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Performance of bivoltine seed crop on graded level of nutrients in tree mulberry

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Abstract
A study conducted in 2022 at Krishi Vigyan Kendra Haradanahalli farm, Chamarajanagar, aimed to determine the optimal nutrient combination for maximizing silkworm seed yield in tree mulberry cultivation. Results indicated that silkworms reared on plants treated with 40 tons of Farm Yard Manure (FYM) per hectare annually, 125% Recommended Dose of Fertilizers (RDF), and foliar spray of POSHAN exhibited superior performance, including a pupation rate of 97.80%, moth emergence percentage of 94.27%, fecundity of 641.61 eggs, and hatchability of 95.28%. This treatment regimen also resulted in the highest net returns (Rs. 3,31,542) and a favorable Benefit-to-Cost (B:C) ratio of 3.59. These findings emphasize the importance of tailored nutrient management practices in optimizing sericulture productivity and economic returns, offering valuable insights for practitioners and policymakers to enhance the sustainability and profitability of the sericulture industry.

Keywords: Bivoltine, tree mulberry, farm yard manures, micronutrients, graded level of nutrients

Introduction
Sericulture is a cornerstone of India's agricultural economy, with the nation ranking as the second-largest producer of mulberry raw silk globally, following China. Together, China and India account for a substantial majority of the world's silk production. Mulberry silk, one of four commercially available silk types in India, holds significant prominence, supported by the cultivation of Mulberry trees as the primary source of nutrition for silkworms. This symbiotic relationship underscores the agricultural importance of silk production in India, highlighting its pivotal role in shaping the nation's sericulture industry and economic landscape. Sericulture relies heavily on nutrition. It enhances silkworm health, growth, development, feed consumption and conversion, which enhances their commercial qualities. Therefore, it is imperative to apply the necessary fertilizer to the mulberry plant as per the recommended quantity for the growth and development of silkworm for successful cocoon production (El-Kayat *et al*., 2013) [2].

Sericulture, the ancient practice of rearing silkworms for silk production, hinges crucially on the production of healthy, disease-free eggs, which serve as the cornerstone for both commercial silk farming and seed propagation. These eggs ensure uniform hatching and establish robust lineage from healthy parent stock, crucial for consistent cocoon yields and the economic sustainability of sericultural enterprises. The quality of parental seed cocoons profoundly impacts the efficacy of hybrid cocoon production, underscoring the direct correlation between seed quality and overall sericultural success. Evaluating seed crop performance, encompassing parameters like survival rate and cocoon weight, serves as a vital metric for assessing seed quality and genetic vigor. Moreover, beyond its immediate impact on cocoon production, high-quality seed profoundly influences broader ecological dynamics within sericultural ecosystems, shaping larval growth, development, and subsequent adult fitness parameters. Thus, this paper aims to highlight the pivotal role of high-quality seed production in enhancing the resilience, efficiency, and sustainability of sericultural practices.

Materials and Methods

A study was conducted during 2022 in a one and half year old well established tree mulberry garden (Variety V-1) with spacing of 6 x 6 feet under irrigated condition. The experiment was conducted using RBD with Factorial concept consisted of sixteen treatments with three replications. After top pruning, the below listed fertilizers were applied and the cultural practices were followed as per the recommended standards.

Treatment details

Factor (A) organic manures	Factor (B) Macronutrients	Factor (C) Micronutrients
A_1 - without FYM 20 t ha-1	B_1 – No RDF	C_1 – without micronutrients
A_2 - with FYM at 40 t ha-1	B_2 -75% RDF	C_2 - with foliar spray of micronutrients (POSHAN)
	B_3 - 100% RDF	
	B_4 - 125% RDF	

Treatment combinations

T_1	$A_1B_1C_1$	T_9	$A_2B_1C_1$
T_2	$A_1B_1C_2$	T10	$A_2B_1C_2$
T_3	$A_1B_2C_1$	T11	$A_2B_2C_1$
T_4	$A_1B_2C_2$	T12	$A_2B_2C_2$
T_5	$A_1B_3C_1$	T13	$A_2B_3C_1$
T_6	$A_1B_3C_2$	T14	$A_2B_3C_2$
T_7	$A_1B_4C_1$	T15	$A_2B_4C_1$
T_8	$A_1B_4C_2$	T16	$A_2B_4C_2$

Experimental details for silkworm rearing

To know the effects of feeding leaves from V-1 tree mulberry raised through the application graded level of nutrients on silkworm growth and yield, FC1 and FC2 silkworm hybrid was reared on these leaves by following standard silkworm rearing practices outlined by Dandin and Giridhar (2014) [1].

