character / Treatment		YLD (days)	FD (days)	LD (days)	Third LW(g)	Fourth LW (g)	Fifth LW (g)	LMP (%)
V_1	Y	14.333	8.333	28.667	0.151	0.653	1.895	13.600
	W	14.167	8.000	28.167	0.152	0.715	2.386	12.334
V_2	Y	13.333	8.000	27.333	0.157	0.674	1.977	13.167
	W	13.167	7.800	26.967	0.159	0.746	2.724	12.000
V_3	Y	13.167	7.800	26.967	0.160	0.707	2.096	12.033
	W	13.000	7.667	26.667	0.162	0.748	2.799	11.667
NPK	Y	14.167	8.667	28.333	0.145	0.662	1.941	15.227
	W	14.000	8.333	27.667	0.147	0.721	2.466	14.667
Control		15.000	9.000	29.500	0.131	0.628	1.885	28.800
F TRT X Instar		0.010	0.010	0.020	0.050	1.640	13.610**	0.100
LSD 5%		-	-	-	-	-	0.159	-

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) (*) significant at 0.05, (**) highly significant at 0.01.

Mostly feeding silkworm during the whole larval duration on treated mulberry leaves with vermicompost improving the traits average.

Table 4 described the effect of interactions between different vermicompost treatments and different groups of tested instars duration on mulberry silkworm characters.

Worst average recorded for control treatment. Treated whole larval duration was better than treated young larval instars. Treatments of V_3 and V_2 were the best treatment for YLD, FD, LD, third LW, fourth LW, fifth LW and LMP traits.

These results are in agreement with the findings of Rawgol *et al*. (2011) and Devamani (2018) who studied the vermicompost and chemical fertilizers on mulberry plant characteristics of plant height, No. of shoots/plant, No. of leaves/plant and leaf yield/ plant the organic fertilizers without chemical showed higher plant growth and economic parameters.

C. Cocoon traits:

Efficacy of vermicompost treatments on silkworm cocoon traits were noted in Table 5 highly significant differences were recorded for all characters except significant differences for PR. Vermicompost and NPK treatments represent best mean values of FCW, FSW, CSR, PW, SP, C/L, CP, PR, Crop/No, Crop/W, fecund and fertilit characters. Treatments of V_3 and V_2 acquired better results for all traits except DCP. Control and NPK treatments acquired best average of DCP.

Using vermicompost for fertilization by rate of V_3 and V_2 is better than NPK and control treatments.

Table 5. Effect of different treatments of vermicompost on silkworm characters

Character / Treatment	CW (g)	CSW (g)	CSR (%)	PW (g)	SP (cg/day)	C/L (No)	CP (%)	PR (%)	DCP (No)	Crop/N (No)	Crop/W (Kg)	Fecund (No)	Fertilit (%)
V_1	1.787	0.302	16.961	1.424	4.029	114.427	88.867	86.000	0.928	8885.7	15.887	366.17	95.431
V_2	1.897	0.336	17.804	1.498	4.489	111.020	89.500	88.000	0.113	8950.5	16.985	424.50	94.686
V_3	1.914	0.353	18.534	1.499	4.712	109.130	92.234	89.000	1.224	9223.4	17.626	452.83	96.527
NPK	1.805	0.314	17.453	1.428	4.194	121.520	91.900	80.000	2.074	9190.5	16.591	380.67	95.065
Control	1.552	0.248	15.840	1.249	3.094	152.110	71.200	76.000	0.562	7120.0	11.053	268.67	94.447
F TRT	82.700**	55.360**	12.290**	57.600**	73.030**	98.170**	43.030**	3.440*	6.530**	15.420**	21.920**	16.690**	0.200
LSD 5%	0.044	0.015	0.797	0.038	0.202	7.089	3.962	9.764	0.853	661.9	16.60	50.880	-

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) (*) significant at 0.05, (**) highly significant at 0.01.

Table.6. Effect of vermicompost treatments for young instar and whole larval duration on silkworm characters.

