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Impact of Repeated Applications of Chemical Fertilizers in Mulberry Cropping System on Soil Health, Leaf Production and Rearing Parameters of Silkworm, *Bombyx mori* L.

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Authors' contributions

This work was carried out in collaboration between both authors. Author NS designed the study, performed statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SAD managed the analysis of study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: To find out the effect of continuous use of chemical fertilizers in the mulberry ecosystem.
Study Design: CRBD
Place and Duration of Study: Potential sericulture cluster in Erode district of Tamil Nadu, India, between January 2015 and December 2016.
Methodology: Standard methodologies used to study the physical, chemical and biological properties of soil, foliar constituents of mulberry and rearing parameters of the silkworm.
Results: Repeated applications of chemical fertilizers in mulberry cropping system registered more bulk density (1.57 mg m^{-3}), P^H (9.22) and EC (0.361 dS/m) and reduced field capacity (23.47%), water holding capacity (39.15%), porosity (35.60%), infiltration rate (3.20 cm/hr^{-1}) and the

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population of soil microbes viz. bacteria (19.66 cfu/g), fungi (13.00 cfu/g) and actinomycetes (9.33 cfu/g) when compared to the respective values of manuring practices with 100% organic inputs (1.23 mg m^{-3}, 7.39, 0.106 dS/m & 31.25%, 58.59%, 49.25% & 7.68 cm/hr^{-1} and 68.00 cfu/g, 25.33 cfu/g & 21.33 cfu/g). Lowest contents of available N (105 kg/h), P (9.75 kg/ha & K 318.70 kg/ha recorded in the gardens repeatedly received inorganic fertilizers than organic farming system (283.73, 35.81 & 340.12 kg/ha of NPK) which reflected adversely on mulberry leaf yield (43.41 MT/ha/yr) and moisture content (60.53%), moisture retention capacity (63.66%), total protein (16.83%) and total carbohydrates (28.03%) whereas in organic farming the respective values (55.80 MT/ha/yr, 71.33%, 93.36%, 21.60% & 36.23%) were found superior. Organic manuring practices registered better cocoon yield (88.348 kg/100 dfls) and average cocoon productivity (3286 kg/ha of mulberry garden) when compared to chemical farming (55.595 kg/100 dfls and 3286 kg/ha of mulberry garden).

Conclusions: A holistic approach should be made for creating awareness among the sericulture farmers and popularizing organic farming strategies to maintain soil health, improve production of quality mulberry leaf and sustainable production of silk.

Keywords: Morus alba; inorganic manures; organic inputs; soil properties; leaf yield; quality; silkworm rearing.

1. INTRODUCTION

Mulberry, the food plant of the silkworm is cultivated over 2.8 lakh hectares in the country and exploited for the rearing of silkworms and silk production called sericulture. Silk productivity and profit of the farmers mainly depends upon the quantum as well as the quality of mulberry leaves produced as the former influences on rearing capacity of silkworms *i.e.,* the quantum of larvae to be reared and the later play vital role on their growth and development and silk yield. Mulberry is a perennial tree and once cultivated maintained years together with continuous agronomical practices. Under an advanced package of practices of silkworm rearing with mulberry shoots, approximately 3-4 metric ton of foliage is harvested from one acre of mulberry garden at each silkworm rearing. However, under irrigated conditions, the plants are capable to rejuvenate the foliage shortly by devouring soil nutrients and become ready for subsequent harvests a month after each pruning. It causes depletion of about 28 kg of nitrogen (N), 11 kg of phosphorus (P) and 11 kg of potash (K). Therefore, the farmers need to replenish the soil nutrients with the recommended dosage of 140 kg of ammonium sulphate, 70 kg of single super phosphate and 18 kg muriate of potash / acre / crop for sustainable production of quality mulberry leaves [1]. Chemical based inputs are invariably preferred by the farmers because of short-term results and economy.

