Organic based nutrient management in mulberry and its impact on silkworm

By

Somagaini Pavankumar
(J-17-M-514)

Thesis submitted to Faculty of Postgraduate Studies
in partial fulfillment of requirements
for the degree of

MASTER OF SCIENCE

IN

SERICULTURE

Division of Sericulture
Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu
Main Campus, Chatha, Jammu-180009

2019

CERTIFICATE-I

This is to certify that the thesis entitled, **Organic based nutrient management in mulberry and its impact on Silkworm** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Sericulture** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu is a record of bonafide research carried out by **Mr. Somagaini Pavankumar,** Registration No. **J-17-M-514** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that such help and assistance received during the course of investigation have been duly acknowledged.

(Dr. Kamlesh Bali)
Major Advisor

Place: Jammu
Date: 01.08.2019

Endorsed

Head
Division of Sericulture
SKUAST-J, Chatha
Date:

CERTIFICATE-II

We the members of the Advisory Committee of **Mr. Somagaini Pavankumar**, Registration No. **J-17-M-514**, a candidate for the degree of **Master of Science in Sericulture,** have gone through the manuscript of the thesis entitled, **Organic based nutrient management in mulberry and its impact on silkworm** and recommend that it may be submitted by the student in partial fulfillment of the requirements for the degree.

Dr. Kamlesh Bali
Associate Professor
Major Advisor & Chairman
Advisory committee

Place: Jammu
Date: 01.08.2019

Advisory Committee Members

Dr. Magdeshwar Sharma
Associate Professor
(Division of Entomology/Sericulture)

Dr. R. S. Bandral
Professor (Entomology)
(Division of Entomology)

Dr. Vishal Gupta
Assistant Professor (Plant Pathology)
(Dean's Nominee)

CERTIFICATE-III

This is to certify that the thesis entitled, **Organic based nutrient management in mulberry and its impact on silkworm** submitted by **Mr. Somagaini Pavankumar**, Registration No. **J-17-M-514,** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, in partial fulfillment of the requirement for the degree of **Master of Science in Sericulture** was examined and approved by the Advisory Committee and External Examiner(s) on 16.09.2019

16/9/19
External Examiner
(Dr. P.S. Shera)
Assistant Entomologist
PAU, Ludhiana

Dr. Kamlesh Bali
Associate Professor
Major Advisor

Head
Division of Sericulture

Head
Division of Sericulture
SKUAST-J

Dean, FOA, Chatha

ABSTRACT

Title of Thesis	:	Organic based nutrient management in mulberry and its impact on silkworm
Name of the Student	:	Somagaini Pavankumar
Registration Number	:	J-17-M-514
Major Subject	:	Sericulture
Major Advisor	:	Dr. Kamlesh Bali
Degree to be awarded	:	M.Sc. Sericulture
Year of award of degree	:	2019
Name of the University	:	Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (J&K)

ABSTRACT

The present study entitled, **Organic based nutrient management in mulberry and its impact on silkworm** was conducted during spring season 2019 at Division of Sericulture, SKUAST-Jammu in order to know the effect of different organic manures alone and in combination with biofertilizer (*Azospirillum*) on growth and yield parameters of mulberry (var. China white), rearing performance of silkworm hybrid ($FC_1 \times FC_2$) and other important metric traits. The results revealed that, among different treatments, application of vermicompost + *Azospirillum* (4.0g/plant) significantly increased mulberry growth parameters *viz.,* plant girth (7.50 ± 0.13cm), plant height (284.67 ± 7.36cm), number of shoots per plant (15.33 ± 1.20), shoot height (146.63 ± 8.03cm), longest shoot (158.27 ± 6.71cm), internodal distance (5.00 ± 0.40cm), number of leaves per plant (1203.33 ± 60.92), fresh leaf yield (3013.00 ± 71.00g/plant), leaf area index (1.54 ± 0.02), moisture content (72.02 ± 1.05%) and moisture retention per cent after 6 hours (74.43 ± 0.01). Observations on larval traits, cocoon and post cocoon parameters of silkworm were also recorded and the results revealed positive impact in case of vermicompost @ 4kg/plant + *Azospirillum* (4.0g/plant) (T_6) with respect to V instar 10 larval weight (46.69 ± 0.66g), larval survival per cent (97.05 ± 0.58) and shorter total larval duration (27.02 ± 0.01D:H), ERR (By wt.14.26 ± 0.01 and By No. 8987 ± 5.51), single cocoon weight (2.06 ± 0.01g), single shell weight (0.48 ± 0.00g), shell ratio per cent (23.10 ± 0.17), total filament length (1308.00 ± 9.07m), non breakable filament length (1308.00 ± 4.73m), filament size (2.50 ± 0.02d) followed by FYM @ 4kg/plant + *Azospirillum* (4.0g/plant) (T_5), Neem cake @ 2.5kg/plant + *Azospirillum* (4.0g/plant) (T_8), Vermicompost @ 4kg/plant (T_2), Silkworm rearing waste @ 3kg/plant + *Azospirillum* (4.0g/plant) (T_7), FYM @ 4kg/plant (T_1), Neem cake @ 2.5kg/plant (T_4), Silkworm rearing waste @ 3kg/plant (T_3) respectively as compared to control (T_9). Based on the present findings it may be concluded that, the application of vermicompost + *Azospirillum* (4.0g/plant) would be an advisable treatment so as to produce quality mulberry leaves and cocoon crop with improved metric traits.

KEYWORDS: Mulberry, silkworm hybrid ($FC_1 \times FC_2$), organic manures, bio-fertilizer.

Signature of Major Advisor **Signature of Student**

ACKNOWLEDGEMENTS

Gratitude takes three forms "A feeling from heart, an expression in words and a giving in return" I sincerely thank all those who directly made this thesis possible.

First of all I would thank to "The Almighty" for His grace and mercy which made it possible for me to complete this present venture and without whose grace this small work could have never seen the light of the day. *It is my privilege to express my deepest sense of gratitude and indebtedness to my Major Advisor, Dr. Kamlesh Bali, Associate Professor, Division of Sericulture, SKUAST-J, Chatha. His guidance helped me in all the time of research and compilation of this thesis and also for his kind and constant cooperation, constructive criticism, critical evaluation of this manuscript through his scholarly eyes and deep indulgence throughout the course of this study, for his keen interest, valuable guidance and providing the necessary working facilities during the course of investigation.*

I would like to recognize the invaluable and dedicated contribution, affectionate behavior and constant encouragement towards my Ex co-major Advisor Dr. R. K. Bali, Professor and Head, Division of Sericulture for his learnt advice, timely suggestion and prudent guidance throughout the study. His role will remain as a source of enduring inspiration throughtout my life.

I am emphatically extend my heartiest thanks to the other esteemed members of my advisory committee, Dr. R.S. Bandral, Professor (Entomology), Dr. Vishal Gupta, Assistant Professor (Plant Pathology), Dr. Magdeswar Sharma, Associate Professor (Entomology) for their valuable suggestions, generous help, sincere advice and excellent encouragement in conducting this research work.

From the profundity of my inner heart, I take the privilege to express my deep humility and devotion to my parents, Sh. Somagaini Chinna Ramanaiah (Father) and Smt. Somagaini Ramanamma (Mother) for their love, affection, unstained faith and confidence in me, unrelenting support and inspiration to move on the right path, which helped me to sail my ship of ambitions and anchor it in a harbor of success.

I am thankful to all my colleagues, seniors and friends particularly, Arti Sharma mam, Palvi Sharma mam, Jasmeena mam, Suraksha mam, Mokshe mam, Kritika Sharma mam, my junior Monika Attri, Aradhana mam, Rubai mam, Raghu sir, Yella Venkatesh, Harsha Sir, Manoj sir, Raghavenra sir and Raghu sir who helped me in any way during my research work. I feel privileged to mention the name of all my UG batch mates especially, Ajith Bugada, Khaja Hussain, Jawahar Reddy, Yeshwanth, Chennaiah, Mastan and Ashok for their timeless support and generous care.

A special mention of thanks to my dear seniors Arti Sharma mam, Palvi Sharma mam, Jasmeena mam for their cooperation and valuable suggestions during the present study.

Not to forget that without my affectionate and lovable friends Lalichetti Sagar, Manohar, Om Prakash, Surender Singh Bhadhu, Sultan this endeavor would have seemed longer. I sincerely thank them for their timeless support and help.

I am also thankful to the non-teaching staff from the Division of sericulture Sh. S.K. Pandita, Sh. Balwanth Singh, Sh. Inderjeet Sharma, Sh. Pritam Kumar Raina, Sh. Vaid Raj, Sh. Inderjeet Sharma, Smt. Anitha Devi, Devender and Sushil who were always ready to help me as and when required.

Last but not least, I feel pleasure in thanking Microsoft, SPSS and OP STAT that enabled me to present thesis in this form. Any omission in this brief acknowledgement does not mean that has been forgotten or lack of gratitude of mine, as all can't be mentioned in two sheets of the paper.

Place: Jammu

Date: 31-7-2019.

S.PK

Somagaini Pavankumar

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER-I

INTRODUCTION

The discovery of silk or culturing of silkworms to produce silk, dates back to around 2700BC, although archeological records point to silk production as early as yangshao period (5000-3000 BC) (Barber, 1992).

Geographically, Asia is the main producer of silk in the world producing over 90 per cent of the total global output. India has the unique distinction of being the only country in the world producing all the four commercial silks namely mulberry, tasar, muga and eri and is the second largest producer and largest consumer of silk in the world. The major mulberry silk producing states in India are Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir which together accounts for 92 per cent of country's total mulberry raw silk production (Anonymous, 2018). Among the states, Karnataka produces more than 60 per cent of the country's raw silk with an area of 88.9 thousand hectares under mulberry cultivation producing 8240 MT of raw silk.

The State of Jammu and Kashmir is well known for the production of quality mulberry silk because of its salubrious climate which is favourable for the bivoltine silk production. During the year, 2016-17, the state produced 973 MT of cocoon and 140 MT of raw silk (Anonymous, 2017).

The sustainability of sericulture largely depends on the production of quality mulberry foliage, this is because, leaf quality influences not only the growth and development of silkworm but also the quality and quantity of silk produced (Krishnaswami, 1986). Mulberry leaf is the sole source of food for silkworm (*Bombyx mori* L.) providing more than 70 per cent of the material to biosynthesize silk proteins, sericin and fibroin. However, the highly intensive mulberry cropping system results in depletion of nutrients in soil, and excess application of inorganic fertilizers and pesticides causes deleterious effect on soil health. Furthermore, it has been observed that soil chemical properties and micro-flora associated with mulberry are adversely affected with the indiscriminate application of chemical fertilizers (Siddaramappa, 2004).

In this context, it is highly imperative to supply major nutrients to mulberry through organic manures and biofertilizers. Organic manures are bulky in nature which encourages the proliferation of soil microflora and supplement the crop with small amounts of major nutrients like NPK and other minor nutrients required by the crop (Lakshmi *et al.*,1977). Introduction of crop benefiting microbial inoculants into soil plays a significant role in the mobilization of various nutrients needed by the crop. Organic manures such as vermicomposting is an eco-friendly technology and has a tremendous scope in the recycling of sericultural residue. Proper utilization of sericulture waste as raw material for vermicomposting serve as organic manure which can substantially bring down the expenditure on chemical fertilizers and helps in improvement of soil health and nutrient availability to mulberry plants leading to leaf quality improvement (Venugopal *et al.*, 2010). Vermicomposts are rich in microbial populations and diversity, particularly fungi, bacteria and actinomycetes. Effect of organic manures especially poultry manure in combination with *Azotobacter* biofertilizer followed by reduced doses of inorganic fertilizers had a significant effect on growth and leaf quality of mulberry plants (Chakraborty and Kundu, 2015). Application of different organic manures and biofertilizers along with lower dose of fertilizers plays a significant role in enhancing the soil fertility in terms of macronutrients, secondary nutrients and microbial population (Shashidhar *et al.*, 2018).

Since mulberry is a non leguminous crop, as such free living and associative nitrogen fixing microorganisms play an important role in improving growth and yield. Studies conducted have shown that the rhizosphere environment of mulberry is more congenial to beneficial microflora. Agastian and Vivekanandan (1997) reported occurance of more nitrogen fixing bacteria (*Azotobacter* spp. and *Azospirillum* spp.) in mulberry rhizosphere.

There are various factors that reflect upon the successful cocoon crop production in sericulture such as mulberry leaf (38.2%), climate (37.0%), silkworm breed (4.2%), rearing techniques (9.3%), silkworm seed (3.1%) and other factors (8.2%) (Miyashita, 1986). Thus the mulberry leaf quality plays a predominant role in healthy growth of silkworms and the economic traits such as larval weight, cocoon weight and grainage parameters which are influenced largely by the nutritional status of the leaves fed to silkworm. The balanced nutritional status of the leaves enables the worms to mature early due to the faster metabolic activity (Sudhakara *et al.,* 2017). The young age silkworm larvae usually prefer moisture rich, succulent and nutritive leaves, preferably the top ones which enable the young larvae to increase the amount of ingestion and digestion capacity thereby ensuring higher productivity (Yokoyama, 1974).

In light of above discussion, the present study was undertaken to estimate the impact of application FYM, vermicompost, silkworm rearing waste, neem cake alone and in combination with *Azospirillum* on the production of quality mulberry foliage which in turn may exhibit significant bearing on growth and other cocoon traits of silkworm with the following objectives

1. To study the effect of organic based nutrients on growth and yield of mulberry.
2. To study the impact of organic based nutrients on rearing performance of silkworm.

CHAPTER-II

REVIEW OF LITERATURE

The literature pertaining to studies on the organic based nutrient management in mulberry and its impact on silkworm in relation to growth and yield of mulberry and cocoon productivity has been reviewed in this chapter under the following headings.

2.1 Effect of organic manures on growth and yield of mulberry

Singhal *et al*. (2000) reported that the process of vermicomposting of sericultural waste was carried out by introducing a mixed culture of juvenile earthworms, *Eisenia fetida*, *Eudrilus euginae* and *Perionyx excavatus* @ 1.5 kg/MT of waste were introduced in each trench. The results revealed that vermicompost play a significant role in mulberry production and can also be used in other agricultural crops for enriching the soil with micronutrients. In mulberry, the application of vermicompost has significantly increased photosynthetic rate and leaf yield.

Kolhar and Patil (2000) reported that replacement of inorganic fertilizers with earthworms @ 1,00,000/ha results in improvement of the leaf yield of mulberry besides upholding of soil health, reduced cost of cultivation over the years and improvement in leaf quality of mulberry.

Krishna and Bongale (2001) revealed that after Farmyard manure (FYM) application @ 40 MT/ha, without the supplementation of fertilizers sustainability of soil fertility and mulberry leaf yield obtained up to four harvests. To achieve better leaf yield and quality, FYM may have to be applied at shorter intervals at least two to three times per year for mulberry garden.

Patil *et al.* (2002) observed that five tonnes of vermicompost + 150 and 200 kg N recorded higher leaf yield in paired row cultivation of V-1 mulberry as compared to 2.5 tonnes of vermicompost + 300 kg N.

Setua *et al*. (2002) conducted a field experiment and revealed that all the composts in combination with N, P and K improved plant growth characters, leaf yield and quality compared with any compost alone or only with N, P and K application. Out of the 4 types of composts, vermicompost in combination with 150, 50, 50 kg N, P and K/ha per year resulted in maximum plant height (92.76 cm), leaves per plant (243.84), leaf yield (16.26 tonnes/ha per year) and K uptake by leaves (87.80 kg/ha per year). Branches per plant (13.63), leaf area (42.63 cm^2), uptake of N (113.36 kg/ha/year) and P (19.72 kg/ha/year) by leaves were also significantly increased over the control. Vermicompost was found to be more efficient in the overall improvement in the qualitative and quantitative characters of mulberry compared to the other composts used.

Reddy *et al*. (2003) conducted a study to determine and compare the effect of FYM and vermicompost on different qualitative and quantitative characters in mulberry. Improvement of leaf yield was minimum in K-2 (10.90MT/crop) and maximum in V-1 (15.73MT/crop). The significant improvement in leaf yield in all varieties was observed in vermicompost plots over the FYM plots. S-13 and V-1 showed high response to vermicompost and FYM which clearly indicated the varietal efficiency to organic manures. Leaf moisture content, moisture retention capacity and chlorophyll content were found high in V-1 and low in K-2. Among the five varieties, S-30 and S-36 showed higher nitrogen and protein content.

Sharma *et al.* (2005) reported that vermicompost enriched with useful / antagonistic microbes after mixing with neem oil cake (2:1) @ 3 kg in nursery bed was helpful in improving the sprouting and survival of cuttings by 46-49 per cent and the package was eco-friendly besides improving the soil health.

Das *et al*. (2005) reported that vermicompost application of 10 metric tonnes with 50 per cent reduction in the full dose of chemical fertilizers (150: 60 : 60 kg NPK / ha / yr) resulted in leaf yield at par with application of 20 metric tonnes of FYM / ha / yr with full recommended dose of chemical fertilizers. Similarly, vermicompost application of 20 metric tonnes with 50 per cent recommended dose of fertilizers improved the leaf yield and quality over the control receiving full dose of FYM and chemical fertilizers.

Rao *et al*. (2005) conducted a study at farmer's level in mulberry garden with vermicompost and FYM revealed the number of leaves / plant was increased from 7.8 to

8.3 due to vermicompost application as compared to FYM. Similarly, maximum leaf yield was observed in vermicompost applied plots. This clearly indicates that sustainable mulberry production is possible through the application of nutrient rich vermicompost.