Silkworm feeding and bed cleaning

The late age silkworms were reared in shelf reared separately as per treatments by feeding three times a day with matured mulberry leaves of V-1 variety raised under different treatments. Bed cleaning was done twice during IV and V instars, by lifting unfed leaves and excreta of the silkworm. Optimum spacing was provided according to the age of the silkworms. After each bed cleaning and when all the silkworms settled for moulting, lime powder was dusted on silkworms following standard rearing practices Dandin and Giridhar (2014) [1].

Mounting and harvesting

Plastic collapsible mountages were used in the experiment. The ripe worms were hand- picked from each treatment and replications were mounted separately treatmentwise on the plastic collapsible mountages. Later on, the cocoons were harvested manually on the seventh day of mounting.

Observations recorded on grainage operations

Rate of pupation (%)

Pupation rate was calculated by using the formula.

$$\text{Rate of pupation (\%)} = \frac{\text{Number of larvae pupated}}{\text{Number of larcae apun coccon}} \times 100$$

Rate of moth emergence (%)

Moth emergence percentage was calculated based on the number of pupae transformed into adults and was computed using the formula.

$$\text{Rate of moth emergence (\%)} = \frac{\text{Number of moth emerged}}{\text{Number of pupae kept for moth emergence}} \times 100$$

Fecundity (eggs / laying): The emerged male and female moths were allowed to mate in wooden trays / plastic trays. Males were separated from females after ensuring three hours of mating. Then five gravid female moths covered individually with cellules were allowed to lay eggs on egg cards in the dark condition. The eggs laid by individual female moth was counted and recorded separately with replication wise in their respective feeding schedules. The freshly laid eggs were subjected to acid treatment within 20 hrs of oviposition.

Acid treatment

The layings were first dipped in two per cent formalin solution for surface dis infection and for proper adhering of eggs to egg cards and then they were washed, shade dried and dipped in HCl of 1.064 specific gravity maintained at 46.1° C for 4 - 5 minutes. The layings were then washed, shade dried and kept for incubation

Hatchability (%)

DFLs from each treatment with replication wise in their respective feeding schedules after acid treatment were incubated at room temperature for hatching. Black boxing was done two days prior to hatching. Hatching percentage was calculated using

$$\text{Hatchability (\%)} = \frac{\text{Number of eggs hatched}}{\text{Total number of eggs in egg sheet}} \times 100$$

Results and Discussion

Pupation rate (%) and Moth emergence percentage

In a recent scientific study comparing two silkworm breeds, notable variations were observed in pupation rates and moth emergence percentages in response to different agricultural treatments. The application of farmyard manure (FYM) at 40 t/ha/yr resulted in the highest pupation rates across both breeds, with significant increases compared to lower application rates (95.56% in FC 1 breed and 94.91% in FC 2 breed). Similarly, treatments involving 125% recommended dose of fertilizer (RDF) NPK and foliar spray applications consistently yielded higher pupation rates and moth emergence percentages (96.47% in FC 1 breed and 95.55% in FC 2 breed), showcasing their effectiveness in enhancing silkworm development. Furthermore, significant interactions between FYM, NPK, and foliar spray treatments were noted, particularly in three-factor interactions, indicating the nuanced influence of these factors on silkworm physiology and development. These findings underscore the importance of tailored agricultural practices for optimizing silkworm breeding outcomes.

Moreover, race-specific characteristics were evident in moth emergence percentages, with distinct trends observed between the two silkworm breeds. While both breeds exhibited improved moth emergence percentages with certain treatments, the highest rates varied between FC 1 and FC 2 breeds, highlighting breed-specific responses to agricultural interventions. Notably, treatments combining FYM, NPK at 125% RDF, and foliar spray of POSHAN consistently yielded the highest moth emergence percentages across both breeds (96.72% in FC 1 breed and 97.80% in FC 2 breed), indicating the potential for targeted management strategies to enhance silkworm productivity. Overall, these findings emphasize the intricate relationship between agricultural practices, breed characteristics, and silkworm development, underscoring the need for tailored approaches to maximize silk production in sericulture systems.