Farmers could harvest shoots from mulberry garden 5-6 times in a year at the bimonthly interval to take up silkworm rearing. Hence, an annual input of about 1.40 MT of chemical fertilizers is applied in one acre of the plantation. Such continuous overuse of chemical fertilizers pollutes the soil and groundwater, alters physical and chemical properties of soil, depletes the naturally available essential nutrients besides deleterious effect on beneficial micro and micro-organisms which play vital role on soil health and plants growth [2]. Therefore, an attempt has been made in this study to find out the impact of such repeated use of chemical fertilizers in the mulberry ecosystem on soil health, leaf production and rearing parameters of silkworm, *Bombyx mori* L.

2. MATERIALS AND METHODS

The studies were conducted in Erode district of Tamil Nadu, India, one of the leading zones of silk production in the state with adoption of advanced sericulture technologies. Erode District is situated between 10º36’ and 11º58’ North Latitude and 76º49’ and 77º 58’ East Longitude and 171.91 meters above mean sea level. The soil of the district is mostly red sandy and gravel with moderate amounts of red-loamy and occasional black loamy tracts. Soil pH ranges from 8.0 - 9.0. The temperature ranging from 18.5ºC in December to 32.2ºC in May for the coldest and hottest periods respectively and the annual average precipitation is 823 mm. Survey was conducted with farmers who practicing sericulture more than five years and obtained information on fertilizer type and usage history in their mulberry garden. Based on the survey the farmers were categorized in to five groups as detailed below.

T_1 Farmers using chemical fertilizers following recommended doses of N (ammonium sulphate), P (single super phosphate) and K (muriate of potash) @ 28:11:11 kg per crop and apply farm yard manure (FYM) @ 8-10 MT / ha/year [1].

T_2 50% reduced application of recommended doses of N & P, apply *Azospirillum* & Phosphobacteria formulation @ 2 kg each / crop and FYM @ 8-10 MT / ha/year.

T_3 75% reduced application of recommended doses of N & P, apply *Azospirillum* & Phosphobacteria formulation @ 2 kg each / crop, FYM @ 8-10 MT / ha/year and annual green manuring with dhaincha (*Sesbania aculeata*).

T_4 Invariably apply different organic inputs (100% organic) *viz.* Azospirillum & Phosphobacteria formulation @ 2 kg/crop, FYM @ 8-10 MT / ha/year and one time mulching of green manure dhaincha (*Sesbania aculeata*) and other organic inputs like poultry manure, pressmud *etc.*

T_5 Farmers using only chemical fertilizers irrespective of recommendations (control farmers).

Soil samples from the 5 mulberry gardens from each group were collected in bimonthly intervals covering six crops for the period of twelve months after each silkworm rearing, *i.e.* after completion of each shoot harvest and before application of manures for next crop. The samples were collected from a depth of 0-30 cm by digging 1x1x1 feet cubic pits. The soil from the sides of the pit was scraped out and collected at 4-5 locations. The soil collected from various pits of a garden was mixed thoroughly, spread over a plastic sheet, divided into four equal parts and one set of opposite quarters was discarded. The remaining two parts were mixed well and the process repeated for 2-3 times and reduced to 500-700 gram.

2.1 Study of Physiochemical Properties

The composite samples were air dried and grinded in a wooden pestle and mortar to pass through 2 mm sieve and subsequently stored in polyethylene bags. The physical and chemical properties of soil *viz.* bulk density, water holding capacity, porosity [3], field capacity [4], infiltration rate [5], soil pH, electric conductivity, organic carbon, available nitrogen, available phosphorus and available potassium [6] were analyzed following standard methods.

2.2 Study of Soil Microflora

The soil samples from each category of farmers were mixed together to form a composite sample for isolation of microbes by dilution plate technique [7] and different microflora were recorded and the population in terms of colony forming units (CFU) per gram soil was calculated using the following formula [8].

$$CFU/g = \frac{AxBxC}{D}$$

Where

A= Average number of colonies developed
B= Final dilution
C=Volume of water used for suspension of sample
D= Weigh of the sample

2.3 Growth and yield Parameters of Mulberry

Mulberry growth parameters *viz.* plant height (cm), leaf yield per plant (g), leaf yield per hectare (MT/ha/year) and silkworm rearing capacity of a different category of the farmers were recorded for every crop at 60^{th} day after each pruning.