Sannappa *et al*. (2005) revealed that the application of FYM @ 20 MT/ha/yr + Azotobacter @ 20kg/ha/yr + NPK @ 300: 120: 120kg/ha/yr to mulberry resulted in higher cocoon yield (291.6g/200 larvae), shell ratio (19.96%), silk productivity (3.503 cg/day) and cocoon filament length (666.0 m).

Baqual and Das (2006) indicated that application of recommended dose of NPK (300:120:120 kg $ha^{-1}year^{-1}$) and FYM (20 MT ha^{-1} $year^{-1}$) to the mulberry plants resulted in higher mulberry leaf yield (30,716 kg $ha^{-1}year^{-1}$) followed by the treatment receiving 225:90:90 kg of NPK along with FYM 40 MT ha^{-1} $year^{-1}$ (27,932 kg of leaf ha^{-1} yr^{-1}). They further, revealed that maximum nitrogen (484.12 kg /ha), phosphorus (59.83 kg /ha) and potassium (244.61 kg/ha) uptake has taken place through leaf due to mulberry coinoculation with Arbuscular mycorrhiza, nitrogen fixing bacteria, and phosphate solubilizing micro-organisms.

Among nitrogen sources, the use of FYM, *Glyricidia maculata* and castor cake at 75, 50 and 25 per cent levels. However, application of 50 % N through *Glyricidia maculata* + 50 % N through urea and 50 % N through castor cake + 50 % N through urea showed better performance with regard to pupal weight, pupal duration, moth emergence, fecundity and hatachability (Ravikumar *et al*., 2006).

Ushakumari *et al*. (2006) reported that vermicompost is the product of the composting process with the action of earthworm and a non-toxic biodegradable waste. vermicompost is a potential source among the sources of available organic manures, due to the presence of readily available plant growth hormones, plant nutrients, antibiotics, vitamins, enzymes and a number of beneficial microorganisms viz., nitrogen fixing, phosphorus solubilising and cellulose decomposing organisms. Vermicompost is an alternating source of organic manure and a substitute for chemical fertilizers on different agicultural, horticultural and mulberry crops. It plays an important role in improving the soil health and fertility for sustainable agriculture.

Salazar (2007) reported the application of 150 kg N/ha per yr from two organic fertilizers viz., vermicompost and compost and chemical fertilizers (control) on mulberry fodder production and quality. Chemical fertilizer resulted in 23 per cent higher dry matter production. Chemical nitrogen significantly higher in crude protein content, while dry matter content was lower. The amount of N in the soil was also high in control treatment to yield fodder and crude protein levels similar to those of organic fertilizers.

Shree *et al.* (2007) reported the effect of vermicompost on the growth and development of mulberry saplings in two popular indigenous varieties (M5 and DD) and concluded that the survival percentage, sprouting percentage, number of branches and leaves/sapling, root length (cm), fresh and dry weight of root (g) and root volume (ml), shoot length (cm) were found better in both the varieties when compared to the control (without the vermicompost).

Chandrakumar *et al*. (2008) revealed that organic treatments viz., vermicompost + biofertilizer (Silica solubilizing bacteria, Azotobacter and Arbuscular), Mycorrhizal fungi + neem cake showed significantly increased bacterial and fungal population in soil (94.33 and 25.33 colonies/g/soil) compared to inorganic NPK applied plots and untreated control.

Sharma *et al*. (2008) reported that compost prepared by seri residue (SR; silkworm litter + rearing waste) or vermicompost (VMC) enriched with useful/antagonistic microbes (Rock phosphate + Phosphate solubilizing bacteria + *Trichoderma harzianum* + Azotobacter + *Trichoderma* pseudokoningii) when mixed with neem oilcake (2:1) @ 2 kg/m^2 in nursery bed helpful in improving the sprouting and survival of cuttings up to 45.4 per cent over the control.

Sori *et al*. (2008) reported that application of the recommended dose of fertilizers + FYM resulted in maximum number of shoots per plant (28.00 and 27.45; 37.78 and 35.11), average shoot height (71.04 and 94.74; 65.84 and 89.48 cm), number of leaves per plant (361.38 and 380.47; 459.50 and 510.90) and fresh leaf yield per plant (403.60 and 538.13; 718.74 and 867.57 g) and leaf area index (11.38 and 18.79) at 45 and 60 days after pruning in crop I and II, respectively.

Dandin *et al*. (2010) reported that neem cake application @ 2MT/ha/year in four split doses reduced the incidence of root –knot disease in mulberry plant. Application of 200 kg FYM + 24 kg neem cake with one kg bionematicide (*Verticillium chlamydosporium*) is helpful in biological control of mulberry root-knot nematode and also increased the mulberry leaf yield.

Mir *et al*. (2011) reported that rooting ability of temperate mulberry genotypes (Goshoerami, Ichinose and SKM-33) is increasing with the application of sand, clay and FYM in the ratio of 6:3:1. Goshoerami excelled in almost all the parameters under overall influence of growth regulators recording highest values of 100 per cent, 65 per cent, 7.800, 13.887 cm, 2.139 g and 1.973 cm3 for sprouting, rooting, number of roots/sapling, length of longest root, root biomass and root volume, respectively. Ichinose recorded highest root shoot ratio of 0.642 while as SKM-33 recorded highest shoot biomass of 3.668 g.

Umesha and Sannappa (2014) conducted a study on the organic manures application through FYM and vermicompost (followed by FYM and sheep manure; FYM and compost) in equal proportion along with recommended doses of chemical and bio-fertilizers to mulberry garden produced better quality of leaves *i.e.,* by way of enhancement of bio-chemical and mineral nutrients. Thus, in the event of shortage /non-availability of FYM, 50% recommended dose of FYM can be compensated through use of vermicompost/sheep manure/compost to be adequate the manurial requirement of mulberry.

Ram *et al.* (2017 a) reported that FYM application @ 10 mt. ha^{-1} + KH@25 kg ha^{-1} + NPK @ 150:50:50 kg ha^{-1} for inorganic and FYM @ 20 mt. ha^{-1} + KH @ 25 kg ha^{-1} for organic mulberry farming have significant effect on season and year wise growth attribute characters, leaf yield and nutritional quality of mulberry variety BC259.

Mallappa *et al.* (2016) revealed the effect of integrated nutrient management on growth and yield of mulberry and found that application of FYM @ 20 t/ha + 50% inorganic N + Pongamia cake (25% N equivalent) + 75% P & 100% K inorganic + PSB + *Pseudomonas florescence* + *Azospirillum* significantly led to higher growth parameters (plant height, number of shoots, number of leaves, internodal length, leaf area, leaf area index, total dry matter production and dry matter production of leaves, (145.7 cm, 39.1, 652.7, 8.2 cm, 11439 cm^2/plant, 1.412, 448.5 g/plant and 159.4 g/ plant, respectively) and leaf yield (13.42 t/ha) which was at par with FYM at 20 t/ha + 50% inorganic N + Pongamia cake (25% N equivalent) + *Azospirillum* + PSB +75% inorganic P & K + *Pseudomonas florescence* (13.23 t/ha) and FYM at 20 t/ha + 50% inorganic N + 100% inorganic P & K + *Azospirillum*+ Pongamia cake (25% N equivalent) + PSB (13.07 t/ha) as compared to FYM @ 20 t/ha + recommended dose of NPK (control).

Ahmed *et al.* (2017) reported that seri waste compost enhances the growth and yield performance of mulberry plant. The total branch number per plant was differed significantly ($p>0.001$) from various fertilizer treatments. Among the six fertilizer treatments, the maximum branch number per plant was found 14.38 in Seri Waste Compost (SWC) + Recommended Basal Doses of Bangladesh Sericulture Research and Training Institute (BSRTI) BRBD treated plot followed by the Cow Dung Compost (CDC+BRBD), Recommended Basal Doses of Bangladesh Sericulture Research and Training Institute (BSRTI) BRBD, Seri waste compost (SWC), Cow Dung Compost (CDC) and control treatments. The minimum total branch number per plant was 9.57 in control treatment. The length of longest shoot was not statistically significant by the fertilizer treatments. But the highest length of longest shoot was obtained 139.38 cm for the Seri Waste Compost (SWC) + Recommended Basal Doses of Bangladesh Sericulture Research and Training Institute (BSRTI) BRBD treatment followed by the other fertilizer treatments.

2.1.1 Role of biofertilizers alone or in combination with organic manures on growth and yield of mulberry

Anilkumar and John (2000) reported that *in-situ* cultivation and in-situ composting of cowpea and combined biofertilizers application resulted synergistic and significant interaction of *in-situ* generation and utilization of green manure along with combined application of microbial inoculants besides chemical fertilizers had contributed to higher productivity in mulberry.

Eranna and Govindan (2002) reported that composite application of microbial culture like N_2 fixer, P mobilizers and P solubilizers can enhance the growth and yield of mulberry and synergistically interact with other beneficial soil microorganisms in the rhizosphere of mulberry plants and could reduce the incidence of plant pathogen.

Sukumar *et al*. (2003) conducted a study on M5 variety to know the effect of combined inoculation of *Azospirillum brasilense* and P-solubilizing *Bacillus megaterium* on mulberry leaf yield and uptake of nutrients with graded levels of recommended N and P (75 and 100 %) significant increase in leaf yield was recorded with dual inoculation when compared to individual inoculation and uninoculated control plants.

Baqual and Qayoom (2004) reported that the main groups of bio-inoculants used in mulberry production are nitrogen fixers (non-symbiotic groups), vesicular Arbuscular mycorrhizal fungi (VAM-F) and phosphate solubilizing bacteria and fungi (PSB-F).

Nagarajaiah *et al*. (2004) revealed that, application of biophos + 100 per cent recommended dose of fertilizer (RDF) recorded higher yield of 6314.8 kg/ha /crop followed by application with *Azospirillum* (6218.6 kg ha-1 crop-1) and *Azotobacter* (5962.5 kg ha-1 crop-1) along with 100 per cent RDF. Among the individual biofertilizers, biophos performed better in enhancing the mulberry leaf yield followed by *Azospirillum* and *Azotobacter.*

Muthuraju *et al*. (2005) revealed that pressmud application enriched with *Aspergillus awamori* and *Azotobacter* species improved the fresh leaf yield of mulberry (6230 kg/ha/yr) over the control (pressmud alone) (6110 kg/ha/yr). Dual application of these two microorganisms also useful in increasing the nutrient uptake in mulberry plants. Seventy five per cent RDF in combination with biofertilizer performed better and equal to that of 100 per cent RDF in enhancing the leaf yield and quality in mulberry.

Sreeramulu *et al*. (2005) reported that biofertilizers are the carrier based preparations containing sympathetic microbes like P- solubilizers or nitrogen fixer in enormous quantity in a feasible state useful for soil or seed application, which is helpful in recovering the growth of the plant and fertility of the soil.

Hemanthkumar *et al*. (2006) revealed that *Azospirillum* application @ 1.6 kg/acre/crop with 75 % of recommended nitrogenous fertilizer significantly increased the leaf yield of mulberry.

Hiremath *et al*. (2006) revealed that the larvae fed on leaves has taken from the treatment of bio-fertilizer 10 Kg each of *Aspergillus awamori* + *Azospirillum brasilense* + 20per cent each recommended nitrogen through Vermicompost, green manure, castor cake, compost fertilizers resulted in higher soluble protein and total sugar content in local leaf of Mysore.

Jayaraj *et al*. (2006) reported that Inoculation with *Azospirillum* increased the number, length and weight of roots, number of leaves, leaf weight besides bud development thus stimulated the mulberry growth. VAM and PSB makes availability of **P** to mulberry plants. Besides, VAM noticeably increases length of root and improves photosynthesis.

Srikantaswamy and Mala (2006) revealed that mulberry plants treated with plant growth promoting rhizobacteria and found this *Azotobacter chroococcum* was more efficient in improving the yield of mulberry with a saving of 50 per cent N application.

Ramarethinam and Chandra (2007) showed the impact of liquid and carrier based application of biofertilizer on the quality of mulberry leaves. Data reported that application of *Azotobacter* (100 ml) + VAM (500 g) + *Phosphobacter* (100 ml) significantly improved the nutritional factors such as total protein (31.6 x 10 g), total chlorophyll content (2.42 mg/g), total carbohydrate (4.2 mg), reducing sugars (0.84), nitrogen (21.6%), phosphorous (48.68 %), potassium (75.6 %), magnesium (98.2 %), calcium (28.2 %), zinc (30.2), manganese (28.4 %), copper (12.8) and iron (18.6 %) over normal practice and control.

Rao *et al*. (2007) revealed that chemical fertilizers are expensive so to reduce the application of these fertilizers alternative cheaper supplements are biofertilizers in cultivation of mulberry and thus it can save upto 50 per cent cost of chemical fertilizers in conditions of semi-arid environment. It resulted in improvement of the soil fertility and improved leaf quality, silkworm growth and cocoon characters.

Shashidhar *et al*. (2009) reported that mulberry raised with 100 per cent recommended N through 20 per cent each of compost + castorcake + *Glyricidia maculata* + Urea and vermicompost + 10 kg each of *Aspergillus awamori* + *Azospirillum brasilense* + Bio-fertilizer + remaining P, K through chemical fertilizers + Recommended FYM resulted in maximum leaf yield per plant and hectare (327.62 g /plant and 45.45 tonnes/ha/yr).

Kumar *et al.* (2012) conducted a survey on the knowledge of sericulturists on adoption of organic farming practices revealed that majority (44.16%) of the sericulturists had low knowledge about organic farming practices followed by medium (35.83%) and high (20%) knowledge, respectively. with respect to the recommended individual organic farming practices, they had correct knowledge about application of FYM (83.33%) and use of ankush (82.50%). None of the sericulturists (100%) had correct knowledge about use of Seri-VAM, Tank silt, Seri-nematoguard, Neem Cake + FYM + Marigold intercrop in mulberry and use of Nysolynx thymus to control uzi pest. only negligible percentage of sericulturists had correct knowledge about use of seri-bioguard(0.83%), Sunhemp as green manure (1.67%), Seri-comporich (2.50%), Seri-mildew guard (1.67%) and Azotobacter biofertilizer (2.50%).

Singh *et al*. (2012) conducted a study on the effect of integrated nutrient management (INM) in mulberry plants. Leaf quality and suitability for silkworm rearing was assessed through bioassay. Maximum leaf yield of 7.71 mt/ha/yr with 20% increase over the existing recommended package was obtained under INM package i.e. 50% of recommended dose of nitrogen (150 kg ha-1yr-1), full doses of phosphate and potash (i.e. 50 kg ha-1 yr-1) combined with biofertlizer (*Azotobacter chroococcum*) @ 10 kg/ ha/ yr and vermicompost @ 10 mt/ ha/1 yr. The results of bioassay also showed superiority of INM practiced over the recommended packages. INM increased productivity of mulberry leaf and 20% additional silkworm layings was possible to rear by the farmers, improve their economic condition and silk production as well.

Sori and Bhaskar (2013) conducted an experiment to know the effect of integrated use of bio-inoculants (*Aspergillus awamori* at 25 kg/ha/year, *Trichoderma harzianum* at 20 kg/ha/year and *Azotobacter* sp. at 20 kg/ha/year), farm yard manure (FYM) and inorganic fertilizers (NPK) on fresh leaf yield and quality variables of M5 mulberry. The results revealed that combined use of treatment components shown a positive effect on fresh leaf yield and quality variables of mulberry plant.

Sujathamma *et al.* (2014) conducted a study and confirms that by adopting INM i.e. following the organic farming in mulberry cultivation, by reducing the quantity of chemical fertilizers it is possible to produce quality mulberry leaf for silkworm rearing. This would further benefit the sericulture industry and particularly the small and marginal farmers who cannot afford to apply the recommended dose of chemical fertilizers in mulberry cultivation resulting in loss of cocoon crops.

Chakraborty and Kundu (2015) reported that the effect of organic manures specially poultry manure in combination with Azotobacter bio fertilizers followed by reduced doses of inorganic fertilizers had a significant effect on growth and leaf quality of mulberry plants.

Kapoor *et al.* (2015) reported that in recent years biofertilizers have gained importance as a major component of the biological nitrogen fixation. They offer an economically attractive and ecologically sound route of providing nutrients to the plants. Biofertilizers are low cost renewable source of nutrients that supplements the chemical fertilizer. Biofertilizers gained importance due to its low cost amongst small and marginal farmers.

Ram *et al.* (2017 b) conducted a study on the integrated effect of treated pressmud and FYM on growth attribute characters, yield and quality of existing BC259 (*Morus alba* L.) mulberry variety. This experiment was also extended to check its adverse effect on bioassay of SK6×SK7 (*Bombyx mori* L.) silkworm. Based on data analyzed, it was found that, the integrated application of 02 mt treated press mud with 05 mt FYM (T_3) performed better than application of 10 mt FYM alone (T_1). The highest annual leaf yield among above experimental sites was ranged from 11.09 to 14.71 mt/ha after the application of T_3 treatment. The total leaf yield gain in T_3 treatment was 15.28 to 19.26% higher than control.

Ram *et al*. (2018) observed that the effect of mixed cake on growth attributing characters and leaf yield of mulberry was significant in both autumn and spring season. The maximum height of shoot, number of leaves per shoot, and leaf yield was observed in T_4 and T_5 treatment over control. While observing the effect of season (S) Treatment (T), it was found that the higher leaf yield was recorded in spring than autumn.

