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Impact of Bio and Inorganic Fertilizer Treatments on Economic Traits of Mulberry Silkworm (*Bombyx mori* L.)

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Abstract: Silkworm (*Bombyx mori* L.) is a monophagous insect that drives almost all required nutrients for its growth and development from mulberry leaf. Nutrition plays a vital role in sericulture. It improves the growth, development, health, feed consumption and conversion of silkworm thereby improving the commercial traits. Application of the required nutrient in the required amount to mulberry plant is, therefore, very essential for the successful silkworm growth and cocoon production. The present study was carried out at the Department of Plant Protection, Faculty of Agriculture Moshtohor, Benha University, Egypt. Chemical fertilizer, bio-fertilizer and its mixture increased the traits of fresh cocoon weight, cocoon shell weight, cocoon shell ratio, total larval duration, hatchability, silk gland weight, filament length and filament weight and filament size. While, application by bio-fertilizer resulted in better values for cocoon shell ratio, cocoon formation percentage, larval weight, total larval duration, silk gland length and filament length. Both chemical and bio fertilizes exhibited better values for pupal weight. Also, bio-fertilizer acquired the best values for pupation ratio and cocoon formation percentage. Control and chemical fertilizer treatment gave the highest values for fecundity and fertility traits. While, mixture and bio-fertilizers resulted in the best values for silk gland length.

Key words: Silkworm · *Bombyx mori* · Mulberry leaf · Bio-fertilizers · Inorganic fertilizers · Biological aspects · Economic traits

INTRODUCTION

Chemical constituents in plants provide information for determining the host range in phytophagous insects [1, 2]. Among various factors, taste information is the key for initiating food intake [1, 3]. The domesticated silkworm, *Bombyx mori* L., is a monophagous insect that can be raised on fresh mulberry leaves (*Morus alba* L.). Several silkworm feeding stimulants have been isolated from mulberry leaves [4, 5] among them, sucrose is a powerful feeding [6] and myo-inositol synergizes the effect of sucrose [7]. Mulberry (*Morus alba* L.) is a sole food plant for silkworm (*B. mori* L.). Good quality leaf production in mulberry is highly dependent on the supply of various inputs especially nitrogen and phosphorus fertilizers [8]. Application of organic fertilizers to mulberry had a significant influence on cocoon yield, shell ratio, silk productivity and single cocoon filament length [9, 10]. Singheal *et al.* [11] pointed that quality of mulberry leaf fed to silkworms is the most important factor that influences successful cocoon production by mulberry silkworm. Also, the inorganic fertilizers has increased mulberry yield leading to better silk worm productivity [12]. I t has been realized that, in the past, this was achieved by the expense of soil health, moreover, some portions of the nutrients applied to the soil are still bound to be unused as they are not available to the plant. Bio-fertilizers and mixture between chemical and bio-fertilizers can be used to reduce the amount of Nitrogen and Phosphorus fertilizers. Rao *et al.* [13] studied that, the influence of VAM fungi and bacterial bio-fertilizer (BBF) with 50% reduction in the recommended dose of (N and P) chemical fertilizers on leaf quality traits of mulberry variety (S-13) and its impact on silkworm (PM x NB4D2) growth and cocoon characters under semi-arid conditions. Bio-inoculants are carrier based preparations containing beneficial micro-organisms in a viable form intended for soil or seed application and designed to improve the soil fertility and help the plant growth by increasing their number and biological activity

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in the rhizosphere [14]. Usage of a combination of organic and inorganic fertilizers, increasing the carbohydrate and crude protein percentage of the mulberry leaves significantly increased the silkworm larval body weight, silk gland weight and ultimately the cocoon yield etc. [15]. The quality of mulberry leaves specially scattered along the canals road sides is inferior. When, rearing silkworm larvae on these leaves will resulted in decrease of silk production.

The objective of the present study is to determine the impact of bio-fertilizers, inorganic fertilizers application and their mixture to increase the quality of mulberry leaves and subsequently the effect on the larval body weight, silk gland weight and ultimately the cocoon yield.

MATERIALS AND METHODS

The native Mulberry (*Morus alba var rosa*) leaves was used to feed the mulberry silkworm larvae. Mulberry trees were treated with bio fertilizes, chemical fertilizers and the mixture of them through the addition in soil. Nitroben containing *Azotobacter* spp. And *Azosprillum* spp. and phosphoren contains *Bacillus magatherium*, two bio-fertilizers obtained from General Organization for Agricultural Equalization Fund (GOAEF)-Public Authority for Agricultural Fund Budget- Ministry of Agriculture, Egypt were used. Also, chemical fertilizer was used as Nitrogen in the form of Urea (46%N), phosphorus in the form of super phosphate (16% P_2O_5) and potassium in the form of potassium sulfate (48 % K_2O).