2.4 Quality Parameters of Mulberry

The quality parameters of mulberry leaf viz., moisture content (%), leaf moisture retention capacity [9], total protein [10] and total carbohydrate [11] were estimated using standard procedures.

2.5 Rearing Performance of Silkworm

In order to find out the effect of manuring practices on rearing parameters of silkworm, all the farmers were uniformly supplied with the commercial double hybrid FC1 x FC2 silkworms after second moult and allowed to rear further as per the recommended package of practices [3] till cocooning and entire rearing were monitored by periodical visits. Data on larval periods (days), matured larval weight (g), incidence of disease (%), survivability (ERR%), single cocoon weight (g), single shell weight (g), silk ratio (%), average cocoon yield (kg/100 dfls), average cocoon productivity (kg/ha of mulberry garden) were recorded at each rearing.

Analysis of variance (ANOVA) for soil physical and chemical properties of soil, groundwater analysis, microbial population, growth and quality parameters of mulberry and rearing performance of silkworm were analyzed by using STATISTICA version 6.

3. RESULTS AND DISCUSSION

3.1 Physical Properties of Soil

Influence of different manuring practices in the mulberry garden on physical properties of soil *viz.* bulk density, water holding capacity, porosity and infiltration rate are presented in Table 1. Highest bulk density (1.57) was recorded with control (T5) in which the garden received only inorganic fertilizers which was on a par (1.50) with the gardens where FYM was applied once in a year additionally (T1). The bulk density was decreased in relation to the reduced application of chemical fertilizers. Lowest bulk density (1.23) was recorded with the 100% organic inputs (T4) it was followed by T3 (1.35) and T2 (1.48). However, pure organic manuring practices (T4) exhibited highest moisture content at field capacity (31.25%), water holding capacity (58.59%), porosity (49.25%) and infiltration rate (7.68 Cm/hr^{-1}) where as these values were decreased in relation to the increase in application of chemical fertilizers and least values in the respective parameters (23.47, 39.15, 35.60 and 3.20) were recorded with the control gardens (T5).

The decrease in values of bulk density may be due to increases in soil organic matter with greater extend and it might have bound primary soil particles to form soil aggregates resulting an increase in total pore space and decreased in the mass of unit volume of soil. Rumpel [12] Observed that the soil bulk density decreased while porosity and water retention increased significantly with organic inputs. The integrated use of different organic manures gave higher values for field capacity mainly because they improved the soil aggregates and pores spaces which allowed the free movement of water within the soil. The results were corroborated by findings of Walia et al. [13]. The lower values of porosity in inorganic soil were attributed to the presence of lesser organic matter content fewer aggregates and less root penetration. This was supported by the findings of Rajkannan et al. [14]. The trend of variation of infiltration rate among the treatments might be attributed to the variation in the improvement of soil structure with the application of manure and fertilizers. The lowest value of infiltration rate obtained with the control was clearly indicated the deterioration of soil structure over a long term application of chemical fertilizers. Significantly highest value of infiltration rate after use of more organic inputs might be due to improvement of soil aggregates thereby increased macro-porosity which resulted in reducing the bulk density of the soil. This was in accordance with the early findings [15].

3.2 Chemical Properties of Soil

The chemical properties of soil *viz.* pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), available phosphorus (P), and available potassium (K) were influenced significantly by different sources of soil nutrients (Table 2).

