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Interactive effects of fertilizer levels, fertigation and foliar spray of liquid nutrients on cocoon yield and quality of mulberry silkworm

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ABSTRACT

A field experiment was conducted at Krishi Vigyan Kendra, Chintamani, situated in the Eastern Dry Zone of Karnataka (Zone-5), during 2024–25 and 2025–26 to investigate the interactive effects of fertilizer levels, fertigation and foliar application of liquid nutrients on cocoon yield and quality of mulberry silkworm. The treatments comprised three levels of recommended dose of fertilizers (RDF), viz., 100, 75 and 50 per cent, two fertigation treatments, viz., Jeevamrutha @ 500 L ha⁻¹ and microbial consortia @ 7.5 L ha⁻¹, and three foliar sprays, viz., Seriboost plus @ 0.7 per cent, Panchagavya @ 5 per cent and humic acid + fulvic acid @ 3 per cent. Among the individual factors, 100 per cent RDF recorded the highest cocoon yield of 376 kg ha⁻¹ crop-1, while microbial consortia and humic acid + fulvic acid recorded 357 and 368 kg ha⁻¹ crop-1, respectively. Significant interactions were observed among fertilizer levels, fertigation and foliar sprays. The three-way combination of 100 per cent RDF + microbial consortia + humic acid + fulvic acid recorded the highest cocoon yield of 448 kg ha⁻¹ crop-1, with superior cocoon weight (18.9 g 10-1 cocoons), pupal weight (15.6 g 10-1 pupae), shell weight (3.3 g 10-1 shells), shell ratio (17.3%) and filament length (895.2 m). In contrast, 50 per cent RDF + Jeevamrutha + Panchagavya recorded the lowest cocoon yield (258 kg ha⁻¹ crop-1), cocoon weight (11.8 g 10-1 cocoons), pupal weight (9.9 g 10-1 pupae), shell weight (1.9 g 10-1 shells), shell ratio (15.8%) and filament length (599.2 m). The study demonstrated that integrated nutrient management involving adequate RDF, microbial consortia fertigation and humic acid + fulvic acid foliar application substantially improved cocoon productivity and quality.

Keywords: Fertilizer levels, Fertigation, Liquid organic nutrients, Foliar spray, Integrated nutrient management

Introduction

Mulberry (*Morus alba* L.) is the principal food plant of the silkworm, *Bombyx mori* L., and its productivity and nutritional quality play a decisive role in cocoon yield and silk quality. The productivity of mulberry is largely governed by the availability and balanced supply of essential nutrients, particularly nitrogen, phosphorus and potassium. Conventional fertilizer application through soil alone may not always ensure efficient nutrient availability throughout the crop growth period, particularly under intensive and repeated leaf harvesting systems. Therefore, judicious management of fertilizer levels in combination with efficient nutrient delivery methods is essential for sustaining vigorous mulberry growth, improving leaf quality and meeting the nutritional requirements of silkworms. Fertigation with liquid organic nutrient sources offers an opportunity for more efficient and timely nutrient delivery to the root zone, while also potentially improving nutrient-use efficiency and soil biological activity (Tahia *et al.*, 2022) [1].

Foliar application of liquid nutrient formulations can further supplement plant nutrient requirements by providing nutrients and bioactive compounds directly through the foliage during critical growth stages. Liquid organic inputs such as microbial consortia, Jeevamrutha, Panchagavya and humic acid–fulvic acid formulations have attracted attention for their potential role in enhancing plant growth, nutrient uptake and physiological activity. However, the individual and interactive effects of fertilizer levels, fertigation and foliar application on the productivity and quality of silkworm cocoons under mulberry-based production systems require systematic evaluation. Hence, the present study was undertaken to assess the interactive effects of different fertilizer levels, fertigation with liquid organic nutrient sources and foliar application of liquid nutrient formulations on cocoon yield and important quality attributes of cocoons, with a view to identifying an effective integrated nutrient management strategy for improving the productivity and quality of mulberry silkworm cocoons.

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Materials and Methods

Experimental site

The field experiment was carried out at Krishi Vigyan Kendra, Chintamani which is situated in the Eastern Dry Zone of Karnataka (Zone-5) and lies between 13.3354° N latitude and 78.0824° E longitude, at an altitude of 865 m above Mean Sea Level. The experiment was carried over two consecutive years, 2024-25 and 2025-26.

Experimental crop

The experiment was carried out in an established five-year-old V-1 mulberry garden with 2.5 m x 2.5 m spacing. The cultural practices were adopted as per the recommendation for irrigated mulberry garden (Dandin *et al.*, 2014) [2]. The pre planted mulberry plant shoots were pruned. Inter cultivation was taken up and the respective treatments were imposed as per research plan.