Treatments of bio-fertilizes, chemical fertilizers and their mixture were as follows:

- Plants without fertilization (control)
- T 1 = 700g Nitroben (Bio-N) + 300g Phosphoren (Bio-P)
- T 2 = 500g Bio-N + 150g Bio-P. (Recommended dose)
- ST 3 = 250g Bio-N + 75g Bio-P
- Chemical fertilizers (Urea (46% N) + super phosphate (16% P_2O_5) + potassium sulphate 48% K_2O) as follows:
- T4 = 800g N + 600g P + 500g K
- T5 = 400g N + 300g P + 250g K. (Recommended dose)
- T 6 = 200g N + 150g P + 125g K.

Mixture between (bio and chemical) fertilizers as follows.

- T7 = 520g N + 390g P + 500g K + 700g Bio-N + 300g Bio-P
- T8 = 260gN+ 195gP + 250gK + 500g Bio-N+ 150g Bio-P (Recommended dose)
- T9 = 130g N + 97.5g P + 125g K + 250g Bio-N + 75g Bio-P

The newly hatched silkworm larvae were divided into ten treatments including control. Each treatment represented by three replicates. Each replicate one hundred larvae. For each Chopped leaves were offered four times daily to young silkworm (first, second and third instars). While, whole leaves were offered for grown silkworm (fourth and fifth instars). The following characters were fresh cocoon weight (FCW), cocoon shell weight (CSW), pupal weight (PW), cocoon shell ratio (CSR), pupation ratio (PR), of cocoon percentage (CP), larval weight (LW), fecundity number of eggs per female (Fecu), fertility fertile eggs per female (fert), total larval duration (TLD), hatchability (Hatch), silk gland weight (SGW), silk gland length (SGL), filament length (FL), filament weight (FW) and filament size (FS), were studied and investigated.

Hatchability Percentage (%): Hatchability percentage of eggs was (estimated according to the following formula of Lea [16]:

$$\text{Hatchability (\%)} = \frac{\text{Number of hatched larvae}}{\text{Number of fertilized eggs}} \times 100$$

Cocoons and Reeled Silk Filament Characters:
A: Fresh cocoon weight (g).
B: Cocoon shell weight (g).
C: Cocoon shell ratio = (B/A) x 100 [17].

Also the weight (mg) and length (m) of reeled silk filament were measured and recorded. The size of the reeled filament (denier) was estimated according to Tanaka [17] formula:

$$\text{The size of filament} = \frac{\text{Weight of reeled filament (mg)}}{\text{Length of reeled filament (m)}} \times 9000$$

The experiments were carried out during two successive spring seasons (2011 and 2012) in the Laboratories of Plant Protection Department, Faculty of Agriculture, Moshtohor Benha University. Mulberry silkworm (*Bombyx mori* L.) eggs were obtained from the Sericulture Research Department of Plant Protection Research Institute, Agricultural Research Center, Ministry of Agriculture and Land Reclamation in Giza, Egypt.

Statistical Analysis: The statistical analysis was carried out using ANOVA with two factors under significance level of 0.05 for the whole results using SPSS (ver. 19) and complete randomized design were used according to Steel *et al.* [18]. Multiple comparisons were carried out applying LSD.

RESULTS AND DISCUSSION

Effect of different fertilizers and their mixtures on some economic characters of mulberry silkworm is presented in Tables 1a and 1b. No significant differences were found between control, chemical, bio-fertilizers and their mixture for weights of fresh cocoon, cocoon shell, larvae and silk gland, pupation ratio and fertility. While the other characters cocoon percentage, fecundity (number of eggs per female), total larval duration, silk ratio, hatchability, silk gland length, filament weight, filament length and filament size showed significant difference.

Part 1: Effect of Bio-Fertilizers: Bio-fertilizers increased fresh cocoon weight, cocoon shell weight, cocoon shell ratio, total larval duration, hatchability, silk gland weight, filament weight, length and size. The application Bio-fertilizer resulted in better values for silk gland length, pupation ratio, cocoon percentage and larval weight.

Part 2: Effect of the Mixture of Both Chemical and Bio-Fertilizer: Mixture fertilizes gave the best values for silk gland length and also, increased fresh cocoon weight, cocoon shell weight, cocoon shell ratio, total larval duration, hatchability, silk gland weight, filament weight, length and size.