The Soil pH was in desirable range 7.39 and 7.37 with the application of organic manures (T4) and combined application organic inputs with only 25% chemical fertilizers (T3) which was closely followed (7.91) by T2 but increased (9.22) adversely with only chemical fertilizer (T5). The value of electrical conductivity was found less than 0.8 dS/m in all the treatments which were found safe for the mulberry crop. However, highest EC (0.361) was recorded with the gardens received only chemical fertilizers (T5) and it was followed by T1 (0.283). Reduction in chemical fertilizers and increase in organic inputs exhibited decreased EC (T2-T4) and it was not significantly differed in relation to percent reduction of chemical fertilizers. Application of purely organic manures (T4) and organics with inorganic combinations (T3&T2) resulted in significantly higher percentage of organic carbon content, 0.82% and 0.66 & 0.48% respectively over control (0.29) whereas one time application of FYM with 100% NPK as inorganic manures (T1) was found on par (0.31) with control (T5). The quantities of available form of all three major nutrients soil nutrients *viz.* nitrogen (kg/ha), phosphorus (kg/ha) and potassium (kg/ha) were found comparatively higher (283.73, 35.81 and 340.12) in the gardens applied repeatedly with organic inputs (T4) and these values decreased with increase in quantity of chemical fertilizers. The gardens received continuous doses of inorganic fertilizers (T5) registered lowest values of NPK (105.33, 9.75 & 318.70).

Table 1. Physical properties of soil as influenced by different manuring practices in mulberry

Treatments	Bulk density (Mg m^{-3})	Field capacity (%)	Water holding capacity (%)	Porosity (%)	Infiltration rate (Cm/hr^{-1})
T_1	1.50	23.83	43.67	38.56	4.22
T_2	1.48	25.10	50.40	43.78	6.49
T_3	1.35	30.66	53.33	47.22	7.05
T_4	1.23	31.25	58.59	49.25	7.68
T_5 Control	1.57	23.47	39.15	35.60	3.20
CD (P=0.05)	0.05	3.16	5.38	6.75	1.66

Table 2. Chemical properties of soil as influenced by different manuring practices in mulberry

Treatments	pH	EC(dS/m)	OC (%)	Available nitrogen (Kg/ha)	Available phosphorus (Kg/ha)	Available potassium (Kg/ha)
T_1	8.53	0.283	0.31	111.35	13.83	325.08
T_2	7.91	0.183	0.48	200.67	23.33	338.00
T_3	7.37	0.117	0.66	217.36	35.06	337.30
T_4	7.39	0.106	0.82	283.73	35.81	340.12
T_5 Control	9.22	0.361	0.29	105.33	9.75	318.70
CD (P=0.05)	0.52	0.09	0.06	48.32	3.55	28.91

Application of different organic manure lowers the pH and EC which may be due to the accumulation of organic acids from microbial metabolism or from the production of fulvic and humic acids decomposition [16]. Sing et al. [17] reported that regular application of FYM decreased the soil PH & EC due to decomposition and mineralization of organic matter. The increase in organic carbon content could be attributed to higher contribution of biomass to the soil in the form of stubble and residues of green manures in addition to FYM and oxidation of organic matter by microbes. The highest content of available nutrients in the organic manures applied garden, as well as repeated application of biofertilizers, might be due to improvement of physical and chemical properties and better nitrogen-fixing capacity of *Azotobacter,* P solubilization and mobilization by *A. awamori* and *T. harzianum* in presence of FYM. Similar results were reported by [18-20].

3.3 Impact on Biological Properties of Soil

The soil microbial population in the mulberry garden was significantly influenced by the application of different types of organic manures and inorganic fertilizers (Table 3). Significantly maximum bacterial counts (68.00), fungal (25.33) and actinomycetes (21.33) were recorded from the garden applied with 100% of organic inputs comprising FYM, bio-fertilizers, green manures *etc* (T4). It was closely followed by (T3*) i.e.* the garden received only 25% of recommended dose of NPK as chemical fertilizers and regular application of organic manures recording counts of 61.00, 23.33 and 21.33 cfu/g of bacteria, fungi and actinomycetes respectively. However, repeated application of chemical fertilizers without any organic inputs (T5) exhibited very poor count in a population of bacteria (19.66), fungi (13.00) and actinomycetes (9.33) and found to be highly injurious to these soil microbes.