These results were similar to the findings of Maribashetty *et al*. (1999) [4] studied the impact of mulberry leaves from bush and tree system of plantations on silkworm performances at different seed multiplication levels. The results recorded that the pupation rate of batches fed with tree mulberry leaves was higher at all multiplication levels. (table 1).

Table 1: Influence of graded level of nutrients on Pupation rate (%) and Moth emergence percentage of FC 1 and FC 2 bivoltine silkworm breeds

Treatment	Pupation rate (%)		Moth emergence percentage	
	FC 1	FC 2	FC 1	FC 2
Farm yard manure (A)				
A_1: FYM @ 20 t ha^{-1}	89.47	90.84	85.22	90.24
A_2: FYM @ 40 t ha^{-1}	95.56	94.91	86.32	90.60
SEm±	0.142	0.373	-	-
CD @ 5%	0.411	1.079	NS	NS
NPK(B)				
B_1: No RDF	88.69	90.61	82.11	87.64
B_2:75% RDF	91.43	92.06	85.78	90.38
B_3: 100% RDF	93.48	93.27	87.28	91.52
B_4: 125% RDF	96.47	95.55	87.91	92.13
SEm±	0.201	0.528	0.839	0.557
CD @ 5%	0.581	1.525	2.423	1.609
Foliar spray (C)				
C_1: No Foliar spray	91.87	92.63	84.28	89.74
C_2: Foliar spray	93.17	93.11	87.25	91.09
SEm±	0.142	-	0.593	0.394
CD @ 5%	0.411	NS	1.713	1.138
Interaction (A×B)				
$A_1 \times B_1$	85.32	87.21	80.40	86.06
$A_1 \times B_2$	87.82	89.59	86.48	92.58
$A_1 \times B_3$	89.42	91.15	85.78	91.56
$A_1 \times B_4$	95.32	95.40	88.22	92.19
$A_2 \times B_1$	92.05	94.01	83.82	89.22
$A_2 \times B_2$	95.03	94.53	85.08	88.19
$A_2 \times B_3$	97.53	95.38	88.78	91.48
$A_2 \times B_4$	97.62	95.70	87.60	92.06
SEm±	0.285	0.747	-	0.788
CD @ 5%	0.822	2.157	NS	2.276
Interaction (B×C)				
$B_1 \times C_1$	87.99	89.92	80.93	87.74
$B_1 \times C_2$	89.38	91.31	83.29	87.53
$B_2 \times C_1$	90.24	92.03	84.31	88.71
$B_2 \times C_2$	92.61	92.09	87.25	92.06
$B_3 \times C_1$	94.00	93.86	86.65	92.14
$B_3 \times C_2$	92.95	92.67	87.90	90.90
$B_4 \times C_1$	95.23	94.73	85.25	90.38
$B_4 \times C_2$	97.71	96.37	90.57	93.88
SEm±	0.285	-	-	0.788
CD @ 5%	0.822	NS	NS	2.276
Interaction (A×C)				
$A_1 \times C_1$	88.82	90.61	83.52	89.65
$A_1 \times C_2$	90.12	91.07	86.92	91.55
$A_2 \times C_1$	94.91	94.66	85.05	89.83
$A_2 \times C_2$	96.21	95.16	87.59	90.64
SEm±	-	-	-	-
CD @ 5%	NS	NS	NS	NS
Interaction (A×B×C)				
T_1: $A_1B_1C_1$	85.91	84.05	80.00	84.59
T_2: $A_1B_1C_2$	88.52	86.59	80.80	87.53
T_3: $A_1B_2C_1$	89.45	87.66	85.18	90.90
T_4: $A_1B_2C_2$	89.73	87.98	87.78	94.27
T_5: $A_1B_3C_1$	92.30	90.56	82.48	92.22
T_6: $A_1B_3C_2$	90.00	88.29	89.08	90.90
T_7: $A_1B_4C_1$	94.76	93.02	86.43	90.90
T_8: $A_1B_4C_2$	96.03	97.63	90.02	93.49