Part 3: Effect of Chemical Fertilizers: Chemical fertilizers increased fresh cocoon weight, shell cocoon weight, cocoon shell ratio, total larval duration, hatchability, silk gland weight, filament weight, length and size. Also, gave the better values for pupal weight, fecundity and fertility traits. Between chemical fertilizers, treatment T6 acquired best values for cocoon shell ratio, pupation ratio, cocooning percentage, fertility, silk gland length, filament weight and filament size. And there were no significant differences between T6 and T5 for fresh cocoon weight, cocoon shell weight, larval weight and total larval duration. Also, there were insignificant differences for pupal weight, hatchability, filament length and silk gland weight.

Treatment T7 shows better values for fresh cocoon weight, cocoon shell weight, cocoon shell ratio, silk gland weight, filament length and filament weight and filament size from mixture fertilizers treatments with insignificant differences with Treatment T8 for pupal weight and fecundity. Also, there was no significant difference between treatment T7 and T9 for hatchability and larval weight. These results are in agreement with those obtained by Rao *et al.* [19], Mary and Saravanan [20] and Waktole and Bhaskar [21] who reported that nutrition plays a pivotal role in sericulture. It improves the growth, development, health, feed consumption and conversion of silkworm thereby improving the commercial traits. Silkworm (*Bombyx mori* L.) is a monophagous insect that drives almost all required nutrients for its growth and development from mulberry leaf. Application of the required nutrient in a balanced amount to mulberry plant is, therefore, very essential for the successful silkworm growth and cocoon production. Objective is determining the effect of bio-inoculants application to mulberry plant on silkworm growth, development and cocoon traits. The results revealed that the larval growth variables and cocoon traits were significantly better when developing worms were fed on mulberry leaves raised by applying the recommended doses of nutrients. Mulberry (*Morus alba* L.) is a sole host plant for silkworm (*B. mori* L.). Good quality leaf production in mulberry is highly dependent on supply of various inputs especially nitrogen and phosphorus fertilizers [8, 21]. The quality of mulberry leaf fed to silkworms is the most important factor that influences successful cocoon production by mulberry silkworm. Use of inorganic fertilizers has increased mulberry yield leading to better silkworm productivity [12]. But it has been realized that, in the past, this was responsible about soil health. Moreover, some portions of the nutrients applied to the soil are still bound to be unused as they are not available to the plant. This increased the cost of mulberry leaf production. In addition, continuous supplementation of chemical fertilizers to mulberry is hazardous to environment [21]. Also, Sannappa *et al.* [9] and Raje Gowda [10] found that, application of organic fertilizers to mulberry had a significant influence on cocoon yield, shell ratio, silk productivity and single cocoon filament length.

Data presented in Tables 1a and 1b indicated that T1 produced the best values for all characters with insignificant differences with treatment T2 of cocoon shell ratio, pupation ratio, filament length, filament weight and larval weight. Also, no significant differences with

Table 1a: Effect of different fertilizers on some economic characters of mulberry silkworm *(Bombyx mori* L.)

Type fertilizer	Treatments	FCW (g)	CSW (g)	CSR %	PW (g)	Pupation	Cocooning %	LW (g)	Fecundity No. egg/female
Bio fertilizer	T1	1.68	0.377	23.285	1.34	96.665	99.165	3.325	533.5
	T2	1.565	0.365	23.14	1.205	97.41	99.165	3.985	519.985
	T3	1.56	0.368	23.595	1.24	100	99.15	3.195	514.835
Chemical fertilizer	T4	1.635	0.378	22.34	1.265	96.485	95.835	2.86	604.67
	T5	1.74	0.387	22.815	1.255	98.245	95.835	3.585	548.135
	T6	1.61	0.384	23.475	1.22	98.29	96.165	3.45	523.5
Mixture (bio + chem. fertilizer)	T7	1.59	0.368	24.95	1.19	94.035	97.5	3.255	535.835
	T8	1.565	0.368	22.75	1.195	100	100	3.315	550.635
	T9	1.475	0.354	21.83	1.155	98.195	98.165	3.845	482
Control		1.52	0.338	21.91	1.18	98.34	99.17	3.22	542.50
F		1.037	1.116	10.399*	1.438	0.933	1.009	0.711	7.347*
LSD		0.17	0.10	1.02	0.10	5.42	2.28	1.29	29.62

Fresh cocoon weight (FCW), cocoon shell weight (CSW), cocoon shell ratio (CSR), pupal weight (PW), larval weight (LW)

Table 1b: Effect of different fertilizers on some economic characters of mulberry silkworm (*Bombyx mori* L).