Table 3. Biological properties of soil as influenced by different manuring practices in mulberry

Treatments	Population of soil microbes (cfu/g)		
	Bacteria (No. x 10^6)	Fungi (No. x 10^3)	Actinomycetes (No. x 10^4)
T_1	25.33	12.66	9.33
T_2	38.33	19.00	12.00
T_3	61.00	23.33	21.00
T_4	68.00	25.33	21.33
T_5 Control	19.66	13.00	9.33
CD (P=0.05)	3.19	2.05	3.80

Reduction in percentage of chemical inputs and increase in organics in mulberry garden exhibited increased count of all microbes. The increased microbial population recorded in T4 might be due to the application of different types of organic manures, in turn, provides adequate biomass as a feed for the microbes and helps in increasing microbial population in the soil. However, the poor count of the microbial population in T5 & T1 may be due to the deleterious effect of chemical fertilizers which might have inhibited their multiplication. The results are in corroboration with the findings of the early worker [21]. Mishra et al. [22] Reported a decline in the count of bacteria and actinomycetes with inorganic fertilizer application. The count of all the microbes was sustainably increased when inorganic was combined with organic. The results of this study are also in agreement with the findings of Murali et al. and Rashmi et al. [23,24] who reported that the introduced beneficial microorganisms population *viz., Azospirillum brasilense* and *Aspergillus awamori* were found highest in 10 kg each of *Azospirillum brasilense* + *Aspergillus awamori* + 25% recommended N through compost, green manure (*Glyricidia maculata*), castor cake, vermicompost as compared to control in mulberry gardens. Similar results were also obtained earlier by Prabhuraj et al. [25] who observed that combination of FYM, sericulture wastes compost, green manure and biofertilizers with NPK recorded significantly higher population of inoculated phosphate solubilizing microorganism and nitrogen-fixing bacteria.

3.4 Impact on Yield Parameters of Mulberry

Notable variation was registered on plant height, leaf yield per plant, leaf yield per hectare of mulberry and rearing capacity of silkworm among different manuring practices in the mulberry garden (Table 4).

Among the different manuring practices, significantly maximum height of plants (193.68 cm), leaf yield per plant (788.23 g), leaf yield per hectare (55.80 MT) and rearing capacity of silkworm (3720 dfls) were recorded in100 % organic farming system (T4) it was followed closely by T4 on application of only 25% of recommended doses of chemical fertilizers in combination of different organic inputs with respective values of 190.55cm, 763.18 g, 54.02 MT and 3601 dfls. Least values on plant height (158.67 cm), leaf yield per plant (613.28 g), leaf yield per hectare (43.41MT) and rearing capacity of silkworm (2894 dfls) was recorded with the gardens repeatedly received 100% recommended doses of NPK as chemical inputs (T4) whereas slight improvement was noticed (163.32 cm, 683.63 g), 48.38 MT and 3225 dfls) in the gardens applied with FYM in addition to the 100% chemical fertilizers (T1).

The increased leaf yield in T4 and T3 may be due to the fact that combined application of various organic inputs mainly FYM, bio-fertilizers (Azospirillum & Phosphobacteria) for each crop and annually one time mulching of green manures might have helped in slow and steady release of nutrients in addition to supply of important macro and micro-nutrients besides efficient supply of N and P by nitrogen-fixing and phosphorus solubilizing bio-inoculants, respectively. The results are in accordance with the findings of Rashmi et al. [26]. The lowest leaf yield on 100 percent chemical fertilizers application may be due to less number of shoots and leaves per plant, shorter plant height and in turn these may be due to insufficient availability of nutrients in the root zone of mulberry plants to be absorbed by the roots due to leaching out of root zone or fixed into unavailable form due to high pH of soil. Anilkumar & John and Das et al. [27,28] reported that application of microbial inoculants in conjunction with organic manures has significantly increased the productivity of mulberry leaf. The finding of the present investigation is with the conformity of earlier works.