Character / Treatment	CW (g)	CSW (g)	CSR (%)	PW (g)	SP (cg/day)	C/L (No)	CP (%)	PR (%)	DCP (No)	Crop/N (No)	Crop/w (kg)	Fecund (No)	Fertilit (%)
Young instars	1.738	0.299	17.168	1.377	4.177	130.709	85.920	83.800	0.980	8592.0	14.999	345.800	94.186
Whole instars	1.844	0.322	17.469	1.460	4.028	112.574	87.560	85.200	0.979	8756.0	16.257	411.330	96.276
F Instars	56.570**	23.380**	1.380	45.920**	5.300*	129.160**	1.860	0.410	0.001	0.670	6.240*	18.040**	1.640
LSD 5%	0.028	0.010	-	0.024	0.128	3.170	-	-	0.539	-	10.50	32.180	-

Where: (*) significant at 0.05, (**) highly significant at 0.01.

Similar results are demonstrated by Das *et al*. (2002) who determined that application of vermicompost improved mulberry silkworm cocoon weight, cocoon shell weight, cocoon shell ratio, cocoon crop by weight and number.

(Table 6) showed the impact of vermicompost treatments during young and whole larval durations on silkworm characters. Results describe the vermicompost treatment during whole larval duration earned best means comparing treatments during young instars. Generally, vermicompost fertilization is raised mulberry silkworm characters.

These results are agree with those observed by Devamani (2018) who applied vermicompost and other fertilization they noticed that cocoon weight, cocoon shell weight, cocoon shell ratio, pupal weight were improved using the vermicompost and organic fertilizers.

Effect of interactions between vermicompost treatments and the two different groups (Y; young instars while W; whole larval instars) of tested instars duration on silkworm traits were illustrated in Table 7.

Generally, control treatment was the lowest mean values for all characters. Second group treatments (treatment during whole larval durations) were the best average for all treatments. Second group of vermicompost V_3 acquired the better results followed by V_2 .So, treatment by vermicompost of V_3 and V_2 were superior to treatment with NPK.

These results are accordance with those found by Singhvi (2014) who carried out vermicompost on *Terminalia tomentosa* and fed Tasar silkworm, *Antheraea mylitta* Drury. He reported that, beneficial effect of vermicompost application on leaf quality and leaf yield, as reflected in better cocoon crop performance.

Effect of interactions between different vermicompost treatments and sexes were found in Table 8 no significant differences were detected. In any case, the average of V_3 and V_2 were better than others for both sexes. Control treatment is the lowest mean for females and males.

Data represented in Table 9 described the effect of interactions between different groups of tested instars duration and sexes on silkworm traits. Treatments during the whole instar duration were higher average than treatment during young instar duration only for females and males.

Table 7. Effect of interactions between different vermicompost treatments and different groups of tested instars duration on silkworm characters.

Character / Treatment		CW (g)	CSW (g)	CSR (%)	PW (g)	SP (cg/day)	C/L (No)	CP (%)	PR (%)	DCP (No)	Crop/N (No)	Crop/W (kg)	Fecund (No)	Fertilit (%)
V_1	Y	1.750	0.292	16.766	1.396	4.171	126.933	86.400	83.000	1.852	8640.000	15.121	310.667	92.794
	W	1.824	0.312	17.156	1.451	3.887	101.920	91.333	89.000	0.004	9131.333	16.653	421.667	98.068
V_2	Y	1.804	0.314	17.473	1.428	4.481	125.300	89.000	86.000	0.225	8900.000	16.053	391.667	94.928
	W	1.991	0.359	18.135	1.570	4.485	92.960	90.000	90.000	0.000	9001.000	17.917	457.333	94.445
V_3	Y	1.825	0.343	18.774	1.421	4.894	120.400	94.800	88.000	0.447	9480.000	17.302	421.000	95.127
	W	2.002	0.362	18.295	1.578	4.531	101.640	89.667	90.000	2.000	8966.700	17.951	484.667	97.924
NPK	Y	1.756	0.297	16.985	1.396	4.247	128.800	88.200	82.000	1.814	8820.000	15.469	337.000	93.632
	W	1.853	0.330	17.921	1.460	4.141	114.240	95.600	80.000	2.333	9561.000	17.713	424.333	96.497
Control		1.552	0.248	15.840	1.243	3.094	152.110	71.200	80.000	0.562	7120.000	11.052	268.667	94.447
F TRT X Instar		5.940**	2.440*	0.940	5.570**	1.310	11.610**	3.220*	0.610	4.590**	1.150	0.660	1.440	0.420
LSD 5%		0.072	0.022	-	0.067	-	7.089	5.603	-	1.207	-	-	-	-

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) (*) significant at 0.05, (**) highly significant at 0.01.