Thangamalar *et al.* (2018) reported that middle pruning along with integrated nutrient management practice of application of 50 per cent organic and 50 per cent recommended dose of inorganic fertilizers are shown optimum for mulberry higher growth and yield attributes, yield economics of mulberry and silkworm with enhanced net return and B: C ratio in both kharif and rabi under irrigated condition.

2.1.2 Rearing performance of silkworm as influenced by organic manures alone or in combination applied to mulberry

Mahmood *et al.* (2002) reported that silkworm larvae when fed on leaves from mulberry (*Morus laevigata*) tree given soil treatment with 2kg well rotten FYM along with 0.2%N concentration consumed more food, gained significantly more weight and produced heavier cocoons, as compared to those fed on leaves from trees treated with 2kg FYM +0.1% N, 2kg FYM + 0.3%N, 2kg FYM + 0.4% N and 2kg FYM alone.

Philomena *et al*. (2003) observed that, lower dose of inorganic fertilizer with higher dose of organic manure (i.e., 75:30:30 kg NPK + 35 MT compost/ha/yr) reported higher ERR by number and weight, pupation rate, single cocoon weight, egg recovery and fecundity.

Ravikumar (2003) reported that silkworms fed with mulberry leaves raised by applying 50 per cent N through FYM + 50 per cent N through urea, 50 per cent N through green leaf manures + 50 per cent N through urea and 50 per cent N through castor cake + 50 per cent N through urea recorded higher larval weight in all the instars, higher ERR and least disease incidence. However, feeding silkworms with leaf obtained by application of 50 per cent N through FYM + 50 per cent N through urea recorded higher cocoon weight, shell weight and shell ratio in CSR2 X CSR4 silkworm breed .

Jaiswal *et al*. (2005) observed that silkworm hybrid reared on mulberry leaves treated with vermicompost application resulted in higher cocoon weight, shell weight and shell ratio in SH6 × NB4D2.

Chinnaswamy *et al*. (2005) observed that multivoltine silkworm pure breed reared on organically raised (silkworm excreta, honge cake, FYM and sheep manure as a sole and in combinations) M5 mulberry leaves under rainfed condition and found Among the treatements, mean cocoon weight was highest with the cocoons obtained by the use of leaves raised with hongecake + silkworm excreta (8.21 g), shell weight (1.07 g) and shell ratio (14.55 %) were highest with leaves obtained from FYM + silkworm excreta over NPK alone.

Setua *et al.* (2005) revealed that Cocoon yield, shell weight, shell percentage and filament length were found higher in vermicompost applied treatments against those with farm yard manure.

Sreenivas *et al*. (2005) observed the rearing performance of different breeds of silkworms fed with leaves of mulberry raised by application of vermicompost revealed increase in cocoon yield and net returns substantially. Hence, sericulturists may be motivated to takeup vermicompost technology for sustainable sericulture and thereby improving their economic status.

Gururaj *et al*. (2006) revealed the impact of vermicompost on mulberry leaf yield and cocoon yield in a period of one year for five crops. The analyzed data shown that the average cocoon yield was significantly increased from 51.0, 58.4 and 50.08 kg to 56.91, 6.46 kg in irrigated M5 and V1 and 35.46 kg in rainfed M-5 respectively.

Munireddy *et al*. (2006) revealed that when PM × CSR2 silkworms were fed on mulberry leaves obtained by the application of 280 kg and 150 kg N through inorganic fertilizers and 2.5 MT of Vermicompost resulted in higher cocoon yield of 16.46 and 16.47 kg / 10,000 larvae.

Pasha *et al*. (2006) observed that bivoltine breed NB4D2 reared on leaves of mulberry produced by the application of silkworm excreta, FYM and honge cake either singly or in combinations resulted in higher mature larval weight, cocoon weight, shell weight, cocoon filament length, pupation rate, pupal weight, moth emergence, fecundity and silk productivity.

Purohit *et al*. (2006) observed that the average annual leaf yield due to combined use of FYM / Compost @ 10 MT/ha/yr, biofertilizers such as nitrofert (*Azotobacter*) @ 10 kg/ha/yr in two equal split doses and phosphofert (VAM) @ 40 kg/ha once in four years were applied along with NPK @ 75:10:50 kg / ha / yr with N in two equal split doses and plant growth regulator (Morizyme-B) @ 0.01% was applied after 15 and 30 days of leaf plucking / pruning during autumn and spring crops the average cocoon yield was 34.29 kg /100 dfls recorded 10.2 per cent increase over control 31.12 kg /100 dfls.

Raju *et al*. (2006) conducted a study on integrated technology package viz., application of green manuring, compost, biofertilizers, and implementation of improved rearing technologies and observed that, there is significant increase in biomass of leaf, cocoon crop survivability and pupation rate.

Rao *et al*. (2006) observed that INM technologies like green manuring with daiancha, vermicomposting, biofertilizers (*Azospirillum* + PSB) and trap cropping improved the leaf yield of mulberry from 40 MT to 60 MT/ha/yr (50 %). Consumption of DFLs increased from 200 DFLs to 400 DFLs/ crop (100 %), average yield of cocoon increased to 75 kg/100 DFLs (from 45 kg, 66 % increase and a range of 68 to 84 kg).

Reddy *et al*. (2006) reported that application of vermicompost (MT/acre), significantly increased the leaf yield (10-15%), cocoon yield (10-15%), DFLs brushing capacity (15-20%), and in terms of cocoon price (10-15%) also.

Saha and Setua (2006) conducted a bioassay with multi x multi and multi x bi silkworm hybrids during two unfavourable and two favourable seasons in Berhampore, West Bengal. The results shown that the application of reduced doses of nitrogen and phosphorus in combination with various types of organic manures increased cocoon yield and other economic characters of rearing and reeling.

Thirunavukkarsu *et al*. (2006) conducted a study with Rhizobium application of phosphobacteria, *Azospirillum*, and FYM/compost to mulberry by adopting green manure cover cropping with dhaincha and found improvement of leaf yield ranged from 3.03 to 15.1 per cent and cocoon yield / 100 dfls from 9.17 to 8.38 per cent.

Kerenhap *et al*. (2007) revealed that mulberry variety treated with poultry manure showed significant difference for all the parameters studied. The larvae fed on poultry manure applied V1 mulberry leaves showed highest moulting percentage. This investigation also shown that the moulting in silkworm has an intimate relationship with nutritive value of the leaf.

Rao *et al*. (2007) studied that silkworm growth and cocoon parameters were found improved in BBF and Vesicular Arbuscular Mycorhiza (VAM) (50% cut in N and P) T_4 and were on par with control (only 100% NPK).

Sudhakara *et al*. (2008) observed that the bivoltine silkworm breed CSR2 fed with leaves of mulberry grown by nitrogen application at recommended level through organic manures and inorganic fertilizers in different combinations with four feeding schedules and FS2 (chawki worms fed with S36 leaves + late age worm fed with M5 leaves) T_{11} combination recorded significantly lower moulting duration (4.10 days) over mulberry grown with recommended FYM + NPK (4.30 days).

Sori (2008) revealed the influence of bio-inoculants growth and yield and its subsequent effect on cocoon productivity of *Bombyx mori* L. (PM x CSR2). The mulberry leaves harvested and fed to 4th and 5th instar larvae showed maximum cocoon yield of 640.88 and 691.11g / DFLs for I and II crop followed by T_4 (638.32 and 684.91g) which were found to superior over other treatment combinations.

Shashidhar (2009) observed that, the cocoons spun by PM x CSR2 fed on mulberry leaves grown by supplying with different types of organic manures exhibited remarkable influence on cocoon traits. Pooled data of three rearings reported that, the maximum single cocoon weight (1.90 g), shell weight (0.365 g) and pupal weight (1.53 g) were recorded when young age silkworm fed with S36 mulberry grown by 100 % Rec. N through 20% each of compost + castorcake + *Glyricidia maculata* + Vermicompost and Urea + 10 kg each of *Aspergillus awamori* + *Azospirillum brasilense* biofertilizer remaining P, K through chemical fertilizers (T8).

Amarnatha *et al*. (2011) reported that, the larval developmental durations of PM × CSR2 hybrid had shorter chawki, fifth instar larval, total larval durations and total moulting while maximum larval, cocoon, pupal and shell weight, shell ratio and silk productivity obtained from the parents (PM and CSR2) fed on mulberry leaves obtained by the application of biofertilizers @ 10 kg/ha each of Aspergillus awamori + Azospirillum brasilense + 20 per cent recommended nitrogen each through castoroilcake, compost, green manure, vermicompost, and 20 per cent N with recommended dose of P and K through inorganic fertilizers and only chemical fertilizers to supply 300: 120: 120 NPK Kgs / ha / year (control) recorded maximum and minimum, respectively, This might be due to the presence of required nutrients supplied through feeding of chawki worms with S36 leaf and late age worms with M5 leaf.

Naika *et al* (2011) revealed that, significantly highest cocoon weight, shell weight and shell ratio were obtained with vermicompost (100 % N) + recommended P and K in respect of PM x CSR-2. Similarly, in case of PM x NB4D2, cocoon weight was more with vermicompost (100% N) + recommended P and K and shell weight and shell ratio were more with enriched vermicompost (100% N) + recommended P and K over rest of the treatments.

Naika *et al.* (2012) conducted a study to know the efficacy of sources of organic manures (Vermicompost, coir pith compost, enriched vermicompost, farm yard manure - FYM, biodigested slurry and urban solid waste compost) on mulberry (V-1 variety) under irrigated condition to meet nitrogen requirement (100%) and its influence was studied on economic performance of PM x CSR-2 silkworm. The study revealed that the batch of silkworms fed on mulberry leaves raised by supplying 100% nitrogen (N) through vermicompost and recommended phosphorus (P) and potassium (K) through chemical fertilizers recorded significantly superior effective rate of rearing, cocoon yield, cocoon weight, shell weight, shell ratio, silk productivity, single cocoon filament length and fibroin contents with least larval duration, disease incidence (flacherie muscardine and grasserie), denier and sericin contents. Further, enriched vermicompost + recommended P and K and recommended FYM and NPK found next best with respect to the economic traits of silkworm. However, these characters were inferior with the group of silkworms fed on mulberry grown by the application of coir pith compost and recommended P and K.

Sori and Bhaskar (2012) conducted a study with an objective to determine the effect of three bio-inoculants application to M5 mulberry plant on silkworm (PM x CSR2) growth, development and coocoon traits. The result 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. However, the recommended rate of chemical fertilizers application was found either the same or on par with 25 per cent reduced Nitrogen and Phosphorous application when supplemented with bio-inoculants (*Aspergillus awamori*, *Trichodermaharzianum* and *Azotobacter* sp).This indicate that 25 per cent reduction of NP application does not adversely affect larval growth and cocoon traits when supplemented with the above three microbes.

Sujathamma *et al.* (2014) reported the beneficial effects of various organics such as green manures, vermicompost, bio-fertilizers and application of certified organic fertilizers need to be highlighted adequately for increasing the mulberry yield and consequent silk quality. Due to continuous application of chemical fertilizers which brings about the depletion of the soil fertility, sustainable yields of cocoons could not be achieved. As an alternative, application of organic manures which helps in the revival of soil health has to be tested for a sustainable increase of yield and quality of mulberry leaf in comparison with application of chemical fertilizers. In this study six treatments comprising of organic nitrogen, organic phosphorous, organic potassium were applied and the bio-efficacy of all these inputs on the quantitative and qualitative parameters of silkworm and cocoon were studied in comparison with chemical fertilizers.

Chakraborty and Chakraborty (2016) observed that cocoons spun by NxYB races of silkworm showed promising results in larval growth and cocoon traits when developing worms were fed with mulberry leaves (S1635) raised by applying the organic manures and other biofertilizers. Pooled data of two silkworms rearing revealed that, average weight of 10 mature larvae ranged from 31.7gm.to 38.1gm; single cocoon weight was with an average 1.3gm., single shell weight varied from 0.214gm to 0.220 gm., shell ratio percent fluctuated from 16.2% to 16.6%; filament length ranged from 673.6m to 680.6 m were recorded when silkworm fed with S1635 mulberry leaves. The cocoons also exhibited reelability having the recovery of silk in the tune of 88.1% to 88.2 % and denier 2.5 gm. This indicates that application of organic manures along with biofertilizers and reduction of recommended chemical fertilizer doses does not adversely affect larval growth and cocoon traits.

Sudhakara and Narayanaswamy (2017) observed the growth of mulberry with the nitrogen application at recommended level through organic manures and inorganic fertilizers in different combination with four feeding schedules, treatments and interactions. Among these chawki worms fed with S36 leaf + late age worm fed with M5 leaf and recommended dose of 20 tonnes compost + 300: 120: 120 kg of NPK / ha / year through fertilizer exhibited significantly higher mature larval weight (40.42 and 40.62 g/10 larvae) and silk gland weights (0.777 and 0.788 g), effective rate of rearing (85.95 and 94.16 %), while the lower disease incidence (14.17 and 14.17 %), moulting duration (4.98 and 4.30 days) and larval duration (26.83 and 26.12 days) respectively.

Sudhakara *et al.* (2017) conducted a study on the role of organic and inorganic fertilizers applied to mulberry on the cocoon parameters of silkworm and found that cocoon weight (1.40 g and 1.50 g), shell weight (0.299 g and 0.325 g), shell ratio (21.44 and 21.70 %), cocoon yield (48.19 and 53.96 kg/ 100 DFLs) and silk productivity (4.46 and 5.23 cg/day) were significantly maximum when chawki worms fed with S36 and late age worm with M5 leaves and worms fed with leaves raised through application of recommended 20 tones compost + 300: 120: 120 kg N, P and K/ha/year through fertilizer.

Ram *et al*. (2018) observed the effect of mixed cake and FYM on season wise performance of silkworm rearing was non -significant in respect of weight and ERR of matured larvae, however, single cocoon, single shell and shell percent and cocoon yield were found significant. Further, it was found that the total cocoon yield in spring season was slightly higher than autumn.

Sudhakara *et al*. (2018) carried out investigations on young-age worm rearing as influenced by the application of N through organic manures and inorganic fertilizers.

Significant differences were exerted with respect to feeding schedules (FS), treatments (T) and interactions (FS × T). Among these chawki worms fed with S36 leaf + late-age worms fed with M5 leaf and recommended 20 tonnes compost + 300: 120: 120 kg N, P and K / ha/ year through fertilizer yielded significantly higher first instar (0.0571 and 0.0615 g/10 larvae), second instar (0.3126 and 0.3210 g/10 larvae), third instar (1.177 and 1.2167 g/10 larvae) and fourth instar larval weights (5.103 and 5.502 g/10 larvae) respectively. Among interactions, both chawki + late-age worms fed with S36 leaf bio-fertilizers 10 kg each of *Azospirillum* + *Aspergillus awamori*/ha/yr + 20 % recommended N through each of compost, green manure, castor oil cake, vermicompost and fertilizer + remaining P, K through fertilizer recorded maximum towards first instar silkworm weight (0.0660 g/10 larvae). However, chawki worms fed with S36 leaf + Late-age worms fed with M5 leaf with a combination of 20 tonnes compost + 300: 120: 120 kg N, P and K / ha / year through fertilizer contributed more towards second, third and fourth instar larval weights (0.3280, 1.2260 and 5.523 g/10 larvae respectively).

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled, “Organic based nutrient management in mulberry and its impact on silkworm” was carried out at the Experimental farm of the Division of Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, during 2018-19. Besides this, cocoon reeling parameters were conducted at Demonstration–Cum-Technical Service Centre, Central Silk Board, CSB Complex Miran Sahib, Jammu. The details of the experimental techniques, materials used and methods followed during the investigation are discussed under following headings.

3.1 Experimental Site

3.1.1 Location

The Experimental Farm of the Division of Sericulture, is located at an altitude of about 332 m above mean sea level, lying between $32^0$39’ N latitude and $74^0$47’ E longitude.

3.1.2 Climate and weather conditions.

Agro climatically, the location represents Zone V of Jammu and Kashmir, characterized by subtropical climate. The Jammu plains and low hills including experimental location normally experience hot dry summer, hot and humid rainy season and cold winter months. The maximum temperature goes up to 45^0C during summers (May to June) and minimum temperature falls to 4^0C during winters and fluctuates between 14-18^0 C. The mean annual rainfall is about 1000-1200 mm. The weather parameters recorded at meteorological observatory of SKUAST-Jammu, Chatha during crop growth period was depicted in fig 1.

3.1.3 Soil

The soil structure of the experimental farm is sandy clay loam with pH 7.12

3.2 Experimental Details

The soil fertility of the experimental site was brought to homogeneous condition without applying any organic manures or fertilizers before raising mulberry crop for the present experiment. Experiment was carried out by applying organic manures alone and in combination with biofertilizer. No inorganic fertilizer was applied to soil before raising mulberry crop for the present experiment. To know the effect of different organic manures on growth, yield and quality of mulberry (var. China white, 2 years old plantation) in relation to rearing performances of silkworm, the following treatment combinations were used.