Experimental design and treatments

The experiment was laid out in split-split plot design with three replications comprising eighteen treatment combinations. The **main plot** consisted of three levels of RDF (*M*) viz., *M*₁: 100% RDF, *M*₂: 75 % RDF and *M*₃: 50 % RDF, **sub plot** consists of two fertigation levels (*S*) viz., *S*₁ - Jeevamrutha @ 500 litres ha⁻¹ after pruning at 45 days interval in 5 splits and *S*₂ - Microbial consortia @ 7.5 litres ha⁻¹ after pruning at 45 days interval in 5 splits and **sub-sub plot** consists of three foliar sprays viz., *F*₁ - Seriboost plus @ 0.7 % at 20 DAP and 40 DAP, *F*₂ - Panchagavya @ 5 % at 20 DAP and 40 DAP and *F*₃ - Humic acid + fulvic acid @ 3 % at 20 DAP and 40 DAP.

Fertigation of liquid formulations

The liquid microbial formulations were applied through the existing drip irrigation system to ensure uniform distribution in the active root zone. Jeevamrutha applied @ 500 litres ha⁻¹ and microbial consortia @ 7.5 litres ha⁻¹ after pruning at 45 days interval in 5 splits.

Foliar spray of liquid manures

Foliar spray of Seriboost plus @ 0.7 %, Panchagavya @ 5 % and Humic acid + fulvic acid @ 3 % were sprayed at 20 DAP & 40 DAP each. Foliar spray formulations deliver essential nutrients and other

beneficial compounds directly to the leaves, which can be particularly beneficial during critical growth periods. By absorbing the nutrients through the leaf cuticle and stomata, the plants can benefit from the immediate availability of nutrients, which may lead to improved health and productivity (Handreck *et al.*, 1994) [3].

Crop management: Apart from the treatment imposition as per the experiment plan to various treatment combination regular agronomic practices, namely irrigation scheduling, inter-cultivation, weed management and plant protection measures, were followed in all treatments throughout the experimental period in accordance with the recommended package of practices for mulberry cultivation (Dandin *et al.*, 2003) [4].

Methodology followed for recording cocoon traits

After the cocoon harvest, ten cocoons from each treatment with respective replications were randomly selected and the mean cocoon weight was computed. The mean cocoon yield across five prunings was considered for estimating the annual cocoon yield (kg ha⁻¹ crop⁻¹) for each year. After obtaining the cocoon weight, same cocoon were cut open and pupal weight was recorded. The 10 cocoon shell weight was recorded, after removing the pupa and last larval skin (exuvium) from the cocoon. The cocoon shell ratio was calculated by the formula as weight of 10 cocoon shells (g) divided by weight of 10 cocoons (g) multiplied by 100. Single cocoon filament length (m) was calculated by randomly selected five cocoons from three replication of each treatment and was reeled using epprouvette. The number of revolutions were recorded and converted into meters by using the formula. $L = R \times 1.125$, where, *L* = total filament length (m/ cocoon), *R* = number of revolutions, 1.125 = circumference of epprouvette.

Soil characteristics

The experimental plot was red sandy loam soil with the mean pH of 6.21, organic carbon 0.44 % and electrical conductivity of 0.25 dS m⁻¹ at the beginning of the experiment. The available N, P₂O₅, and K₂O content of the soil were 252.51 kg ha⁻¹, 28.9 kg ha⁻¹, and 280.08 kg ha⁻¹, respectively.

Table 1a. Cocoon yield and quality parameters as influenced by different levels of RDF, fertigation and foliar spray of liquid nutrients