T_9: $A_2B_1C_1$	93.92	91.94	81.85	90.90
T_{10}: $A_2B_1C_2$	94.10	92.17	85.78	87.53
T_{11}: $A_2B_2C_1$	94.61	92.82	83.43	86.52
T_{12}: $A_2B_2C_2$	94.45	97.24	86.72	89.85
T_{13}: $A_2B_3C_1$	95.42	97.45	90.83	92.07
T_{14}: $A_2B_3C_2$	95.35	97.62	86.72	90.90
T_{15}: $A_2B_4C_1$	94.69	97.45	84.07	89.85
T_{16}: $A_2B_4C_2$	96.72	97.80	91.13	94.27
SEm±	0.403	-	1.678	-
CD @ 5%	1.163	NS	4.846	NS

Note: (NS – Non-Significant)

Factor (A)	**Factor (B)**	**Factor (C)**
Organic manures	Macronutrients	Micronutrients
A1 – with FYM @ 20 t ha-1	B1 – No RDF	C1 – No micronutrients
A2 – with FYM @ 40 t ha-1	B2 – 75% RDF	C2 – with foliar spray of
	B3 – 100% RDF	micronutrients (POSHAN)
	B4 – 125% RDF	

Fecundity (No.), Hatchability (%) and Dead eggs (No.)

In an extensive silkworm rearing study, fecundity, hatchability, and dead egg count were meticulously examined as key parameters. Notably, application of farmyard manure (FYM) at 40 t/ha/yr significantly boosted fecundity, yielding a remarkable increase to 611.61 eggs compared to 20 t/ha/yr (601.45 eggs). Similarly, NPK application at 125% recommended dose led to the highest fecundity, with 637.64 eggs, while foliar spray treatments notably improved outcomes, with a peak fecundity of 640.62 eggs. Interaction analysis highlighted synergistic effects, with specific combinations such as FYM at 40 t/ha/yr, NPK at 125% RDF, and foliar spray of POSHAN yielding the highest fecundity of 641.61 eggs. Hatchability, crucial for egg viability, responded favorably to treatments, with the highest percentage of 95.28% observed in the combination of FYM, NPK at 125% RDF, and foliar spray of POSHAN. Moreover, dead egg count was significantly reduced, with the lowest recorded at 4.77 eggs in the treatment combining FYM, NPK, and foliar spray applications. These numerical insights underscore the efficacy of optimized agronomic practices in enhancing silkworm reproductive performance and egg viability, thus informing strategic decisions in sericulture management.

The results are in conformity with the findings of Rajanna *et al.*, (2000) [5] found that silkworms fed on the leaf obtained by application of FYM + recommended NPK produced highest cocoon weight (18.85g/ 10 cocoons), pupal weight (15.20 g/10 pupae), rate of pupation (97.69%), moth emergence (95.52%), fecundity (626 eggs/laying) and hatchability (97.29%) followed by sheep manure in NB4D2 race

Similar results were recorded by Sanappa *et al.*, (2002) [6] where they reported that, feeding of silkworm with mulberry at five times daily with whole shoots raised with 125 kg of N/ha/yr gave the highest pupal weight (17.84 g/10), moth emergence (96.40%), fecundity (569.5 eggs/laying) and hatchability (95.85%). (table 2).

Table 2: Influence of graded level of nutrients on Fecundity (No.), Hatchability (%) and Dead eggs of FC 1 and FC 2 bivoltine silkworm breeds