Type fertilizer	Treatments	Egg fertility %	TLD	Hatchability %	SGW (g)	SGL (cm)	FL (m)	FW (g)	FS (dn)
Bio fertilizer	T1	98.755	30.31	99.325	1.03	30.16	1341.7	0.319	2.155
	T2	98.39	31.09	99.37	1.19	28.765	1671.825	0.341	2.125
	T3	98.475	29.565	99.545	1.135	30.395	1459.6	0.338	2.16
Chemical fertilizer	T4	98.765	31.71	99.63	1.32	27.63	1380.1	0.327	2.235
	T5	98.5	31.1	99.36	1.13	25.38	1373.4	0.3015	2.14
	T6	98.78	31.285	99.555	1.005	27.93	1273.2	0.3325	2.255
Mixture (bio + chem. fertilizer)	T7	96.635	31.42	99.3	1.155	29.64	1293.6	0.328	2.315
	T8	98.58	32.155	99.28	1.015	28.22	1180.25	0.2745	2.07
	T9	98.11	30.335	99.485	1.06	28.53	1106.7	0.2615	2.22
Control		98.57	31.43	98.88	0.97	26.98	1098.00	0.236	1.93
F		1.073	7.505*	0.644	0.711	1.001	0.704	1.912	5.030*
LSD		1.89	1.03	0.39	0.42	2.32	419	0.05	0.09

Total larval duration (TLD), silk gland weight (SGW), silk gland length (SGL), filament length (F L), filament weight (F W) and filament size (F S)

treatment T3 of total larval duration, hatchability, silk gland weight, silk gland length and filament size [9]. All fertilizers treatments gave better results for cocoon shell weight, filament length, weight & size, silk gland length & weight and hatchability. And, fresh cocoon weight, cocoon shell ratio and pupal weight showed better values for all treatment except treatment T9. Generally, bio-fertilizers and mixture between chemical and bio-fertilizers can be used to reduce amount of Nitrogen and Phosphorus fertilizers. Similar results were reported by Rao *et al.* [13], who studied the influence of VAM fungi and bacterial bio-fertilizer (BBF) with 50% reduction in the recommended dose of (N and P) chemical fertilizers on leaf quality traits of mulberry variety (S-13) and its impact on silkworm (PM x NB4D2) growth and cocoon characters under semi-arid conditions. Four different treatments were imposed i.e., T1: Control (only 100% NPK); T2: VAM (50% cut in P); T3: BBF (50% cut in N) and T4: BBF and VAM (50% cut in N and P). The results revealed that reduction (50%) in the dose of chemical fertilizers in T2, T3 and T4 did not affect the leaf quality traits or cocoon parameters; this may be due to the effect of microbial inoculants in these treatments, which had efficiently regulated the normal growth, metabolism and physiological activity in plants. Among the three bio-fertilizer treatments, leaf quality, silkworm growth and cocoon parameters were found improved in T4 and was on par with T1 control. The dual inoculation (T4) proved economical and beneficial with regard to saving of 50% cost of chemical fertilizers and improvement in soil fertility, leaf quality and cocoon parameters, thus this technology can be recommended to sericulture farmers of semi-arid conditions. From all mentioned results it is clear that bio-fertilizers was the best one followed by the mixture between chemical and bio-fertilizers and finally chemical fertilizers in increasing the studied characters (fresh cocoon weight, cocoon shell weight, cocoon shell ratio, total larval duration, hatchability, silk gland weight, filament weight, length and size, silk gland length and pupal weight). This may be due to easy absorption of bio-fertilizer and it is free of any harmless to plant and subsequently to mulberry silkworms eating it.

CONCLUSION

Mulberry silkworm *Bombyx mori* L. is monophagous. So that, any deficiency of quality and quantity of mulberry leaves leads to reduce the quality and quantity of cocoon production. Mulberry trees of *Morus alba var rosa* was applied with different treatments of chemical, bio-fertilizers (nitroben and phosphoren (and their mixture. Bio-fertilizers nitroben is contains of *Azotobacter* sp. and *Azosprillum* sp. While, phosphoren contains *Bacillus magatherium*. Seventeen economic characters were taken into consideration. Chemical, bio-fertilizers and their mixture increased fresh cocoon weight, cocoon shell weight, cocoon shell ratio, total larval duration, hatchability, silk gland weight, filament length and filament weight and filament size. While, application by bio-fertilizer resulted in better values for cocoon shell ratio, cocoon percentage, larval weight, total larval duration, silk gland length and filament length. Both chemical and bio fertilizes exhibited better values for pupal weight. From the previous mentioned results fertilizers may be arranged from the side of its importance to mulberry trees and silkworms as follows: Bio-fertilizers, mixture of both (chemical and bio-fertilizers) and finally the chemical fertilizers.

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