T_1 **:** FYM @ 4kg /plant

T_2 **:** Vermicompost @ 4kg /plant

T_3 **:** Silkworm rearing waste @ 3kg /plant

T_4 **:** Neem cake @ 2.5kg/plant

T_5 **:** FYM @ 4kg /plant + *Azospirillum* (4.0g /plant)

T_6 **:** Vermicompost @ 4kg /plant + *Azospirillum* (4.0g/plant)

T_7 **:** Silkworm rearing waste @ 3kg /plant + *Azospirillum* (4.0g/plant)

T_8 **:** Neem cake @ 2.5kg/plant + *Azospirillum* (4.0g /plant)

T_9 **:** Control (No manure/fertilizer application)

3.2.1 Experimental layout

The treatments were applied in randomized block design (RBD) with three replications after pruning of mulberry plants in the last week of December, 2018. All cultural practices were carried out as per the package of practices for mulberry garden under pit system of cultivation (Dandin *et al*., 2010) as detailed below:

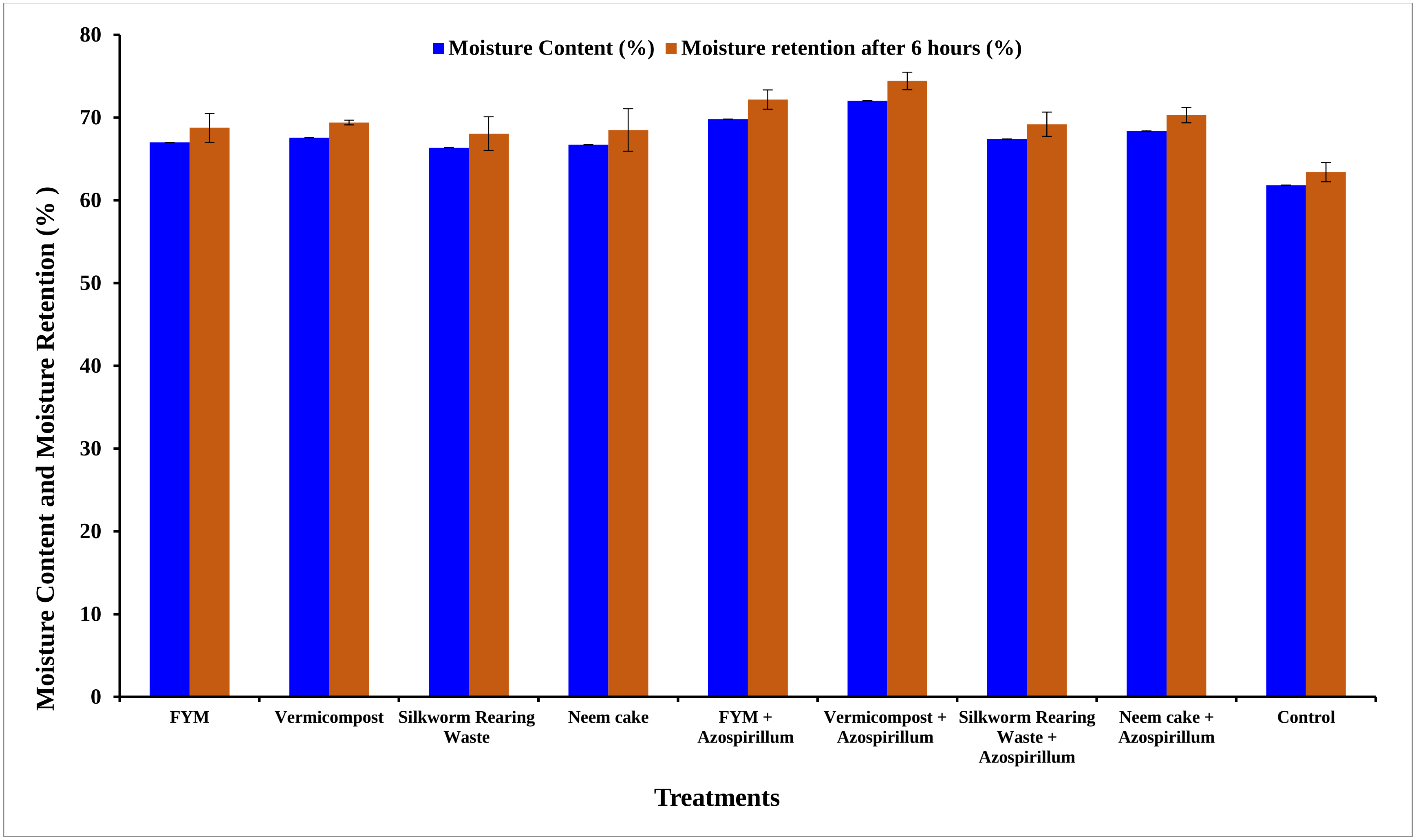
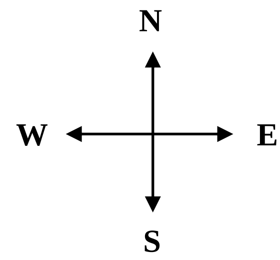


Fig. 2: Effect of organic manures alone and in combination with Azospirillum on moisture content and moisture retention per cent in mulberry leaves.

R-I	R-II	R-III
T_1	T_3	T_5
T_2	T_4	T_8
T_3	T_1	T_7
T_4	T_6	T_3
T_5	T_9	T_2
T_6	T_8	T_1
T_7	T_5	T_9
T_8	T_2	T_6
T_9	T_7	T_4



Layout of experimental field

3.3 Mulberry Parameters

Different mulberry parameters *viz.,* plant girth, plant height, number of shoots per plant, shoot length, average longest shoot, internodal length, number of leaves per plant, fresh leaf yield, leaf area index, moisture content of leaf and moisture retention after 6 hours were recorded 60 days after pruning .

3.3.1 Plant girth:

The plant girth (cm) was measured from individual plant with vernier caliper. The mean plant girth was calculated from each treatment.

3.3.2 Plant height:

Plant height (cm) was measured from the base of the plant to the tip of fully opened leaf.

3.3.3 Number of shoots per plant:

The number of shoots per plant was recorded at an interval of 60th day after pruning and the mean numbers of shoots per plants were calculated as follows

$$\text{Number of shoots/plant} = \frac{\text{Total number of shoots}}{\text{Number of plants}}$$

3.3.4 Shoot length:

The length of the shoot (cm) was measured from the base to the tip of fully opened leaves of the main shoot.

3.3.5 Average longest shoot:

The length of individual shoot (cm) was measured. Among all the shoots longest shoot length was recorded from individual plant. The mean of longest shoot was calculated from treatments of replications.

3.3.6 Inter nodal length:

The internodal length (cm) was measured between the fourth and fifth leaf from the top of the plant. The mean internodal distance was calculated from treatments of replications.

3.3.7 Number of leaves per plant:

The number of fully opened leaves in each shoot was counted and calculated as follows:

Number of Leaves = Average number of shoots per plant × Average number of leaves per shoot

3.3.8 Fresh leaf yield (g/plant):

Leaves from treatments of replications maintained exclusively for estimation were harvested and their weight was recorded and the mean yield per plant was worked out.

3.3.9 Leaf Area Index (LAI):

Leaf Area Index was measured by the ratio of the leaf area of a plant to the ground area occupied by the plant (Sestak *et al*., 1971). In the present study leaf area was measured by leaf area meter.

$$\text{LAI} = \frac{\text{Leaf area per plant}(\text{cm}^2)}{\text{Land area occupied by plant}(\text{cm}^2)}$$

3.3.10 Moisture content of leaf (%)

Moisture percentage in leaf was estimated through gravimetric method by taking the difference between fresh and dry weights and expressed in percentage on fresh weight basis (A.O.A.C., 1970).

$$\text{Moisture percentage} = \frac{\text{Weight of fresh leaves} - \text{Weight of dry leaves}}{\text{Weight of fresh leaves}} \times 100$$

3.3.11 Moisture retention capacity

Leaf moisture retention capacity was calculated by using following formula and expressed in percentage (%).

$$\frac{\text{Fresh weight of leaves} - \text{weight of leaves at 6 hours after harvest}}{\text{fresh weight of leaves}} \times \text{LMC}$$

Leaf moisture retention (%) = 100 - Leaf moisture loss

3.4 Experimental Rearing Trial

Seed of $FC_1 \times FC_2$ was procured from Regional Sericulture Research Station, Dehradun and released from cold storage, incubated and reared during Spring, 2019 in a Complete Random Block Design as per the standard rearing techniques of Krishanaswamy (1978).

The details of experiments are as under:

Hybrid	:	$FC_1 \times FC_2$
Replicates	:	Three
No. of treatments	:	9
Experimental design	:	CRD

The numbers of larvae per rearing tray were 100 in such a way that each tray represents a single independent replicate in a completely randomized design. Each treatment was replicated 3 times. The rearing tray with 100 larvae fed with mulberry leaves grown without the application of manures/fertilizers served as control (standard).

3.5 Silkworm Growth Parameters

3.5.1 Larval characters

Following observations were recorded for different parameters of larval stages

3.5.2 I age larval duration

It is the duration of larvae from the day of brushing to I moult and was recorded in days and hours for each replicate.

3.5.3 II age larval duration

It is the duration of larvae from I moult to initiation of II moult and was recorded in days and hours for each replicate.

3.5.4 III age larval duration

It is the duration of larvae from II moult to initiation of III moult and was recorded in days and hours for each replicate.

3.5.5 IV age larval duration

It is the duration of larvae from III moult to initiation of IV moult and was recorded in days and hours for each replicate.

3.5.6 V age larval duration

It is the duration of larvae from IV moult upto pre-spinning and was recorded in days and hours for each replicate.

3.5.7 Total larval life duration (Days and Hours)

It was recorded as average larval life in days from brushing to pre-spinning stage including moulting duration for each replication.

3.5.8 Weight of 10 mature larvae (g)

Ten mature larvae were picked randomly from each replicate on 5^{th} day of fifth instar and weighed using digital balance. The maximum larval weight was recorded in each replicate.

3.5.9 Larval survival percentage

The larval survival percentage represents the number of worms surviving during rearing up to pre spinning stage and was calculated by using the following formula:-

$$\frac{\text{Number of larvae surviving at pre} - \text{spinning stage}}{\text{Total number of larvae retained after III moult}} \times 100$$

3.6 Cocoon characters

Following observations were made for different parameters at cocoon stage:

3.6.1 Cocoon yield/10000 larvae:

By weight (kg)

This parameter was recorded as an average weight of cocoons harvested in kg converted for 10,000 larvae and was worked out by using the following formulae:-

$$\text{By weight } = \frac{\text{Cocoon yield in kg}}{\text{Total number of larvae retained after III moult}} \times \ 10{,}000$$

By number:

It was recorded as an average number of cocoons harvested and converted for 10,000 larvae and was worked out by using the following formulae:-

$$\text{By number} = \frac{\text{Cocoon yield by number}}{\text{Total number of larvae retained after III moult}} \times 10{,}000$$

3.6.2 Single cocoon weight (g):

Twenty five male and twenty five female cocoons were randomly selected and weighed on digital balance to determine the average cocoon weight by using the following formula:

$$\frac{\text{Weight of 25 male(g)} + \text{25 female cocoon (g)}}{50}$$

3.6.3 Single shell weight (g):

Same twenty five male and twenty five female cocoon shells from each replicate were weighed on digital balance to determine average single shell weight. The formula applied was as under

$$\frac{\text{Weight of 25 male(g)} + \text{25 female cocoon shells (g)}}{50}$$

3.6.4 Shell ratio percentage

It is the average ratio of twenty five male and twenty five female cocoon shell to that of average cocoon weight of same cocoons per replicate and was calculated by using the following formula:-

$$\frac{\text{Average weight (g)of 25cocoon shells of each sex}}{\text{Average weight of same cocoons of each sex}} \times 100$$

3.7 Post Cocoon Characters

The reeling parameters were conducted at Demonstration Cum Technical Service Centre of Central Silk Board, Miran Sahib, Jammu.

3.7.1 Total filament length:

Filament length (m) indicates the total reelable length of silk filament obtained from a single cocoon in meters. It is the average length of the silk reeled from a single cocoon.

$$\text{TFL} = \frac{\text{Length of raw silk reeled (m)} \times \text{Number of cocoons maintained per end}}{\text{Number of reeled cocoons} *}$$

*Number of reeled cocoons = Number of cocoons taken for testing – Number of new unreelable cocoons/Number of converted carry over cocoons

3.7.2 Non breakable filament length (m):

It is a length at which cocoon filament breaks and is replaced by another cocoon. It was recorded as per the following formula:-

$$\text{NBFL} = \frac{\text{Length of silk filament reeled} \times \text{No. of cocoons maintained per end}}{\text{No of reeling ends} *}$$

*Indicates number of castings + Number of carry over cocoons – Number of converted carry over cocoon.

3.7.4 Filament size (d):

It was determined by using filament reeled from ten cocoons from each replicate and was calculated by using the following formula:-

$$\frac{\text{Weight (g) of raw silk reeled}}{\text{Length (m) of silk reeled} \times \text{No. of cocoons maintained per end}} \text{ x } 9000 \text{ (m)}$$

STATISTICAL ANALYSIS

The data presented in the thesis for various parameters were tabulated and subjected to Analysis of variance techniques by using statistical package (SPSS 16.0). Effects of different treatments on mulberry, silkworm growth, cocoon and post cocoon parameters were analyzed using one way ANOVA. Differences between means were tested by using Tukey's HSD ($P < 0.05$)

Plate 3: Glimpses of Cocoon operations during experiment

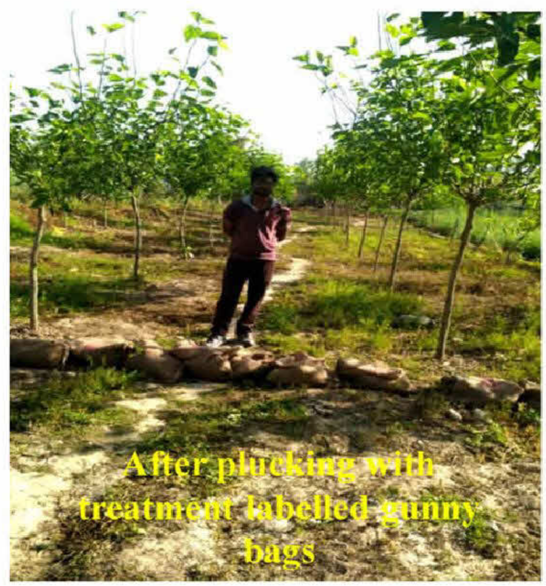


Plate 1: Glimpses of mulberry garden operations during experiment

Plate 2: Glimpses of Silkworm rearing operations during experiment

Plate 2: Glimpses of Silkworm rearing operations during experiment

CHAPTER-IV

RESULTS

The present study entitled, "Organic based nutrient management in mulberry and its impact on silkworm" was conducted during spring, 2019 at Division of Sericulture, SKUAST-Jammu in order to know the effect of organic based nutrients on growth and yield parameters of mulberry tree (var. China white), rearing performance of silkworm, *Bombyx mori* L. hybrid ($FC_1 \times FC_2$) and other important metric traits. The experimental results obtained from this investigation are presented here under:

4.1 Effect of different organic based nutrients on growth and yield of mulberry

4.1.1 Growth and yield parameters of mulberry

The data presented in the table1 reveals that application of different organic manures alone and in combination with *Azospirillum* showed significant impact on plant girth (cm) ($F = 144.715$; $df = 8$; $p < 0.001$), maximum being with the application of vermicompost + *Azospirillum* (7.50 ± 0.13) followed by FYM + *Azospirillum* (T_5) (7.20 ± 0.06) and T_8 (6.90 ±0.01) respectively over other treatments. While the lowest result was recorded in control (T_9) (5.10 ± 0.06) which was at par with T_3 (5.06 ± 0.07).

Application of vermicompost + *Azospirillum* exhibited better result for plant height ($F = 4.887$; $df = 8$; $p = 0.002$), (284.67 ± 7.36) which was at par with T_5 (279.33 ± 5.53) and T_8 (275.50 ± 10.15) whereas it was significantly less in control (T_9) (227.50 ± 7.50).

Shoot length ($F = 3.491$; $df = 8$; $p = 0.013$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (146.63 ± 8.03) which was at par with T_5 (143.90 ± 7.43) whereas it was significantly less in control (T_9) (90.50 ± 11.02). However, non significant differences were observed between T_8 (135.23 ± 8.77), T_2 (132.93 ± 3.84), T_7 (127.60 ± 6.34), T_1 (121.93 ± 10.53), T_4 (117.00 ± 13.82) and T_3 (116.57 ± 8.71).

Longest shoot ($F = 3.477$; $df = 8$; $p = 0.013$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (158.27 ± 6.71) which was at par with T_5 (157.37 ± 4.64) and T_8 (155.93 ± 10.40) whereas it was significantly less in Control (T_9) (114.67 ± 5.83). However, no significant difference was found in number of shoots per plant and internodal length in mulberry.

The data presented in the table 2 reveals that application of different organic manures alone and in combination with biofertilizer (*Azospirillum*) to mulberry tree exhibited significant result in respect of number of leaves per plant ($F = 2.825$; $df = 8$; $p = 0.032$), maximum being with the application of vermicompost + *Azospirillum* (T_6) (1203.33 ± 60.92) followed by T_5 (1164.67 ± 102.53) which was found statistically at par with T_8 (1108.33 ± 62.69) whereas it was significantly less in control (T_9) (742.00 ± 40.22).

Fresh leaf yield ($F = 32.694$; $df = 8$; $p < 0.001$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (3013.00 ± 71.00) which was at par with T_5 (2991.00 ± 67.10) whereas it was significantly less in Control (T_9) (1997.00 ± 38.74). However, non significant differences were observed between T_2 (2672.00 ± 62.02) and T_7 (2645 ± 54.90).

Leaf area index ($F = 7.386$; $df = 8$; $p < 0.001$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (1.54 ± 0.02) which was at par with T_5 (1.51 ± 0.01) and T_8 (1.50 ± 0.01) whereas it was significantly less in Control (T_9) (1.31 ± 0.06).