Treatment	**Fecundity (No.)**	**Hatchability (%)**	**Dead eggs (No.)**
Farm yard manure (A)			
A_1: FYM @ 20 t ha^{-1}	601.45	88.73	11.27
A_2: FYM @ 40 t ha^{-1}	611.61	89.65	10.35
SEm±	0.175	0.169	0.163
CD @ 5%	0.504	0.489	0.471
NPK(B)			
B_1: No RDF	567.73	86.41	13.59
B_2:75% RDF	596.24	87.97	12.03
B_3: 100% RDF	624.50	89.10	10.90
B_4: 125% RDF	637.64	93.27	6.73
SEm±	0.247	0.239	0.230
CD @ 5%	0.713	0.691	0.666
Foliar spray (C)			
C_1: No Foliar spray	603.93	88.75	11.25
C_2: Foliar spray	609.13	89.63	10.37
SEm±	0.175	0.169	0.163
CD @ 5%	0.504	0.489	0.471
Interaction (A×B)			
$A_1 \times B_1$	564.26	86.01	13.99
$A_1 \times B_2$	582.60	88.41	11.59
$A_1 \times B_3$	621.28	87.54	12.46
$A_1 \times B_4$	637.64	92.95	7.05
$A_2 \times B_1$	571.20	86.82	13.18

$A_2 \times B_2$	609.88	87.52	12.48
$A_2 \times B_3$	627.73	90.66	9.34
$A_2 \times B_4$	637.64	93.60	6.40
SEm±	0.349	0.339	0.326
CD @ 5%	1.008	0.978	0.941
Interaction (B×C)			
$B_1 \times C_1$	565.75	86.40	13.60
$B_1 \times C_2$	569.71	86.42	13.58
$B_2 \times C_1$	593.51	87.65	12.35
$B_2 \times C_2$	598.97	88.28	11.72
$B_3 \times C_1$	621.78	88.85	11.15
$B_3 \times C_2$	627.23	89.36	10.64
$B_4 \times C_1$	634.67	92.11	7.89
$B_4 \times C_2$	640.62	94.44	5.56
SEm±	0.349	0.339	0.326
CD @ 5%	1.008	0.978	0.941
Interaction (A×C)			
$A_1 \times C_1$	599.21	88.51	11.49
$A_1 \times C_2$	603.68	88.95	11.05
$A_2 \times C_1$	608.64	89.00	11.00
$A_2 \times C_2$	614.59	90.30	9.70
SEm±	0.247	-	-
CD @ 5%	0.713	NS	NS
Interaction (A×B×C)			
T_1: $A_1B_1C_1$	563.27	85.89	14.11
T_2: $A_1B_1C_2$	565.25	86.12	13.88
T_3: $A_1B_2C_1$	580.13	88.27	11.73
T_4: $A_1B_2C_2$	585.08	88.56	11.44
T_5: $A_1B_3C_1$	617.81	87.63	12.37
T_6: $A_1B_3C_2$	624.75	87.46	12.54
T_7: $A_1B_4C_1$	635.66	92.25	7.75
T_8: $A_1B_4C_2$	639.63	93.65	6.35
T_9: $A_2B_1C_1$	568.23	86.92	13.08
T_{10}: $A_2B_1C_2$	574.18	86.72	13.28
T_{11}: $A_2B_2C_1$	606.90	87.04	12.96
T_{12}: $A_2B_2C_2$	612.85	88.01	11.99
T_{13}: $A_2B_3C_1$	625.74	90.07	9.93
T_{14}: $A_2B_3C_2$	629.71	91.26	8.74
T_{15}: $A_2B_4C_1$	633.68	91.97	8.03
T_{16}: $A_2B_4C_2$	641.61	95.23	4.77
SEm±	0.494	-	-
CD @ 5%	1.426	NS	NS

Note: (NS – Non-Significant)

Factor (A)	Factor (B)	Factor (C)
Organic manures	Macronutrients	Micronutrients
A1 – with FYM @ 20 t ha-1	B1 – No RDF	C1 – No micronutrients
A2 – with FYM @ 40 t ha-1	B2 – 75% RDF	C2 – with foliar spray of
	B3 – 100% RDF	micronutrients (POSHAN)
	B4 – 125% RDF	

Conclusion

Our study highlights the critical influence of mulberry leaf quality on various aspects of silkworm physiology and productivity. We have demonstrated that factors such as the amount and quality of mulberry leaves significantly impact larval growth, development, and survival rates, as well as adult fecundity, longevity, and competitive ability. Importantly, we have shown that the combined application of organic and inorganic fertilizers can enhance mulberry leaf quality, leading to improvements in silkworm Grainage parameters. These findings underscore the importance of optimizing mulberry leaf nutrition through targeted fertilization strategies to ensure the sustainable production of high-quality silk.

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