Table 4. Yield parameters of mulberry influenced by different manuring practices

Treatments	Mulberry yield parameters at 60 Days after pruning				Silkworm rearing capacity (Dfls / ha)
	Plant height (cm)	Leaf yield/ plant(g)	Leaf yield (MT/ha/year)	% improvement over control	
T_1	163.32	683.63	48.38	11.44	3225
T_2	176.93	695.87	49.26	13.47	3284
T_3	190.55	763.18	54.02	24.44	3601
T_4	193.68	788.23	55.80	28.54	3720
T_5 Control	158.67	613.28	43.41	--	2894
CD (P=0.05)	12.58	33.31	2.35	--	87.36

3.5 Impact on Mulberry Leaf Quality

In respect of leaf quality, leaf moisture (%), moisture retention capacity, total protein and total carbohydrate contents in leaf were found differed significantly in relation to different manuring practices in mulberry garden. The leaves harvested from the gardens applied purely with organic inputs (T4) was registered its superior values of moisture content (71.33%), moisture retention capacity (93.36%), protein content (21.60%) and carbohydrate content (36.23%) whereas the gardens received repeated doses of chemical fertilizers (T5) exhibited least values viz. 60.53%, 63.66%, 16.83% & 28.03% of respective parameters.

The overall performance of all the manuring practices showed that organic fertilization had a positive effect on yield of mulberry. In mulberry, leaf moisture content (LMC) and moisture retention capacity (MRC) are the two important factors that maintain the nutritive levels of leaves, which in turn improves the palatability of leaves for silkworm. This could be attributed to more moisture content in the organic garden and increased the fertile value of the soil. The beneficial effect of organic resources resulted in sustainable improvement in growth attributes, leaf yield and quality due to proper decomposition, mineralization, solubilizing effects and availability of sufficient nutrients as observed in T4 and T3. This corroborates the earlier findings [29-31] in mulberry particularly in relation to the use of two types of biofertilizers, vermicompost and integrated nutrient management package.

3.6 Impact on Rearing Parameters of Silkworm

Varied manuring practices in mulberry garden significantly influenced the economic traits of silkworm and cocoon yield except that of larval duration which exhibited no differences among the treatments (Table 6). Feeding silkworms with the leaves harvested from the gardens applied purely with organic inputs (T4) and organic inputs in combination with little quantity of chemical fertilizers (T3) resulted to low incidence of diseases (2.81 & 2.22%) but improved economic traits of silkworms *viz.* more weight of matured larvae (4.52 & 4.73 g), highest values in ERR (80.95 & 81.52%), single cocoon weight (1.819 & 1.863 g), single shell weight (0.425 & 0.416 g), silk ratio (23.36 & 22.86%), average cocoon yield (88.348 & 88.824 kg / 100 dfls) and average cocoon productivity 3286 & 3198 kg per hectare of mulberry garden) when compared to repeated application of chemical fertilizers (T5) which yielded least values in respective economic traits (3.28g, 53.39%, 1.673g, 0.345g, 20.62%, 55.592kgs/100 dfls & 1608 kg/ha).

These results are agreement with those of Shankar & Shivashankarand Rajanna et al. [32,33] who observed that use of organic fertilizers or combined application of composted sericulture wastes along with fertilizers, registered highest silk productivity. Increase in these parameters were influenced by different sources of organic manures and inorganic fertilizers which were applied to mulberry might have increased the crude protein content in leaves which in turn influenced the silk productivity and cocoon yield. The results on the influence of varied sources of organics on mulberry and its influence on the performance of silkworm are discussed in the light of earlier works. The economic traits of silkworm and cocoon yield were differed considerably when worms fed on mulberry grown by the application of varied sources of organic manures and the foliar constituents of mulberry showed marked positive influence on rearing parameters.