Table 8. Effect of interactions between different vermicompost treatments and sexes on silkworm traits.

Character / Treatment	Cocoon weight (g)		Cocoon shell weight (g)		Cocoon shell ratio (%)		Pupae weight (g)		Silk productivity (C.g)	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
V_1	1.883	1.692	0.291	0.312	15.494	18.428	1.530	1.318	3.894	4.164
V_2	2.013	1.782	0.331	0.341	16.509	19.099	1.619	1.379	4.430	4.536
V_3	2.033	1.794	0.343	0.362	16.956	20.113	1.628	1.370	4.591	4.834
NPK	1.907	1.702	0.311	0.317	16.276	18.630	1.534	1.322	4.164	4.224
Control	1.618	1.487	0.229	0.266	13.870	17.809	1.327	1.159	2.857	3.331
F TRT X Sex	1.830		1.360		1.140		1.510		1.25	

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) (*) significant at 0.05, (**) highly significant at 0.01.

Table 9. Effect of interactions between different groups of tested instars duration and sexes on silkworm traits.

Character / Treatment	Cocoon weight (g)		Cocoon shell weight (g)		Cocoon shell ratio (%)		Pupae weight (g)		Silk productivity (C.g)	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Young Instars	1.856	1.619	0.295	0.303	15.755	18.580	1.500	1.254	4.132	4.223
Whole instars	1.925	1.763	0.307	0.337	15.887	19.051	1.556	1.365	3.843	4.212
F Instar X Sexes	7.210**		5.370*		0.440		4.870*		4.570*	
LSD 5%	0.035		0.011		-		0.029		0.156	

Where: (*) significant at 0.05, (**) highly significant at 0.01.

Table 10. Effect of interactions between different vermicompost treatments, different groups of tested instars duration and sexes on silkworm traits.

Character / Treatment		Cocoon weight (g)		Cocoon shell weight (g)		Cocoon shell ratio (%)		Pupae weight (g)		Silk productivity (C.g)	
		♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
V_1	Y	1.868	1.632	0.287	0.297	15.382	18.151	1.519	1.273	4.102	4.239
	W	1.897	1.751	0.295	0.327	15.606	18.705	1.540	1.362	3.687	4.088
V_2	Y	1.947	1.660	0.322	0.305	16.557	18.390	1.563	1.293	4.603	4.360
	W	2.079	1.903	0.341	0.377	16.461	19.809	1.676	1.464	4.257	4.712
V_3	Y	1.977	1.673	0.341	0.344	17.195	20.354	1.574	1.267	4.870	4.917
	W	2.088	1.916	0.345	0.380	16.716	19.873	1.682	1.474	4.311	4.751
NPK	Y	1.871	1.642	0.230	0.299	15.771	18.199	1.514	1.278	4.227	4.268
	W	1.944	1.762	0.327	0.334	16.782	19.060	1.555	1.366	4.102	4.180
Control		1.618	1.487	0.228	0.266	13.870	17.809	1.327	1.157	2.860	3.331
F TRT X Instar X Sex		0.690		1.000		0.350		0.420		0.960	
LSD 5%		-		-		-		-		-	

Where: V_1, V_2, V_3 (vermicompost treatments), NPK (mineral treatment), TRT (treatment) (*) significant at 0.05, (**) highly significant at 0.01.

These results are coincidence with the finding of Rawgol *et al*. (2011) studied the efficacy of vermiwash-smeared mulberry leaves on cocoon characters of multivoltine hybrid mulberry silkworm, *Bombyx mori* L., they observed that, significant positive effect on cocoon characters including fresh cocoon weights, weights of shell cocoons, dry weight of de-flossed cocoons, and shell ratio percent as compared with controls.

Data registered in Table 10 represented interactions between different of vermicompost treatments, groups for tested instars duration and sexes on mulberry silkworm characters.

Regardless the insignificant differences obtained for FCW, FSW, CSR, PW and SP characters, different treatments earned highest mean values for females and males comparing with females and males control.

Treatments of V_3 and V_2 for whole larval duration for both sexes were better than other treatments. Vermicompost in general improve mulberry silkworm characters. Similar results were obtained by Chakraborty (2018) investigated the effect of different fertilization including Vermicompost on *Terminalia arjuna* and its impact on *Antheraea mylitta* Drury. He stated that, application of vermicompost in combination with reduced doses of inorganic fertilizers have had a significant effect on growth, leaf yield of Arjun plantation as well as rearing parameters of Tasar silkworm.