Moisture content of leaf ($F = 3.073$; $df = 8$; $p = 0.023$), is depicted in fig 2. In respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (72.02 ± 1.05) which was at par with T_5 (69.80 ± 1.16) whereas it was significantly less in Control (T_9) (61.82 ± 1.17) which was at par with T_4 (66.71 ± 2.58) and T_3 (66.36 ± 2.03). However, non significant differences were observed between T_8 (68.36 ± 0.93), T_2 (67.57 ± 0.28), T_7 (67.40 ± 1.46) and T_1 (67.00 ± 1.75).

Table 1: Effect of organic manures alone and in combination with Azospirillum on growth parameters of mulberry (var. China white)

Treatments	Plant girth (cm)	Plant height (cm)	Number of shoots per plant	Shoot height (cm)	Longest shoot (cm)	Internodal length (cm)
T_1: FYM @ 4kg /plant	6.10 ± 0.06 bc	258.00 ± 8.89 ab	12.67 ± 1.20	121.93 ± 10.53 ab	141.17 ± 7.30 ab	5.27 ± 0.19
T_2: Vermicompost @ 4kg /plant	6.40 ± 0.01 c	265.17 ± 4.57 ab	14.33 ± 1.20	132.93 ± 3.84 ab	149.43 ± 6.50 ab	5.20 ± 0.21
T_3: Silkworm rearing waste @ 3kg /plant	5.06 ± 0.07 a	251.33 ± 5.93 ab	12.00 ± 0.58	116.57 ± 8.71 ab	124.10 ± 14.34 ab	5.40 ± 0.06
T_4: Neem cake @ 2.5kg /plant	5.80 ± 0.10 b	253.83 ±10.46 ab	12.00 ± 0.58	117.00 ± 13.82 ab	139.60 ± 7.66 ab	5.37 ± 0.15
T_5: FYM @ 4kg /plant + *Azospirillum* (4.0g /plant)	7.20 ± 0.06 de	279.33 ±5.53 b	15.00 ± 1.00	143.90 ± 7.43 b	157.37 ± 4.64 b	5.07 ± 0.09
T_6: Vermicompost @ 4kg /plant + *Azospirillum* (4.0g /plant)	7.50 ± 0.13 e	284.67 ± 7.36 b	15.33 ± 1.20	146.63 ± 8.03 b	158.27 ± 6.71 b	5.00 ± 0.40
T_7: Silkworm rearing waste @ 3kg /plant + *Azospirillum* (4.0g /plant)	6.30 ± 0.05 c	264.17 ±7.97 ab	13.67 ± 1.45	127.60 ± 6.34 ab	142.57 ± 4.58 ab	5.23 ± 0.18
T_8: Neem cake @ 2.5kg /plant + *Azospirillum* (4.0g /plant)	6.90 ± 0.01 d	275.50 ±10.15 b	14.67 ± 1.86	135.23 ± 8.77 ab	155.93 ± 10.40 b	5.17 ± 0.23
T_9: Control (No manure/fertilizer application)	5.10 ± 0.06 a	227.50 ±7.50 a	11.00 ± 1.15	90.50 ± 11.02 a	114.67 ± 5.83 a	5.43 ± 0.18

Values are Means ± SE

Means within a column followed by different letters are significantly different at P<0.05

Table 2: Effect of organic manures alone and in combination with Azospirillum on yield parameters of mulberry (var. China white)

Treatments	Number of leaves per plant	Fresh leaf yield (g/plant)	Leaf area index (LAI)	Moisture content (%)	Moisture retention (%) after 6 hours
T_1: FYM @ 4kg /plant	992.67 ± 1.35 ab	2585.00 ± 50.93 bc	1.47 ± 0.02	67.00 ± 1.75 ab	68.76 ± 0.01 d
T_2: Vermicompost @ 4kg /plant	1056.67 ± 91.60 ab	2672.00 ± 62.02 c	1.49 ± 0.01	67.57 ± 0.28 ab	69.41 ± 0.01 f
T_3: Silkworm rearing waste @ 3kg /plant	864.33 ± 73.27 ab	2317.00 ± 47.13 b	1.44 ± 0.01	66.36 ± 2.03 a	68.06 ± 0.01 b
T_4: Neem cake @ 2.5kg /plant	988.00 ± 75.62 ab	2571.00 ± 57.12 bc	1.46 ± 0.01	66.71 ± 2.58 a	68.45 ± 0.01 c
T_5: FYM @ 4kg /plant + *Azospirillum* (4.0g /plant)	1164.67 ± 102.53 ab	2991.00 ± 67.10 d	1.51 ± 0.01	69.80 ± 1.16 b	72.17 ± 0.02 h
T_6: Vermicompost @ 4kg /plant + *Azospirillum* (4.0g /plant)	1203.33 ± 60.92 b	3013.00 ± 71.00 d	1.54 ± 0.02	72.02 ± 1.05 b	74.43 ± 0.01 i
T_7: Silkworm rearing waste @ 3kg /plant + *Azospirillum* (4.0g /plant)	1050.67 ± 96.72 ab	2645.00 ± 54.90 c	1.48 ± 0.01	67.40 ± 1.46 ab	69.19 ± 0.01 e
T_8: Neem cake @ 2.5kg /plant + *Azospirillum* (4.0g /plant)	1108.33 ± 62.69 ab	2842.00 ± 50.06 cd	1.50 ± 0.01	68.36 ± 0.93 ab	70.30 ± 0.01 g
T_9: Control (No manure/fertilizer application)	742.00 ± 40.22 a	1997.00 ± 38.74 a	1.31 ± 0.06	61.82 ± 1.17 a	63.42 ± 0.02 a

Values are Means ± SE
Means within a column followed by different letters are significantly different at $P<0.05$

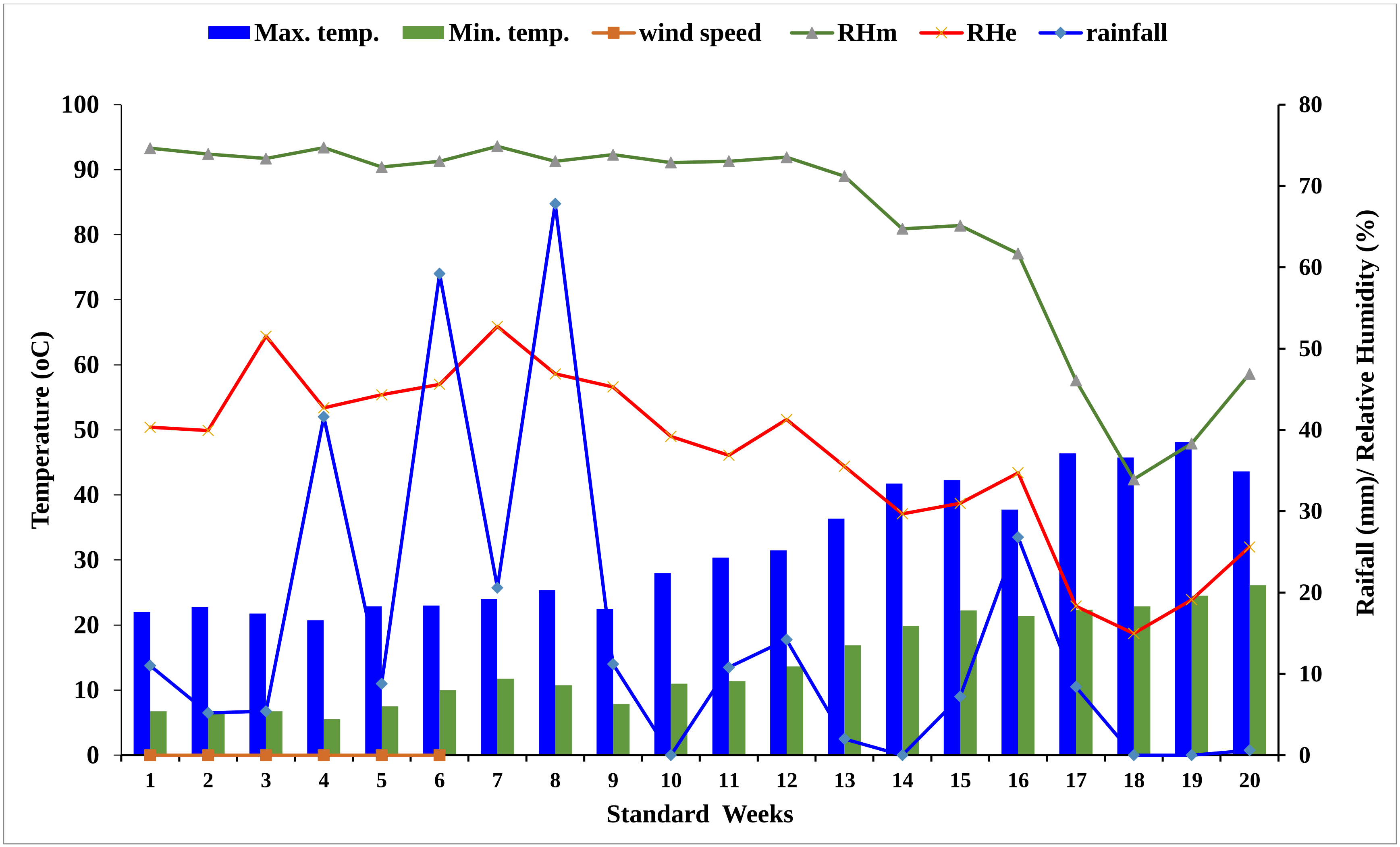


Fig. 1: Meterological data during crop period

Moisture retention of leaf after 6 hours ($F = 70063.530$; $df = 8$; $p < 0.001$) fig 2. In respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (74.43 ± 0.01) followed by T_5 (72.17 ± 0.02) and T_8 (70.30 ± 0.01) respectively over other treatments whereas it was significantly less in Control (T_9) (63.42 ± 0.02).

4.2 Effect of different organic manures alone and in combination with Azospirillum on rearing performance of silkworm

4.2.1 Larval growth parameters

At larval stages, the observations were recorded on the duration of larval instars, moulting and total larval duration (D:H)

The data presented in Table 3 reveals that I instar larval duration was 4:00±0.00 (D:H). However, II instar larval duration was 3:00±0.00 (D:H) and there is no significant difference was found between the treatments in I and II instar duration.

III instar larval duration (D:H) ($F = 19.551$; $df = 8$; $p < 0.001$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) resulted in significantly shorter larval duration (4:01 ± 0.01) followed by T_5 (4:03 ± 0.01), T_8 (4:03 ± 0.01) and T_2 (4:04 ± 0.01) while significantly higher larval duration was registered in Control (T_9) (4:12 ± 0.01). However, non significant differences were observed between T_1 (4:06 ± 0.01) and T_4 (4:07 ± 0.01).

IV instar duration (D:H) ($F = 36.705$; $df = 8$; $P < 0.001$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) resulted in significantly shorter larval duration (5:01 ± 0.00) followed by T_5 (5:03 ± 0.01) and T_8 (5:04 ± 0.00) respectively over other treatments while significantly higher larval duration was registered in control (T_9) (5:13 ± 0.01). However, non significant differences were observed between T_2 (5:05 ± 0.01) and T_7 (5:06 ± 0.01).

Table 3: Effect of organic manures alone and in combination with Azospirillum on total larval duration (D:H)

Treatments	I age larval duration (D:H)	I moult	II age larval duration (D:H)	II moult	III age larval duration (D:H)	III moult	IV age larval duration (D:H)	IV moult	V age larval duration (D:H)	Total larval duration (D:H)
T_1: FYM @ 4kg /plant	4:00 ±0.00	0.24	3:00±0.00	0.23	4:06±0.01 bc	0.24	5:07±0.01 cde	0.27	7:11±0.01 de	28:02±0.01 e
T_2: Vermicompost @ 4kg /plant	4:00±0.00	0.24	3:00±0.00	0.23	4:04±0.01 ab	0.24	5:05±0.01 bcd	0.26	7:08±0.01 bc	27:16±0.01 c
T_3: Silkworm rearing waste @ 3kg /plant	4:00±0.00	0.24	3:00±0.00	0.23	4:09±0.01 cd	0.24	5:10±0.01 ef	0.28	7:14±0.01 e	28:12±0.01 g
T_4: Neem cake @ 2.5kg /plant	4:00±0.00	0.24	3:00±0.00	0.23	4:07±0.01 bc	0.24	5:08±0.01 de	0.27	7:13±0.01 e	28:06±0.01 f
T_5: FYM @ 4kg /plant + *Azospirillum* (4.0g /plant)	4:00±0.00	0.24	3:00±0.00	0.23	4:03±0.01 ab	0.24	5:03±0.01 ab	0.26	7:02±0.01 a	27:09±0.01 b
T_6: Vermicompost @ 4kg /plant + *Azospirillum* (4.0g /plant)	4:00±0.00	0.24	3:00±0.00	0.23	4:01±0.01 a	0.24	5:01±0.00 a	0.25	7:00±0.00 a	27:02±0.01 a
T_7: Silkworm rearing waste @ 3kg /plant + *Azospirillum* (4.0g /plant)	4:00±0.00	0.24	3:00±0.00	0.23	4:05±0.01 abc	0.24	5:06±0.01 bcd	0.27	7:08±0.01 cd	27:20±0.01 d
T_8: Neem cake @ 2.5kg /plant + *Azospirillum* (4.0g /plant)	4:00±0.00	0.24	3:00±0.00	0.23	4:03±0.01 ab	0.24	5:04±0.00 abc	0.26	7:03±0.01 ab	27:11±0.01 b
T_9: Control (No manure/fertilizer application)	4:00±0.00	0.24	3:00±0.00	0.24	4:12±0.01 d	0.24	5:13±0.01 f	0.30	7:19±0.01 f	29:02±0.01 h

Values are Means ± SE
Means within a column followed by different letters are significantly different at P<0.01

V instar duration (D:H) ($F = 83.585$; df = 8; $P < 0.001$) in respect of this parameter application of vermicompost + *Azospirillum* (T_6) resulted in significantly shorter larval duration (7:00 ± 0.00) which was found statistically at par with T_5 (7:02 ± 0.01) followed by T_8 (7:03 ± 0.01) while significantly higher larval duration was recorded in Control (T_9) (7:19 ± 0.01). However, non significant differences were observed between T_3 (7:14 ± 0.01) and T_4 (7:13 ± 0.01).

Total larval duration (D:H) ($F = 1183.000$; df = 8; $P < 0.001$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) resulted in significantly shorter larval duration (27:02 ± 0.01) followed by T_5 (27:09 ± 0.01) which was found statistically at par with T_8 (27:11 ± 0.01).While significantly higher total larval duration was observed in Control (T_9) (29:02± 0.01).

The data presented in the Table 4 revealed that when worms were fed with mulberry grown through application of different organic manures alone and in combination with biofertilizer (*Azospirillum*), resulted in significantly higher weight of 10 mature larvae ($F = 16.463$; df = 8; $P < 0.001$) maximum being with the application of vermicompost + *Azospirillum* (T_6) (46.69 ± 0.66) followed by T_5 (44.22 ± 0.90) which was found statistically at par with T_8 (44.03 ± 0.56) and T_2 (43.13 ± 0.49) whereas, significantly lower results were observed in control (T_9) (37.66 ± 0.33). However, non significant differences were observed between T_7 (42.66 ± 0.33), T_1 (42.32 ± 0.72), T_4 (42.00 ± 0.58) and T_3 (41.98 ± 0.58).

With respect to, larval survival per cent ($F = 14.615$; df = 8; $P < 0.001$), application of vermicompost + *Azospirillum* (T_6) resulted in significantly higher larval survival per cent (97.05 ± 0.58) followed by T_5 (96.27 ± 0.67) which was found statistically at par with T_8 (95.74 ± 0.43), T_2 (94.97 ± 1.06), T_7 (94.23 ± 0.52) and T_1 (93.77 ± 0.95) Whereas significantly lower larval survival per cent was registered in control (T_9) (88.04 ± 0.58). However, non significant differences were observed between T_4 (92.17 ± 0.89) and T_3 (91.87 ± 0.58).

Table 4: Effect of different organic manures alone and in combination with Azospirillum on larval traits.