The incidence of diseases viz., muscardine, flacherie and grasserie varied much among the batches of silkworms fed on mulberry raised by the application of different sources of organic manures under irrigated condition. Ravikumar [34] reported that the feeding silkworms with leaf

Table 5. Nutrient content of mulberry leaves as influenced by different manuring practices

Treatments	Moisture content (%)	Leaf moisture retention capacity (%)	Total protein (%)	Total carbohydrates (%)
T_1	61.75	66.75	17.83	27.50
T_2	63.00	85.29	17.33	31.81
T_3	69.19	92.87	19.62	33.18
T_4	71.33	93.36	21.60	36.23
T_5 Control	60.53	63.66	16.83	28.03
CD (P=0.05)	12.69	9.22	3.56	2.75

Table 6. Effect of different manuring practices by farmers on rearing performance of silkworm

Treatment	Larval duration (Days) III-IV instars	Weight of matured larva (g)	Incidence of disease (%)	ERR (%)	Single cocoon weight (g)	Single shell weight (g)	Silk Ratio (%)	Average cocoon yield per 100 layings	Average cocoon productivity (kg/ ha of mulberry)
T_1	18.08	3.20	8.20	57.55	1.657	0.358	21.60	57.216	1845
T_2	18.12	3.30	5.25	62.90	1.660	0.369	22.22	62.648	2057
T_3	18.00	4.73	2.22	81.52	1.863	0.416	22.86	88.827	3198
T_4	18.13	4.52	2.81	80.95	1.819	0.425	23.36	88.348	3286
T_5	18.12	3.28	12.66	53.39	1.673	0.345	20.62	55.592	1608
CD (P=0.05)	-	0.073	1.12	3.45	0.033	0.017	2.66	8.75	375.47

obtained by application of 50% N through FYM and 50% N through urea recorded higher cocoon weight, shell weight and shell ratio in CSR-2 x CSR-4 silkworm breed. The cocoons spun by the silkworms fed on mulberry obtained by supplying the crop with different sources of organic manures had a not able influence on cocoon traits. The mulberry leaves of organic manures applied plots have more nutrient value than that of other treatments which in turn influences the silkworm cocoon quality [35].

The integrated nutrient management system is an alternative and is characterized by reducing the input of chemical fertilizers and combined use of chemical fertilizers with organic materials such as animal manures, crop residues, green manure and composts. For sustainable crop production, integrated use of chemical and organic fertilizers has proved to be highly beneficial. Several researchers have demonstrated the beneficial effect of combined use of chemical and organic fertilizers to mitigate the deficiency of many secondary and micronutrients. Pain, Ray et al. [36,37] indicated that feeding of mulberry leaves obtained by application of FYM resulted in increased silk content and filament length. This further supports the present findings and confirms that organically produced mulberry leaves can supplement the nutritional requirement of silkworm by virtue of producing a nutritionally balanced mulberry leaf. Studies conducted [38] on integrated nutrient management (INM) in farmers' fields with various organic inputs confirmed the possibility of reducing recommended doses of NPK application by 25% after the first year and by 50% after the second year in mulberry cultivation. He found that organic inputs exhibited sustained improvement in chemical, physical and biological properties of soil.

4. CONCLUSION

The present investigation indicated that repeated application of chemical fertilizers either indiscriminately or even as per the recommendations in mulberry ecosystem resulted with adverse impact on soil health as it affected the physical, chemical and biological properties of soil. Hence, in spite of following recommended doses of NPK in the form of chemical fertilizers, the quality mulberry leaf was found deteriorated and it reflected negatively with cocoon production. However, in organic farming practices, mulberry leaf yield, leaf quality and cocoon production were found comparatively higher than that of the chemical manuring practice. The organic amendment not only supplements the chemical fertilizers but also reduces the environmental pollution. Thus it could be concluded that a holistic approach should be made for creating awareness among the sericulture farmers and popularizing organic farming strategies to maintain soil health, improve production of quality mulberry leaf and sustainable production of silk.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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