From the previous results, it could be concluded that Vermicompost treatments enhancing the plant parameters and silkworm characters this may be due to the composition which contain both macro, microelements and growth promoter, while the NPK containing the macro elements (NPK).

Same results are obtained by Sinha *et al.* (2009) recorded that, Earthworms vermicompost is proving to be highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional composts and a 'protective' farm input (increasing the physical, chemical & biological properties of soil, restoring & improving its natural fertility against the 'destructive' chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NKP (nitrogen 2 -3%, potassium 1.85-2.25% and phosphorus 1.55-2.25%), micronutrients, beneficial soil microbes and also contain 'plant growth hormones & enzymes'. It is scientifically proving as 'miracle growth promoter & also plant protector' from pests and diseases. Vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP to plants in shorter time, the vermicompost does.

Conclusion

Three vermicompost treatments were compared with recommended rate of NPK and null treatments (control). Vermicompost treatments improve plant characters. Treatments of V_3, V_2 and V_1 have shortage YLD, FD and WLD traits. Mostly feeding silkworm during the whole larval duration on treated mulberry leaves with vermicompost improving the average of larval traits. V_3 and V_2 treatments were the best treatment for YLD, FD, LD, third LW, fourth LW, fifth LW and LMP traits. Also, the vermicompost fertilization by rate of V_3 and V_2 is better than NPK and control for cocoon characters. Feeding with vermicompost treatment during whole larval duration earned best means comparing treatments during young instars for both sexes. So, fertilizations by rate of 1and 2 tons vermicompost per 0.42 hectare are recommended for rearing mulberry silkworm instead of NPK fertilization.

References

Abbasi SA, Ramasamy EV (1999) Biotechnological methods of acids derived from earthworm-processed organic wastes on plant growth. Bioresour Technol 84, 7-14.

Anwar M, Patra DD, Chand S, Kumar A, Naqvi AA , Khanuja SPS (2005) Effect of organic manures and inorganic fertilizer on growth, herb and oil yield, nutrient accumulation, and oil quality of French basil. Commun Soil Sci Plant Anal 36(1-14), 1737-1746.

Arancon NQ, Edwards CA, Bierman P, Welch C, Metzger JD (2004) Influences of vermicomposts on field strawberries: 1. effects on growth and yields. Bioresour Technol 93, 145-153.

Arancon NQ, Edwards CA, Bierman P, Metzger JD, Lucht C (2005) Effects of vermicomposts produced from cattle manure, food waste and paper waste on the growth and yield of peppers in the field. Pedobiologia 49, 297-306.

Argüello JA, Ledesma A, Núñez SB, Rodríguez CH, Díaz Goldfarb MDC (2006) Vermicompost effects on bulbing dynamics nonstructural carbohydrate content, yield, and quality of 'Rosado Paraguayo' garlic bulbs. Hortscience 41(3), 589-592.

Atiyeh RM, Edwards CA, Subler S, Metzger JD (2001) Pig manure vermicompost as a component of a horticultural bedding plant medium: Effects on physicochemical properties and plant growth. Bioresour Technol 78, 11-20.

Azarmi R, Giglou MT, Taleshmikail RD (2008) Influence of vermicompost on soil chemical and physical properties in tomato (*Lycopersicum esculentum*) field. Afr J Biotechnol 7(14), 2397-2401.

Chakraborty B (2018) Evaluation of the leaf productivity of *terminalia arjuna* and its impact on commercial traits of tropical tasar silkworm (*Antheraea mylitta* Drury) under organic based agroforestry system. Int J Adv Sci Eng Technol 6(7), 52-54.

Das PK, Bhogesha K, Theerthaprasad BM, Katiyar RS, Vijayakumari KM, Madhava, *et al.* (2002) Vermicomposting of sericultural wastes and its impact on mulberry production. In: Advances in Indian Sericulture Research (Eds. S.B. Dandin, R.K. Mishra and V.P. Gupta), CSR&TI, Mysore, pp: 189-193.

Devamani M (2018) Impact of INM on Selected Mulberry and Silkworm Traits. Int J Sci Res 8(3), 1207-1210.

Gajalakshmi S , Abbasi SA (2004) Earthworms and vermicomposting. Indian J Biotechnol 3(10), 486-494.