Treatments	Weight of 10 mature larvae (g)	Larval Survival per cent
T_1: FYM @ 4kg /plant	42.32 ± 0.72 b	93.77 ± 0.95 bc
T_2: Vermicompost @ 4kg /plant	43.13 ± 0.49 bc	94.97 ± 1.06 bc
T_3: Silkworm rearing waste @ 3kg /plant	41.98 ± 0.58 b	91.87 ± 0.58 ab
T_4: Neem cake @ 2.5kg /plant	42.00 ± 0.58 b	92.17 ± 0.89 ab
T_5: FYM @ 4kg /plant + *Azospirillum* @ 4.0g /plant	44.22 ± 0.90 bc	96.27 ± 0.67 bc
T_6: Vermicompost @ 4kg /plant + *Azospirillum* (4.0g /plant)	46.69 ± 0.66 c	97.05 ± 0.58 c
T_7: Silkworm rearing waste @ 3kg /plant + *Azospirillum* (4.0g /plant)	42.66 ± 0.33 b	94.23 ± 0.52 bc
T_8: Neem cake @ 2.5kg /plant + *Azospirillum* (4.0g /plant)	44.03 ± 0.56 bc	95.74 ± 0.43 bc
T_9: Control (No manure/fertilizer application)	37.66 ± 0.33 a	88.04 ± 0.58 a

Values are Means ± SE

Means within a column followed by different letters are significantly different at $P<0.01$

Table 5: Effect of different organic manures alone and in combination with Azospirillum on cocoon traits

Treatments	Cocoon yield /10000 larvae		Single Cocoon Weight (g)	Single Shell Weight (g)	Shell ratio %
	By wt.	By No.			
T_1: FYM @ 4kg /plant	13.22 ± 0.02 c	8483 ± 4.04 d	1.97 ± 0.01 bc	0.40 ± 0.01 bcd	20.31 ± 0.33 bc
T_2: Vermicompost @ 4kg /plant	13.88 ± 0.02 e	8649 ± 2.31 f	2.00 ± 0.01 cd	0.43 ± 0.01 cdef	21.38 ± 0.55 bc
T_3: Silkworm rearing waste @ 3kg /plant	13.01 ± 0.01 b	8219 ± 1.73 b	1.93 ± 0.01 b	0.37 ± 0.01 b	19.57 ± 0.72 ab
T_4: Neem cake @ 2.5kg /plant	13.09 ± 0.01 b	8376 ± 2.89 c	1.96 ± 0.01 bc	0.39 ± 0.01 bc	20.07 ± 0.80 abc
T_5: FYM @ 4kg /plant + *Azospirillum* (4.0g /plant)	14.08 ± 0.02 f	8872.7 ± 4.1 h	2.03 ± 0.01 de	0.46 ± 0.01 ef	22.66 ± 0.26 c
T_6: Vermicompost @ 4kg /plant + *Azospirillum* (4.0g /plant)	14.26 ± 0.01 g	8987 ± 5.51 i	2.06 ± 0.01 e	0.48 ± 0.00 f	23.10 ± 0.17 c
T_7: Silkworm rearing waste @ 3kg /plant + *Azospirillum* (4.0g /plant)	13.41 ± 0.01 d	8592 ± 1.73 e	1.99 ± 0.01 cd	0.42 ± 0.01 bcde	20.98 ± 0.53 bc
T_8: Neem cake @ 2.5kg /plant + *Azospirillum* (4.0g /plant)	14.01 ± 0.01 f	8763 ± 2.52 g	2.02 ± 0.01 de	0.45 ± 0.01 def	22.24 ± 0.57 bc
T_9: Control (No manure/fertilizer application)	12.03 ± 0.01 a	7847 ± 2.89 a	1.80 ± 0.01 a	0.31 ± 0.00 a	17.00 ± 0.13 a

Values are Means ± SE

Means within a column followed by different letters are significantly different at P<0.01

4.2.2 Cocoon parameters

The following observation on cocoon parameters were recorded when silkworm hybrid, ($FC_1 \times FC_2$) was fed with mulberry grown by the application of different organic manures alone and in combination with *Azospirillum*.

The data regarding cocoon parameters presented in Table 5 revealed that cocoon yield by weight in kg (F = 2368.000; df = 8; P < 0.001) through application of vermicompost + *Azospirillum* (T_6) exhibited better results (14.26 ± 0.01) followed by T_5 (14.08 ± 0.02) which was found statistically at par with T_8 (14.01 ± 0.01). While significantly lower cocoon yield by weight was registered in control (T_9) (12.03 ± 0.01). However, non significant differences were observed between T_3 (13.01 ± 0.01) and T_4 (13.09 ± 0.01).

Cocoon yield by number (F = 1136.000; df = 8; P < 0.001), in rex spect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (8987 ± 5.51) followed by T_5 (8872 ± 4.1) and T_8 (8763 ± 2.52). While significantly lower cocoon yield by number was registered in control (T_9) (7847 ± 2.89).

Single cocoon weight (F = 74.302; df = 8; P < 0.001), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (2.06 ± 0.01) followed by T_5 (2.03 ± 0.01) which was found statistically at par with T_8 (2.02 ± 0.01). While significantly lowest single cocoon weight was registered in control (T_9) (1.80 ± 0.01). However, non significant differences were observed between T_1 (1.97 ± 0.01) and T_4 (1.96 ± 0.01).

Single shell weight (F = 38.893; df = 8; P < 0.001), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (0.48 ± 0.00) followed by T_5 (0.46 ± 0.01) and T_8 (0.45 ± 0.01) respectively over other treatments. While, significantly lower single shell weight was observed in control (T_9) (0.31 ± 0.00).

Shell ratio (F = 13.634; df = 8; P < 0.001) in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (23.10 ± 0.17) which was at par with T_5 (22.66 ± 0.26) whereas it was significantly less in control (T_9) (17.00 ± 0.13). However, non significant differences were observed between T_8 (22.24 ± 0.57), T_2 (21.38 ± 0.55), T_7 (20.98 ± 0.53) and T_1 (20.31 ± 0.33).

Table 6: Effect of different organic manures alone and in combination with Azospirillum on post cocoon traits

Treatments	Total filament length (m)	Non breakable filament length (m)	Filament size (d)
T_1: FYM @ 4kg /plant	1141.00 ± 3.21 c	1019.00 ± 2.08 c	2.86 ± 0.01 def
T_2: Vermicompost @ 4kg /plant	1165.00 ± 3.46 c	1058.00 ± 3.21 d	2.81 ± 0.01 cd
T_3: Silkworm rearing waste @ 3kg /plant	1018.00 ± 2.65 b	971.00 ± 1.73 b	2.90 ± 0.02 f
T_4: Neem cake @ 2.5kg /plant	1049.00 ± 7.55 b	1012.00 ± 3.61 c	2.89 ± 0.01 ef
T_5: FYM @ 4kg /plant + *Azospirillum* (4.0g /plant)	1269.00 ± 8.19 e	1165.00 ± 3.61 f	2.73 ± 0.01 b
T_6: Vermicompost @ 4kg /plant + *Azospirillum* (4.0g /plant)	1308.00 ± 9.07 e	1308.00 ± 4.73 g	2.50 ± 0.02 a
T_7: Silkworm rearing waste @ 3kg /plant + *Azospirillum* (4.0g /plant)	1163.00 ± 4.73 c	1049.00 ± 2.89 d	2.83 ± 0.01 cde
T_8: Neem cake @ 2.5kg /plant + *Azospirillum* (4.0 g /plant)	1215.00 ± 10.07 d	1141.00 ± 5.13 e	2.79 ± 0.01 bc
T_9: Control (No manure/fertilizer application)	968.00 ± 5.03 a	806.00 ± 3.79 a	2.93 ± 0.01 f

Values are Means ± SE
Means within a column followed by different letters are significantly different at P<0.01

4.2.3 Post Cocoon parameters

Following observation were recorded for different parameters of post cocoon characters.

The data presented in the table 6 revealed that worms were fed with mulberry grown by the application of different organic manures alone and in combination with *Azospirillum*, exhibited significant results in respect of total filament length (m) ($F = 304.891$; $df = 8$; $p < 0.001$) with maximum being with the application of vermicompost + *Azospirillum* (T_6) (1308.00 ± 9.07) which was at par with T_5 (1269.00 ± 8.19) whereas it was significantly less in Control (T_9) (968.00 ± 5.03). However, non significant differences were observed between T_2 (1165.00 ± 3.46), T_7 (1163.00 ± 4.73) and T_1 (1141.00 ± 3.21).

Non-breakable filament length (m) ($F = 1522.000$; $df = 8$; $p < 0.001$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) exhibited better results (1308.000 ± 4.73) followed by T_5 (1165.00 ± 3.61) and T_8 (1141.00 ± 5.13) respectively over other treatments. Whereas, significantly lower results was recorded in control (T_9) (806.00 ± 3.79). However, non significant differences were observed between T_2 (1058.00 ± 3.21) and T_7 (1049.00 ± 2.89).

Filament size (d) ($F = 133.762$; $df = 8$; $p < 0.001$), in respect of this parameter application of vermicompost + *Azospirillum* (T_6) resulted in significantly finer denier (2.50 ± 0.02) followed by T_5 (2.73 ± 0.01) and T_8 (2.79 ± 0.01) respectively over other treatments. However, coarser denier was observed in control (T_9) (2.93 ± 0.01).

CHAPTER-V

DISCUSSION

The success of silkworm rearing largely depends on the availability of quality mulberry leaves which in turn improves the growth, development, health, feed consumption by silkworms resulting in better silk production (Sori and Bhaskar, 2012). As feeding of quality mulberry leaves is the most important pre-requisite for producing quality silk hence the mulberry cultivation with nutrient management is also important (Singh *et al*., 2012). Keeping in view the importance of organic manures and its impact on mulberry growth and yield parameters, growth and its metric traits of silkworm, the present study was carried out.

5.1 Impact of organic manures alone and in combination with Azospirillum on mulberry growth and yield parameters

The results obtained during the current investigation revealed significant increase in mulberry growth and yield parameters *viz.*,plant girth (7.50±0.13) (cm), plant height (284.67±7.36) (cm), number of shoots per plant (15.33±1.20), shoot length (146.63±8.03) (cm), longest shoot (158.27±6.71) (cm), internodal distance (5.00±0.40) (cm), number of leaves per plant (1203.33±60.92), fresh leaf yield (3013.00±71.00) (g/plant), leaf area index (1.54±0.02) and moisture content (72.02±1.05) % and moisture retention per cent after 6 hours (74.43 ± 0.01) through the combined application of vermicompost @ 4kg/plant + *Azospirillum* (4.0g /plant) (T_6). This is due to the fact that combined application of organic manures and biofertilizers not only helps in sustaining the soil fertility but also improve the mulberry productivity, nutrient use efficiency, biodiversity and soil environment (Senapati *et al.*, 2005 and Moradi *et al.*, 2014). These results are in close conformity with the results obtained by Naika *et al.* (2012); Singh *et al.* (2012); Dhanalakshmi *et al.* (2014); Moradi *et al.* (2014); Umesha and Sannappa (2014); Sudhakara *et al*. (2017) in which they used vermicompost with 50 per cent of NPK and *Azospirillum* with 25 per cent of compost, green manure, castor oil cake and vermicompost. But there is slight variation in the results as obtained by Suvarna (2007), revealed that highest number of leaves per plant in case of *Azospirillum* application and lowest in case of neem cake and vermicompost application in brinjal crop. The difference between the results can be attributed to the selection of different crops and dosage of manures applied under different agro-climatic conditions.

The results of Baqual and Das (2006) in improving mulberry leaf quality and quantity by application of *Azospirillum* confirms the present findings and economic potentiality of using *Azospirillum* in combination with FYM in mulberry cultivation. Jayathilake *et al.* (2006) reported similar results in which *Azospirillum* in combination with FYM and *Azotobacter* in combination with FYM and chemical fertilizer was used and recorded 14.79 and 13.36 per cent more yield than control respectively and revealed its beneficial effect as earlier described by Shinde *et al.* (1992); Naika *et al.* (2012); Umesha and Sannappa (2014) and Mallappa *et al.* (2016).

Neem cake @ 2.5kg /plant + *Azospirillum* (4.0g /plant) (T_8) showed results at par with T_5 *i.e.* FYM @ 4kg /plant + *Azospirillum* (4.0g /plant) and vermicompost @ 4kg /plant + *Azospirillum* (4.0g /plant) (T_6) for various parameters except number of leaves per plant which were more in FYM @ 4kg /plant + *Azospirillum* (4.0g /plant) (T_5) and vermicompost (4.0g /plant) + *Azospirillum* (4.0g /plant) (T_6) (1164.67±102.53 and 1203.33±60.92) as compared to neem cake @ 2.5kg /plant + *Azospirillum* (4.0g /plant) (T_8) (1108.33 ± 62.69), thereby showing negative effect of neem cake on number of leaves per plant. The negative impact of neem cake on leaf yield was supported by the results achieved by Suvarna (2007) and Rizvi *et al.* (2015) who suggested the application of neem cake for improving soil health and reduction in nematode population causing root-knot disease.

Application of vermicompost alone @ 4kg/plant (T_2), showed positive impact for all the studied parameters of mulberry except for less number of leaves per plant (1056.67 ± 91.60) in comparison to FYM @ 4kg/plant + *Azospirillum* (4.0g /plant) (T_5), vermicompost @ 4kg/plant + *Azospirillum* (4.0g /plant) (T_6) and neem cake @ 2.5kg/plant + *Azospirillum* (T_8) (1164.67±102.53, 1203.33±60.92 and 1108.33 ± 62.69, respectively). However, all other parameters showed values at par to other treatments. These findings suggest the economic viability of vermicompost and recommend its use in mulberry cultivation as it possesses significant positive impact on growth and yield parameters of mulberry. These findings showed close conformity with the results obtained by Dhanalakshmi *et al.* (2014); Suvarna (2007); Singh *et al.*(2012); Moradi *et al.* (2014) and Umesha and Sannappa (2014) who recommended the use of vermicompost for better yield.

The application of silkworm rearing waste @ 3kg/plant + *Azospirillum* (4.0g /plant) (T_7) showed lesser values for all the studied parameters of mulberry in comparison to vermicopost @ 4kg/plant (T_2), FYM @ 4kg/plant + *Azospirillum* (4.0g /plant) (T_5), vermicompost @ 4kg/plant + *Azospirillum* (4.0g /plant) (T_6) and neem cake @ 2.5kg/plant + *Azospirillum* (4.0g /plant) (T_8). The findings of Chakraborty and Kundu (2015), who obtained similar results with application of silkworm rearing waste with *Azotobacter* support these observations.

Organic manures viz., FYM @ 4.0kg/plant (T_1), neem cake @ 2.5 kg/plant (T_4) and silkworm rearing waste @ 3kg/plant (T_3) respectively, also showed positive effect on various growth and yield parameters of mulberry in decreasing order of its impact, with slight variation to other treatments which showed higher values for different parameters and in comparison to control (T_9) in which no additional inputs were given thus significant difference in values was recorded. The results of Chowdhury *et al.* (2009); Kalaiyarasan *et al.* (2015); Ahmed *et al.* (2017); Mallappa *et al.* (2016); Shyla *et al.*(2016); Ram *et al.* (2017); Sudhakara *et al.* (2017); Ram *et al.* (2018); Shashidhar *et al.*(2018); Sudhakara *et al.* (2018) and Thangamalar *et al.*(2018), supported the current findings and suggested the use of organic based nutrients including FYM, neem cake, silkworm rearing waste and manures for improving the soil health and attaining better quality and quantity of mulberry leaf as well as silk.

5.2 Impact of organic manures alone and in combination with Azospirillum on cocoon traits of silkworm

The importance of mulberry in sericulture industry can be realized from the fact that mulberry leaves form the only food material required by silkworm *Bombyx mori* L. (Chanotra *et al*., 2019). Production of high quality silk therefore demands the overall improvement of the host plant manifested in terms of qualitative and quantative leaf production.

Silkworm larvae fed with mulberry leaves raised with the application of vermicompost @ 4 kg/plant + *Azospirillum* (4.0g /plant) (T_6) showed higher values for cocoon yield per 10000 larvae by number and by weight (8987±5.51 and 14.26±0.01 kg respectively), single cocoon weight (2.06±0.01) (g), single shell weight (0.48±0.00) (g) and shell ratio per centage (23.10±0.17). Significant increase was also observed for the same treatments in case of post cocoon metric traits including total filament length (1308.00±9.07) (m), non-breakable filament length (1308.00±4.73) (m) and filament size (2.50 ± 0.02) (d). These results are in confirmation with the findings of Naika *et al.* (2011) and Venugopal *et al*. (2010) who recommended the application of vermicompost for better growth and yield in mulberry as well as in silkworm. Mahmood *et al*. (2002) reported the similar results when silkworm larvae were fed with mulberry leaves supplemented with FYM and different doses of NPK and Sori and Bhaskar (2012), reported increase in post cocoon characters by feeding the larvae on mulberry leaves grown in FYM treatment soil, suggesting the application of FYM in mulberry cultivation for obtaining higher yield and better post cocoon traits.

Application of FYM @ 4 kg/plant + *Azospirillum* (T_5) and neem cake @ 2.5kg/plant + *Azospirillum* (T_8) resulted in significant increase in cocoon yield per 10000 larvae by number and by weight (8763±2.52 and 14.01±0.01kg respectively), single cocoon weight (2.02 ± 0.01) (g), single shell weight (0.45±0.01) (g) and shell ratio percentage (22.24±0.57) and in case of post cocoon parameters, total filament length (1215.00±10.07) (m), non breakable filament length (1141.00±5.13) (m) and filament size (2.89±0.01) (d). Results of the present study are supported by the findings of Rizvi *et al.* (2015), who also suggested the application of neem cake improving soil health.

Moreover, application of vermicompost @ 4 kg/plant (T_2) and silkworm rearing waste @ 3 kg/plant + *Azospirilum* (4.0g /plant) (T_7) respectively revealed positive impact on all the traits under study and in both the cases the impact of treatments remained at par. Earlier similar results have been reported by Umesha and Sannappa (2014) and

Ahmed *et al.* (2017), who revealed the positive impact of silkworm rearing waste on mulberry leaves and other important cocoon characters.

Significant positive impact was recorded for various parameters in silkworm larvae and post cocoon parameters with respect to mulberry leaves treated with T_1, T_4, and T_3 comprising of FYM @ 4.0kg/plant, Neem cake @ 2.5 kg/plant and silkworm rearing waste @ 3kg/plant respectively. Values for all the studied characteristics showed results at par for T_1, T_4, and T_3 except in case of cocoon yield per 10000 larvae by number which was recorded to be higher in T_1 (8483±4.04) as compared to T_4, and T_3 (8376±2.89 and 8219±1.73 respectively), along with single shell weight (g) which was also recorded to be higher in T_1 (0.40±0.01) as compared to T_4, and T_3 (0.39±0.01 and 0.37±0.01 respectively) and non breakable filament length (m) which was recorded to be lowest in Sericulture rearing waste (T_3) (971.00 ±1.73) and found to be higher in compared to FYM @ 4.0kg/plant (T_1) and Neem cake @ 2.5 kg/plant (T_4) (1019.00±2.08 and 1012.00±3.61 respectively). Similar results for post cocoon characters were earlier reported by Chakraborty and Kundu (2015) and Ram *et al.* (2017 a), who indicated the positive impact of FYM and silkworm rearing waste on quality and quantity of mulberry leaf and ultimately on commercial metric traits of silkworm also.

Application of integrated organic manures including *Azospirillum*, FYM, silkworm rearing waste, vermicompost and neem cake to mulberry and in turn feeding the leaves to bivoltine silkworm breeds resulted in improved rearing and post cocoon parameters of silkworms. Silkworm larvae fed with mulberry leaves grown with different treatments of organic based nutrients showed positive and significant increase in various stages of larval growth and in yield as well as in other post cocoon traits in comparison to control (T_9), in which no supplement application was given. The current investigation suggested the application of organic based nutrients mainly the vermicompost + *Azospirillum* (T_6) for obtaining better rearing and yield performance. These observations obtained from the current study are in confirmation with that of Jagadeesh *et al.* (2005) and Sudhakara *et al.* (2017).

CHAPTER-VI

SUMMARY AND CONCLUSION

The present investigation entitled, "Organic based nutrient management in mulberry and its impact on silkworm" was carried out at Division of Sericulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Chatha in order to know the impact of various organic based manures alone and in combination with *Azospirillum* on growth and yield of mulberry and performance of silkworm hybrid ($FC_1 \times FC_2$). The study revealed that application of FYM, vermicompost, silkworm rearing waste, neem cake alone and in combination with *Azospirillum* showed the positive impact on soil health in terms of activity of microbial population which was reflected in the improvement of growth and yield of mulberry leaves and in turn exhibiting significant impact on growth and larval characters as well as on other cocoon traits of silkworm.

The results obtained during the current investigation revealed significant increase in mulberry growth parameters with organic manures alone and in combination with bio-fertilizer with respect to plant girth, plant height, number of shoots per plant, shoot length, longest shoot, inter-nodal distance, number of leaves per plant, leaf area, leaf area index, moisture content and moisture retention after 6 hours.

The observations recorded on larval traits revealed that silkworm hybrid ($FC_1 \times FC_2$) fed with mulberry leaves grown with the application of vermicompost @ 4kg/plant + *Azospirillum* (4.0g/plant) showed maximum V instar 10 larval weight (46.69±0.66), larval survival per cent (97.05±0.58) and total larval duration (27.02±0.01) followed by application of FYM + *Azospirillum* (T_5) with respect to V instar 10 mature larval weight (44.22 ± 0.90), larval survival per cent (96.27±0.67) and total larval duration (27.09±0.01) respectively. Minimum values were recorded in case of T_9 *i.e.* control (No manure/fertilizer application) with respect to V instar larval weight (47.66±0.33), larval survival per cent (88.04±0.58) and total larval duration (29.02 ± 0.01).

The combined application of vermicompost @ 4kg/plant + *Azospirillum* (4.0g/plant) revealed positive impact on various metric traits and post cocoon parameters and maximum values were recorded with respect to ERR (By wt. 14.26±0.01 kg; By No.8987±5.51), single cocoon weight (2.06±0.01g), single shell weight (0.48±0.00g), shell ratio per cent (23.10± 0.17), total filament length (1308.00±9.07m), non breakable filament length (1308.00± 4.73m), filament size (2.50±0.02d) followed by T_5 *i.e.*, FYM + *Azospirillum* (2.73±0.01) with respect to ERR (By wt.14.08±0.02 ; By No. 8872.7±4.1), single cocoon weight (2.03± 0.01g), single shell weight (0.46±0.01g), shell ratio (22.66±0.26), total filament length (1269.00±8.19m), non breakable filament length (1165.00±3.61m), filament size (2.73± 0.01d) respectively.

On the basis of current findings, it may been concluded that, the application of vermicompost @ 4kg /plant + *Azospirillum* (4.0g/plant) after pruning would be an advisable treatment so as to produce good quality mulberry leaves which in turn may improve soil health and cocoon crop as well with improved metric traits. This could be due to considerable research evidence that earthworms stimulate the microbial decomposition of organic matter significantly, thereby releasing the nutrients in available form to mulberry tree which has a direct effect on quality of mulberry leaves, which might have enhanced palatability and acceptability of leaves, increased feeding efficiency of silkworms and thereby resulting in good cocoon yield. Whereas, other organic manures like FYM, silkworm rearing waste and neem cake may require some more time to breakdown into simpler molecules and to release nutrients to the soil and making them available to mulberry tree for its utilization. Thus, application of vermicompost + *Azospirillum* (T_6) could form a suitable organic manure and biofertilizer combination for mulberry cultivation from overall sericultural point of view.

REFERENCES

A.O.A.C. 1970. Official Methods of Analysis. (Ed. Daniel Banes), published by A.O.A.C., Washington, D.C., pp. 105.

Agastian, S. T. P. and Vivekanandan, M. 1997. Effect of induced salt stress on growth and uptake of mineral nutrients in mulberry (*Morus alba* L). *Indian Journal of Agricultural Sciences*, **67**(10): 469-472.

Ahmed, F., Sultana, R., Ahmed, O. and Iqbal, Md. T. 2017. Seriwaste compost enhances mulberry leaf yield and quality in Bangladesh. *American Journal of Plant Nutrition and Fertilization Technology*, **7** (1): 1-10.

Amarnatha, N., Narayanaswamy, T. K., Shankar, M. A., Sreeramulu, K. R. and Krishna, K. S. 2011. Integrated organic based nitrogen management approach in mulberry on larval traits of silkworm, *Bombyx mori* L. *International Journal of Science and Nature*, **2**(3): 452-455.

Anilkumar, A. S. and John, P. S. 2000. Integrated nutrient management for sustainable Mulberry production in humid tropics. In: Chinnaswamy, L. P., Govindan, R., Krishnaprasad, N. K. and Reddy, D. N. R (eds.). *Proceedings of National Seminar on Tropical Sericulture*, University of Agricultural Sciences, Bangalore, pp. **1**: 53-57.

Anonymous, 2017. *Economic Survey Government of Jammu and Kashmir*. Directorate of Economics and Statistics, pp. 84.

Anonymous 2018. http//www.texmin.nic.in.[Accessed online: 16 June, 2018]

Baqual, M. F. and Das, P. K. 2006. Influence of biofertilizers on macronutrient uptake by the mulberry plant and its impact on silkworm bioassay. *Caspian Journal of Environmental Sciences*, **4**(2): 98-109.

Baqual, M. F. and Qayoom, S. 2004. Biofertilizers and the promises that they hold. *Indian Silk*, **43**(3):15-16.

Barber, E. J. W. 1992. Prehistoric textiles: the development of cloth in the Neolithic and Bronze Ages with Special reference to the Aegean (reprint, illustrated ed.). Published by Princeton University Press, USA, P. 31.

Chakraborty, B. and Chakraborty, S. K. 2016. Influence of bio and organic nutrients on economic traits of mulberry silkworm (*Bombyx mori* L). *International Journal of Innovative Research in Science, Engineering and Technology,* **5**(12): 21204-21209.

Chakraborty, B. and Kundu, M. 2015. Effect of biofertilizer in combination with organic manures on growth and foliar constituents of mulberry under rainfed lateritic soil condition. *The International Journal of Engineering and Science,* **4**(3):16-20.

Chandrakumar, H. L., Kumar, A. C. T., Kumar, N. G., Chakravarthy, A. K. and Puttaraju, T. B. 2008. Effect of organic sources of nutrients on soil microbes. *Journal of Soil Biology and Ecology,* **28**(2): 186-189.

Chanotra, S., Bali, R. K. and Bali, K. 2019. Morpho-physiological characterization of mulberry genotypes (*Morus* spp.) for inheritance in future breeding programme. *Journal of Pharmacognosy and Phytochemistry.* **8**(1): 2695-2701.

Chinnaswamy, K. P., Pasha, S. N. and Fatima, S. 2005. Productivity of multivoltine silkworm seed breed – pure mysore on organically grown rainfed mulberry. In: *20th Congress of the International Sericultural Commission*, Bangalore, India., pp. 119-123.

Chowdhury, P., Setua, G. C., Ghosh, A., Kar, R., Shivnath, Maity, S. K. and Bajpai, A. K. 2009. Organic farming approach for sustainable quality leaf production in mulberry (*Morus alba* L.) var. S-1635 under irrigated condition. *Journal of Crop and Weed,* **5**(1): 38-43.

Dandin, S. B., Jayaswal, J. and Giridhar, K. 2010. *Handbook of Sericulture Technologies.* Central Silk Board, Bangalore, India, p. 25.

Das, P. K., Katiyar, R. S., Bhogesha, K. and Rajanna, L. 2005. Concept of Integrated Plant Nutrient Management System. In: Rajanna, L., Das, P. K., Ravindran, S., Bhogesha, K., Mishra, R. K., Singhvi, N. R., Katiyar, R. S. and Jayaram, H. (eds.). *Mulberry Cultivation and Physiology*. Central Silk Board, Bangalore, pp. 99-118.

Dhanalakshmi, V., Remia, K. M., Shanmugapriyan, R. and Shanthi, K. 2014. Impact of addition of vermicompost on vegetable plant growth. *International Research Journal of Biological Sciences*, **3**(12): 56-61.

Eranna, N. and Govindan, R. 2002. Role of biofertilizer in mulberry production. *Indian Journal of Sericulture*, **41**: 92-99.

Gururaj, R., Magadum, S. B. and Dandin, S. B. 2006. Impact of use of vermicompost on mulberry leaf and cocoon yield in chamarajanagara agroclimatic conditions in Karnataka. In: *Proceedings of National Seminar on Soil Health and Water Management for Sustainable Sericulture*, 27th and 28th September, 2006, Regional Sericultural Research Station (A unit of CSB), Bangalore, India, pp.61-62.

Hemanthkumar, L., Ravikumar, J., Vijayakumar, R., Muthulakshmi, M., Samuthiravelu, P., Jayaraj, S. and Qadri, S. M. H. 2006. Comparative studies on nitrogen-fixing bacteria, *Azospirillum* and *Azotobacter* on mulberry leaf production. In: *Proceedings of National Seminar on Soil Health and Water Management for Sustainable Sericulture*. 27th and 28th September, Regional Sericultural Research Station (A unit of CSB), Bangalore, India, pp.114-115.

Hiremath, S. S., Srikar, L. N., Narayanaswamy, T. K., Poddar, U. S. and Shankar, M. A. 2006. Biochemical constituents of silkworm, (*Bombyx mori* L) as influenced by mulberry grown through organic based nutrient management. *Sericologia*, **46**(3): 351-355.

Jagadeesh, N., Philomena, K. L., Magadum, S.B and Kamble, C. K. 2005. Studies on generation of bivoltine seed cocoons by integrated eco-friendly technology package. In: *Progress of Research in Organic Sericulture and Seri-byproducts utilization*, 27th and 28th September, 2005, Regional Sericultural Research Station (A unit of CSB), Bangalore-India, pp.142-147.

Jaiswal, K., Goel, R., Singh, S., Kumar, R. and Gupta, S. 2005. Influence of different organic manures on a few traits of mulberry and silk cocoons under Lucknow conditions. In: *Progress of Research in Organic Sericulture and Seri-byproducts Utilization*, Seri Scientific Publishers, Bangalore, pp. 127-130.

Jayaraj, S., Dandin, S. B., Veeraiah, T. M., Quadri, S. M. H. and Rao, K. J. V. 2006. INM technology development and dissemination for sustainable sericulture through farmer-participatory mode in three states in South India-an overview. In: *Proceedings of National Seminar on Soil Health and Water Management for Sustainable Sericulture*. 27th and 28th September, 2006, Regional Sericultural Research Station (A unit of CSB), Bangalore-India, pp.18-26.

Jayathilake, P. K. S., Reddy, I. P., Srihari, D. and Reddy, K. R. 2006. Productivity and soil fertility status as influenced by integrated use of n-fixing biofertilizers, organic manures and inorganic fertilizers in onion. *The Journal of Agricultural Sciences*, **2**(1): 41-48.

Kalaiyarasan, V., Nandhini, U. D. and Udhayakumar, K. 2015. Seriwaste vermicompost- A trend of new sustainable generation – A Review. *Agricultural Reviews,* **36**(2): 159-163.

Kapoor, A., Pandit, M. and Ametha, M. 2015. Organic Agriculture: Biofertilizer - A Review. *International Journal of Pharmaceutical & Biological Archives*, **6**(5): 1-5.

Kerenhap, W., Thiagarajan, V. and Kumar, V. 2007. Biochemical and bioassay studies on the influence of different organic manures on the growth of mulberry variety V-1 and silkworm, *Bombyx mori* L. *Caspian Journal of Environmental Sciences*, **5**(1):51-56.

Kolhar, R. C. and Patil, G. M. 2000. Effect of in-situ vermiculture on growth and yield of S41 mulberry. In: Chinnaswamy, K. P., Govindan, R., Krishnaprasad, N. K. and Reddy, D. N. R. (eds.). *Proceedings of National Seminar on Tropical Sericulture*, University of Agricultural Sciences, Bangalore, 1: 45-47.

Krishna, M. and Bongale, U. D. 2001. Role of organic manures on growth and quality of mulberry leaf and cocoons. *Indian Silk*, **40** (2): 11-12.

Krishnaswami, S. 1978. New technology of silkworm rearing. *Indian silk*, **16** (12): 7-15.

Krishnaswami, S. 1986. *New Technology of Silkworm Rearing.* Bulletin No. 2. Central Sericultural Research and Training Institute, Mysore, pp 23.

Kumar, P. C., Naika, R., Madhu, P. V. L., Bhaskar, R. N. and Narayanaswamy, B. 2012. Knowledge of sericulturists on organic farming practice in Chickballapur district. *Journal of Agriculture and Veterinary Science*, **1**(3): 1-4.

Lakshmi, V., Sathyanarayanarao, A., Vijaya Lakshmi, M., Lakshmikumari, M., Tilak, K. V. B. R. and Subba Rao, N. S. 1977. Establishment and survival of *Spirillum lipoferum*. In: *Proceedings of Indian Academy of Science*, **86**(8): 397-404.

Mallappa, B., Narayana, V. S., Siddappa and Biradar, S. 2016. Effect of Integrated nutrient management on growth and yield of mulberry (*Morus alba* L.). *The Bioscan*, **11**(2): 1303-1305.

Mir, M. R., Khan, I. L., Noor-ud-Din, S., Baqual, M. F. and Kamili, A. S. 2011. Improving mulberry wealth in Kashmir province. *Indian Silk*, **49**(11): 4-6.

Miyashita, V.1986. A report on mulberry cultivation and training methods suitable to bivoltine rearing in Karnataka, Central Silk Board, Bangalore, India, p.86.

Mahmood, R., Tahir jan, Md. and Idrees Khan, Md. 2002. Effect of nitrogen (farmyard manure + urea) treated mulberry trees on the larval development and cocoon weight of silkworm (*Bombyx mori* L.). *Asian Journal of Plant Sciences*, **1**(2): 93-94.

Moradi, H., Fahramand, M. Sobhkhizi, A., Adibian, M., Noori, M., Abdollahi, S. and Rigi, A. 2014. Effect of vermicompost on plant growth and its relationship with soil properties. *International Journal of Farming and Allied Sciences*, **3**(3): 333-338.

MunireddY, Patil, R. R. and Hadimani, D. K. 2006. Effect of feeding mulberry leaves obtained by applying graded levels of nitrogen on rearing performance of silkworm, *Bombyx mori* L. In: *National Conference on Strategies for Sericulture Research and Development*, 9th –10th March, 2006, Department of Sericulture, Bangalore University, SP-17 (Abst.), p.112.

Muthuraju, M., Ravi, M. V. and Siddaramappa, R. 2005. Use of enriched pressmud as a source of organic manure for irrigated mulberry crop. *Mysore Journal of Agricultural Sciences,* **39**(2):74-80.

Nagarajaiah, C., Shivakumar, H. R. and Jagadish, K. S. 2004. Impact of bio-fertilizers and levels of NPK on growth and leaf yield of mulberry. In: *Proceedings of National Seminar on Prospects of Organic Sericulture and Seri-Byproduct Utilization*, 29-30 October, Sericulture College, University of Agricultural Sciences, Chintamani, (Abst)21, P.39.

Naika, R., Sannappa, B. and Devaiah, M. C. 2012. Economic evaluation of organics on mulberry and cocoon production – a study. *International Journal of Advanced Biological Research*, **2**(2): 215-219.

Naika, R., Sannappa, B., Bhaskar, R.N. and Devaiah, M. C. 2011. Investigation on the sources of organics for mulberry and its impact on quantitative traits of the silkworm. *International Journal of Science and Nature,* **2**(1): 114-117.

Pasha, S. N., Chinnaswamy, K. P., Fatima, S. and Geethadevi, T. 2006. Productivity of bivoltine silkworm seed breed NB4D2 on organically raised mulberry. In: *Proceedings of National Conference on Strategies for Sericulture Research and Development*, 9-10th March 2006, Department of Sericulture, Bangalore University, SP-32 (Abst.), p.74.