Ghazy MU (2008). Rearing first three instars of mulberry silkworm *Bombyx mori* L., under polythene cover. Bull Ent Soc Egypt 85, 271 – 279.

Hosny A, Megalla AH, Mahmoud SM (2002) Evaluation of some economic parameters of the silkworm, *Bombyx mori* L., by using some disinfectants during the larval stage. 2nd international conference 21-24 December, Plant Protection Research Institute, Cairo, Egypt, 1, 217- 220.

Karmegam N, Alagumalai K, Daniel T (1999) Effect of vermicompost on the growth and yield of green gram (*Phaseolus aureus* Roxb.). Trop Agric 76, 143-146.

Lazcano C, Domínguez J. (2011) The use of vermicompost in sustainable agriculture impact on plant growth and soil fertility. In: Soil Nutrients, (Eds) Miransari, M. PP: 1-23.

Lazcano C, Revilla P, Malvar RA, Domínguez J (2011) Yield and fruit quality of four sweet corn hybrids (*Zea mays*) under conventional and integrated fertilization with vermicompost. J Sci Food Agric 91(7), 1155-1340.

Lea H Z (1996) Basic principles and practical techniques of silkworm. Breeding department of biology, Kangwon National University, Chunchon, Korea .

Mahesh DS, Doreswamy C, Chikkalingaiah, Ramakrishna N, Subbarayappa CT, Venkatesh M (2018) Rearing performances of PM X CSR_2 fed with mulberry raised through different organic manures. Adv Biores 9(5), 96-99.

Patil SV, Mallikarjunappa RS, Dandin SB, Eswara RMS (2001) Evaluation of improved genotypes of mulberry through leaf chemical analysis and bioassay with silkworm races NB4D2. Sericologia

41(2), 219-226.

Rasool A, Parviz SZ, and Mohammad RS (2008) Effect of Vermicompost on growth, yield and nutrition status of tomato (Lycopersicum esculentum). Pak J Biol Sci 11, 1797-1802.

Rathore MS, Singh M, Panwar D, Shekhawat NS (2007) Vermicomposting: towards clean and green farming. Green Farming, 1(1): 28-30.

Rawgol KY, Maddi PP, Sharma V, Kale DK (2011) Effeciacy of vermiwash-smeared mulberry leaves on cocoon characters of multivoltine hybrid mulberry silkworm, *Bombyx mori* L.: Kolar gold race. Int J Res Sci Technol 1(2), 1-22.

Rekha GS, Kaleena PK, Elumalai D and Srikumaran, MP (2018) Effects of vermicompost and plant growth enhancers on the exo-morphological features of Capsicum annum (Linn.) Hepper. Int J Recycl Org Waste Agric 7, 83–88.

SAS institute (1998) SAS user's guide. Statistics SAS Institute Cary, N. C.

Singhvi NR (2014) Effect of vermicompost application on leaf yield in terminalia tomentosa W&A and tasar cocoon production. Plant Arch 14(1), 97-99.

Sinha PS, Angina R, Singh BD, Griyaghey UP, Sharatchandra B, Sinha BR RP (2005) Studies on the vermiculture technique and efficacy of vermicompost in substituting NPK and FYM requirements of *Morus alba* L. Indian J Agric Res 39(4), 235-241.

Sinha R, Herat S, Valani D, Chauhan K (2009) Earthworms vermicompost: a powerful crop nutrient over the conventional compost & protective soil conditioner against the destructive chemical fertilizers for food safety and security am-euras. J Agric Environ Sci 5(S), 1-55.

Vasanthi K, Chairman K, Ranjit Singh AJA (2013) Vermicomposting of leaf litter ensuing from the trees of Mango (*Mangifera indica*) and Guava (*Psidium guujuvu*) leaves. Int J Adv Res 1(3), 33-38.

Venugopal A, Chandrasekhar M, Naidu BV, Raju S (2010). Vermicomposting in sericulture using mixed culture of earthworms (*Eudrillus eugineae*, *eisenia foetida* and *perionyx excavates*)- A review. Agric Res Commun Cent 31(2), 150 – 154.

Wani MY, Mir MR, Baqual MF, Mehraj K, Bhat TA, Rani S (2017) Role of foliar sprays in sericulture industry. Journal of Pharmacogn Phytochem 6(4), 1803-1806.

Zhen LX, Tan YF, Huang GX, Maben (1988) Mulberry cultivation. FAO Agric Serv Bull 73(1), 68 -69.