Patil, V. C., Kulkarni, S. S., Angadi, S. A. and Roodagi, L. I. 2002. Preliminary studies on the recommendation of agronomical package for V-1 mulberry under rainfed condition at Dharwad region. *Indian Journal of Sericulture,* **41**(2): 171-173.

Philomena, K. L., Subramanayam, M. R., Jagadeesh, N. and Kamble, C. K. 2003. Qualitative and quantitative analysis of varieties as influenced by using organic manure (compost) and inorganic fertilizers for production of quality seed cocoons.

In: *Proceedings of National Seminar on Silkworm Seed Production*, Silkworm Seed Technology Laboratory, Bangalore, pp. 69–74.

Purohit, K. M., Das, B. D., Brahma, K. C. and Saxsena, N. N. 2006. Studies on integrated nutrient management in rainfed mulberry at farmers level in the eastern ghat highland zone of koraput district in Orissa. In: *Proceedings of National Seminar on Soil Health and Water Management for Sustainable Sericulture*. 27th and 28th September, 2006, Regional Sericultural Research Station (A unit of CSB), Bangalore-India, pp.111-112.

Raju, J. P., Jagadeesh, N., Dayananda and Veeraiah, T. M. 2006. Impact of integrated technology package on mulberry leaf and cocoon production in Anekal bivoltine seed area. In: *Proceedings of National Seminar on Soil Health and Water Management for Sustainable Sericulture*, 27th and 28th September, Regional Sericultural Research Station (A unit of CSB), Bangalore, India, p.111.

Ram, R. L., Chatterjee, S., Maji, C., Kar, R. and Singh, Y. V. 2017 a. Integrated effect of treated pressmud and fym on mulberry leaves and bioassay of silkworm in acid soils of Kalimpong hills, India. *International Journal of Current Microbiology and Applied Sciences*, **6**(1): 767-783.

Ram, R. L., Chatterjee, S., Maji, C., Sharma, P. K. and Singh, Y. V. 2017 b. Integrated effect of FYM and potassium humate on mulberry leaves and bioassay of silkworm in acid soils of Kalimpong hills. *International Journal of Bio-resource and Stress Management*, **8**(3): 405-412

Ram, R. L., Maji, C., Trivedi, K. and Singh, R. P. 2018. Integrated effect of mixed cake and farm yard manure on mulberry sericulture in acid soils of Kalimpong hills. *Current Journal of Applied Science and Technology*, **26**(6): 1-11.

Ramarethinam and Chandra, K. 2007. Effect of liquid and carrier based biofertilizer application on the quality of mulberry leaves (*Morus alba* L.) with special reference to its nutritive value to silkworm (*Bomyx mori* L.). *Pestology*, **31** (1): 13-19.

Rao, K. J. V., Rao, S. T. V. S., Reddy, K. B. and Jayaraj, S. 2005. Large scale production of vermicompost by sericulture farmers. In: *Proceedings of National Seminar on Composting and Vermicomposting*, Central Sericultural Training and Research Institute, Mysore, India, p. 145.

Rao, R. D. M., Kodandaramaiah, J., Reddy, M. P., Katiyar, R. S. and Rahmathulla, V. K. 2007. Effect of VAM fungi and bacterial biofertilizers on mulberry leaf quality and silkworm cocoon characters under semiarid conditions, *Caspian Journal of Environmental Sciences*. **5**(2): 111-117.

Rao, R. N., Rao, T. V. S. S., Rao, K. J. V. and Jayaraj, S. 2006. Impact of INM/IPM/IFSM packages in increasing productivity and sericulture income. In: *Proceedings of National Seminar on Soil Health and Water Management for Sustainable Sericulture*, 27th and 28th September, 2006, Regional Sericultural Research Station (A unit of CSB), Bangalore, India, pp.123-124.

Ravikumar, A. 2003. *Performance of silkworm hybrids as influenced by different sources of nitrogen to mulberry*. Ph.D. (Seri.) thesis. University of Agricultural Sciences, Bangalore, p. 186.

Ravikumar, A., Narayanaswamy, T. K. and Shankar, M. A. 2005. Efficacy of different groups of organics supplied to mulberry at varied levels on rearing performance of commercial silkworm (*Bombyx mori* L.) hybrid. *Mysore Journal of Agricultural Sciences*, **39**(2): 513-517.

Reddy, B. K., Ramarao, D. M., Reddy, M. P. and Suryanarayana, N. 2003. Studies on the effect of farm yard manure and vermicompost on quantitative and qualitative characters of mulberry under semi-arid conditions of Andhra Pradesh. *Advances in Plant Sciences*, **16** (1): 177 – 182.

Reddy, M. B., Naidu, D. W., Anand, B. V. V. and Sharma, V. L. N. 2006. A saga of vermicomposting in mulberry gardens of west Godavari, Andhra Pradesh. In: *Proceedings of National Seminar on Soil Health and Water Management for*

Sustainable Sericulture. 27th and 28th September, 2006, Regional Sericultural Research Station (A unit of CSB), Bangalore, India, p.64.

Rizvi, R., Singh, G., Safiuddin, Rizwan, A. A., Sartaj, A. T. and Mahmood, I. 2015. Sustainable management of root-knot disease of tomato by neem cake and Glomus fasciculatum. *International Journal of Soil and Crop Scicences,* **1**: 1008859.

Saha, A. K. and Setua, G. C. 2006. Effect of integrated nutrient management on quality of mulberry leaves assessed through bioassay. *Uttar Pradesh Journal of Zoology*, **26**(3): 287-291.

Salazar, E. J. A. 2007. Yield and quality of mulberry fodder (*Morus alba* L.) fertilized with different fertilizers. *Agronomia mesoamericana*, **18**(2): 255-261.

Sannappa, B., Naika, R., Govindan, R., Jagadeesh, K. T. S. and Venkataramana, G. V. 2005. Growth and yield traits of mulberry as influenced by different levels of vermicompost. In: *Proceedings of National Seminar on Composting and Vermicomposting*, Central Sericultural Training and Research Institute, Mysore, India, p. 166.

Senapati, H. K., Pal, A. K. and Samant, P. K. 2005. Effect of chemical fertilizer, organic manure, lime and biofertilizer on yield of turmeric (*Curcuma longa*). *Indian Journal of Agricultural Sciences*, **75**(9): 593-595.

Sestak, Z. J., Catsky, P.G., Japris. 1971. Plant analysis in production manual of methods Junk, V.N.V. (Eds.). W. Publication, The Hague, pp. 343-381.

Setua, G. C., Banerjee, N. D., Sengupta, T., Das, N. K., Ghosh, J. K. and Saratchandra, B. 2002. Comparative efficacy of different composts in 'S1' mulberry (*Morus alba* L.) under rainfed condition. *Indian Journal of Agricultural Sciences*, **72**(7): 389-392.

Setua, G. C., Das, N. K., Banerjee, N. D., Sengupta, T., Sudhakar, P., Sen, S. and Saratchandra, B. 2005. Effect of integrated nutrient management on quality leaf production in mulberry (*Morus alba* L.) under rainfed, alluvial soil conditions. *Indian Journal of Agricultural Sciences*, **75**(8): 474-478.

Sharma, D. D., Mala, V. R., Das, P. K. and Dandin, S. B. 2008. Effect of composts enriched with useful/antagonistic microbes on suppression of nursery diseases in mulberry. *Sericologia*, **48** (1): 101-108.

Sharma, D. D., Mala, V. R., Rajan, Das, P. K. and Dandin, S. B. 2005. Effect of compost and vermicompost enriched with useful / antagonistic microbes on suppression of nursery diseases in mulberry. In: *Proceedings of National Seminar on Composting and Vermi-composting*, Central Sericultural Training and Research Institute, Mysore, p. 162.

Shashidhar, K. R. 2009. *Organic based nutrient management in mulberry (Morus indica L.) and its influence on rearing performance of silkworm (Bombyx mori* L), M.Sc. (Agri.) thesis, University of Agricultural Sciences, Bangalore, p.152.

Shashidhar, K. R., Narayanaswamy, T. K., Bhaskar, R. N., Jagadish, B. R., Mahesh, M. and Krishna, K. S. 2009. Influence of organic based nutrients on soil health and mulberry (*Morus indica* L.) Production. *Journal of Biosciences*, **1**(1): 94-100.

Shashidhar, K. R., Narayanaswamy, T. K., Sudhakar, S. N. and Bhaskar, R. N. 2018. Impact of different sources of organic nutrients on chemical composition of S-36 mulberry and soil under irrigated condition. *International Journal of Current Microbiology and Applied Sciences*, **7**(1): 2233-2238.

Shinde, P. H., Naik, R. L., Nazikar, R. B., Kadam, S. K. and Khaire, V. M. 1992. Evaluation of vermicompost. IN: *Proceedings of National Seminar on Organic Farming*. 8th and 9th October, 1992, MPKV, Pune, India, pp. 92-98.

Shree, M. P., Kumar, S. S., Mahadeva, A., Nagaveni, V. and Srilakshmi, N. 2007. Influence of vermicompost on growth and development of mulberry saplings. *Journal of Plant Biology*, **34**(2): 123-125.

Shyla, P. N., Fatima, S., Prabhakar, V., Pallavi, Rashmi, S., Harish, B. S. and Sharma, R. C. 2016. Influence of customized fertilizers on bio-chemical composition of V1 Mulberry. *International Journal of Advanced Research in Biological Sciences*, **3**(3): 261-264.

Siddaramappa, R. 2004. Soil health and nutrient management, operational methodologies and package and practices in organic farming. In: *National Seminar, APOF*. Bangalore, India, pp. 13-14.

Singh, M. K., Chowdhuri, R. S., Naqvi, A. H., Ghosh, M. K. and Bindroo, B. B. 2012. Studies on integrated nutrient management on leaf yield and quality of silk of mulberry (*Morus alba* L.) grown under rainfed situation. *Journal of Crop and Weed*, **8**(2): 80-82.

Singhal, B. K., Chakraborti, S., Mala, V. R., Sarkar, A. and Datta, R. K. 2000. Photosynthesis for crop improvement in mulberry (*Morus* sp.) – A review. *Sericologia*, **40**: 27-55.

Sori, W. 2008. *Influence of bio-inoculants on growth and yield of rainfed mulberry* (*Morus alba* L.) *and botanicals on performance of silkworm, Bombyx mori* L. Ph.D (Seri.) thesis. University of Agricultural Sciences, Bangalore, p.189.

Sori, W. and Bhaskar, R. N. 2012. Effect of bio-inoculants applied to M5 mulberry under rain-fed condition on growth and cocoon traits performance of silkworm (*Bombyx mori* L.). *Momona Ethiopian Journal of Science, **4***(2): 29-39.

Sori, W. and Bhaskar, R. N. 2013. Responses of fresh leaf yield and quality variables of M5 mulberry to bio-inoculants, farm yard manure (FYM) and inorganic fertilizers under rain-fed conditions. *African Journal of Plant Science,* **7**(4): 131-136.

Sori, W., Bhaskar, R. N., Govindan, R., Radhakrishna, D. and Gowda, A. 2008. Effect of bio-inoculants on fresh leaf yield and quality paramertes of M5 mulberry variety under rainfed condition. In: *Moriculture*.18th All India Congress of Zoology & SCIAZE, University of Lucknow, India, pp. 39-48.]

Sreenivas, B. T., Veeraiah, T. M. and Dandin, S. B. 2005. Impact of IVLP on vermicompost production and sustainable Sericultural income. In: *Proceedings of National Seminar on Composting and Vermicomposting*, Central Sericultural Training and Research Institute, Mysore, p. 163.

Sreeramulu, K. R., Srikantaiah, M., Hanumanthappa, M. and Gowda, A. 2005. Improvement in growth due to combined inoculation of *Azospirilum brasilense* and *Bacillus megaterium*. In: *Progress of Research in Organic Sericulture and Seri-Byproduct Utilization*, Seri Scientific Publishers, Bangalore, pp. 102-104.

Srikantaswamy, K. and Mala, V. R. 2006. Evaluation of plant growth promoting rhizobacteria on nutrient and disease management for quality mulberry leaf production through participatory approach in semi-arid conditions of Chamarajanagar area. In: *Proceedings of National Conference on Strategies for Sericulture Research and Development*. 9^{th}-10^{th} March 2006, Bangalore University, Bangalore. pp.19-20.

Sudhakara, S. N. and Narayanaswami, T. K. 2017. Late age worm (*Bombyx mori* L.) rearing performance as influenced by feeding schedules of mulberry leaf raised through the concept of organic based nutrient management. *International Journal of Current Research*, **9**(10): 58502-58505.

Sudhakara, S. N., Narayanaswamy, T. K. and Narayanaswamy, K. C. 2017. Role of integrated use of organic manures and inorganic fertilizers on mulberry and its impact on cocoon parameters of silkworm (*Bombyx mori* L.). *International Journal of Current Microbiology and Applied Sciences*, **6**(11): 3922-3927.

Sudhakara, S. N., Narayanaswamy, T. K. and Narayanaswamy, K. C. 2018. Significance of feeding mulberry leaf in different schedules raised through organic based nutrient management on the body weight of young-age worms. *International Journal of Advanced Biological Research*, **8**(1): 33-37.

Sudhakara, S. N., Narayanaswamy, T. K., Smitha, G. M., Neelunangia, Chikkalingaiah and Chinnaswamy, K. P. 2008. Late age worm (*Bombyx mori* L.) rearing performance as influenced by feeding schedules of mulberry leaf raised through the concept of organic based nutrient management. In: *Proceedings of International Conference on Trends in Seribiotechnology*. Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, India. p. 57.

Sujathamma, P., Savithri, G., Vijayakumari, N., Asha, K. V., Vijaya, T., Sairam, K. V. S. S. and Sreerama, R. N. 2014. Effect of organic fertilizers on quantitative and qualitative parameters of silk cocoon production. *International Journal of Plant, Animal and Environmental Sciences,* **4**(2): 272-279.

Sukumar, J., Padma, S. D. and Bongale, U. D. 2003. Improvement of mulberry leaf yield and quality through combined inoculation of beneficial microorganisms and their cost effective secondary level multiplication. In: *20th Congress of the International Sericultural Commission*, Bangalore, India. pp. 6267.

Suvarna, G. 2007. *Effect of FYM, vermicompost, neem cake and biofertilizers on growth, yield and quality of brinjal (Solanum melongena* L.), M.Sc. (Horti.) thesis, ANGRAU, Rajendranajar, p. 42.

Thangamalar, A., Ramamoorthy, K., Prabhul, S., and Priyadharshini, P. 2018. Influence of different pruning techniques and integrated nutrient management on growth, leaf yield of mulberry and its impact on silkworm (*Bombyx mori* L.) bioassay. *International Journal of Current Microbiology and Applied Sciences,* **7**(2): 2963-2971.

Thirunavukkarsu, T., Mary flora, C. A., Guha, A., Jayaraj, S. and Qadri, S. M. H. 2006. Observation on the effect of INM practices on soil health mulberry root system and mulberry and cocoon yields. In: *Proceedings of National Seminar on Soil Health and Water Management for Sustainable Sericulture*. 27th and 28th September, 2006, Regional Sericultural Research Station (A unit of CSB), Bangalore, India, pp. 34-35.

Umesha, A. and Sannappa, B. 2014. Bio-chemical and mineral constituents of mulberry leaf raised through organic based nutrients in red loamy soil. *International Journal of Advanced Research,* **2**(9): 348-355.

Ushakumari, K., Sailajakumari, M. S. and Sheeba, P. S. 2006. Vermicompost : A potential organic nutrient source for organic farming. In: *18th World Congress of Soil Science*. July 9th -10th, 2006, Philadelphia, Pennsylvania, USA. p. 335.

Venugopal, A., Chandrasekhar, M., Naidu, B. V. and Raju, S. 2010. Vermicomposting in sericulture using mixed culture of earthworms (*Eudrillus eugineae*, *Eisenia foetida* and *Perionyx excavatus*) – A review. *Agricultural Reviews*, **31**(2): 150–154.

Yokoyama, T. 1974. *Text Book of Tropical Sericulture*. Japan Overseas Cooperation Volunteers, Tokyo, pp. 444-537

VITA

Name of student	**:**	Somagaini Pavankumar
Father's name	**:**	S.C. Ramanaiah
Mother's name	**:**	S. Ramanama
Nationality	**:**	Indian
Date of birth	**:**	03-01-1993
Permanent home address	**:**	House Number 4/408, Super Bazaar Road, Proddatur (Mandal), District- Y.S.R Kadapa, State- Andhra Pradesh
Email address	**:**	Somagainipavankumargoud1993@gmail.com
Telephone no.	**:**	9849559318
Educational Qualification	**:**	B.Sc. (Hons) Horticulture
University	**:**	Dr. Y.S.R. Horticultural University
Year of award	**:**	2017
%/OGPA	**:**	7.9/10

CERTIFICATE-IV

Certified that all the necessary corrections as suggested by the external examiner and the Advisory committee have been duly incorporated in the thesis entitled, **Organic based nutrient management in mulberry and its impact on silkworm** submitted by **Mr. Somagaini Pavankumar**, Registration No. **J-17-M-514.**

Dr. Kamlesh Bali
Major Advisor & Chairman of
Advisory committee

Place: Jammu
Date: 18.09.2019

No- AUJ/DoS/2019-20/F-PF/246
Dt- 18-09-2019

Head
Division of Sericulture

Head
Division of Sericulture