Treatments	Cocoon yield (kg ha ⁻¹ crop ⁻¹)			Cocoon weight (g 10 ⁻¹ cocoons)			Pupal weight (g 10 ⁻¹ pupae)			Shell weight (g 10 ⁻¹ shell)			Shell ratio (%)			Filament length (m)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
Main factor: RDF levels (M)																		
<i>M</i> ₁	360.0	392.0	376.0	15.7	19.0	17.3	13.2	15.6	14.4	2.5	3.4	3.0	16.1	17.8	16.9	794.2	842.8	818.5
<i>M</i> ₂	326.5	362.0	344.2	13.7	16.4	15.1	11.5	13.6	12.6	2.2	2.9	2.5	15.9	17.3	16.6	686.5	797.3	741.9
<i>M</i> ₃	275.3	303.5	289.4	12.2	14.6	13.4	10.3	12.1	11.2	1.9	2.5	2.2	15.6	16.8	16.2	606.5	735.4	671.0
S.Em ±	7.5	8.7	8.1	0.43	0.59	0.51	0.35	0.44	0.39	0.08	0.15	0.12	0.11	0.33	0.22	31.04	20.03	25.13
CD@5%	29.4	34.3	31.7	1.69	2.30	2.00	1.38	1.71	1.54	0.32	0.61	0.46	NS	NS	NS	121.89	78.65	98.69
Sub factor: Fertigation with liquid organic manures (S)																		
<i>S</i> ₁	301.7	331.4	316.5	13.3	15.9	14.6	11.2	13.1	12.1	2.1	2.7	2.4	15.8	17.1	16.4	661.9	773.1	717.5
<i>S</i> ₂	339.5	373.7	356.6	14.5	17.5	16.0	12.2	14.4	13.3	2.3	3.1	2.7	15.9	17.4	16.7	729.6	810.6	770.1
S.Em ±	4.7	6.3	5.5	0.11	0.25	0.16	0.10	0.18	0.11	0.03	0.07	0.05	0.25	0.17	0.19	13.46	9.92	9.58
CD@5%	16.2	21.8	18.9	0.38	0.86	0.55	0.34	0.64	0.39	0.12	0.23	0.17	NS	NS	NS	46.58	34.33	33.14
Sub-sub factor: Foliar spray of organic liquid manures (F)																		
<i>F</i> ₁	320.5	351.9	336.2	13.9	16.6	15.3	11.7	13.8	12.7	2.2	2.9	2.6	15.8	17.3	16.6	694.6	812.9	753.7
<i>F</i> ₂	291.9	318.8	305.3	13.0	15.5	14.2	10.9	12.9	11.9	2.1	2.7	2.4	15.7	17.0	16.4	646.4	732.5	689.4
<i>F</i> ₃	349.4	387.0	368.2	14.8	17.8	16.3	12.4	14.7	13.6	2.4	3.2	2.8	16.0	17.6	16.8	746.2	830.1	788.2
S.Em ±	10.0	12.1	11.0	0.38	0.58	0.47	0.30	0.45	0.37	0.08	0.13	0.10	0.24	0.22	0.20	25.87	23.93	23.65
CD@5%	29.1	35.3	32.1	1.10	1.68	1.38	0.88	1.32	1.08	0.23	0.37	0.30	NS	NS	NS	75.50	69.83	69.03
Interaction (M × S)																		
<i>M</i> ₁ × <i>S</i> ₁	337.0	367.6	352.3	15.2	18.3	16.8	12.8	15.1	13.9	2.4	3.3	2.8	16.0	17.7	16.9	766.6	823.5	795.0

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Treatments	Cocoon yield (kg ha ⁻¹ crop ⁻¹)			Cocoon weight (g 10 ⁻¹ cocoons)			Pupal weight (g 10 ⁻¹ pupae)			Shell weight (g 10 ⁻¹ shell)			Shell ratio (%)			Filament length (m)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
M ₁ x S ₂	383.1	416.5	399.8	16.2	19.6	17.9	13.6	16.1	14.8	2.6	3.5	3.1	16.2	17.9	17.0	821.8	862.1	841.9
M ₂ x S ₁	301.1	332.5	316.8	13.0	15.5	14.2	10.9	12.8	11.9	2.1	2.7	2.4	15.8	17.1	16.4	646.6	772.2	709.4
M ₂ x S ₂	351.8	391.5	371.7	14.4	17.4	15.9	12.1	14.3	13.2	2.3	3.1	2.7	16.0	17.5	16.7	726.5	822.4	774.4
M ₃ x S ₁	266.9	294.0	280.5	11.6	13.7	12.7	9.8	11.5	10.6	1.8	2.3	2.1	15.5	16.6	16.0	572.4	723.5	648.0
M ₃ x S ₂	283.7	313.1	298.4	12.9	15.4	14.1	10.9	12.8	11.8	2.0	2.6	2.3	15.6	16.9	16.3	640.6	747.3	694.0
S.Em ±	8.1	10.9	9.5	0.19	0.43	0.28	0.17	0.32	0.20	0.06	0.12	0.09	0.44	0.29	0.33	23.32	17.18	16.59
CD@5%	28.1	37.8	32.7	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 1b. Cocoon yield and quality parameters as influenced by different levels of RDF, fertigation and foliar spray of liquid nutrients

Treatments	Cocoon yield (kg ha ⁻¹ crop ⁻¹)			Cocoon weight (g 10 ⁻¹ cocoons)			Pupal weight (g 10 ⁻¹ pupae)			Shell weight (g 10 ⁻¹ shell)			Shell ratio (%)			Filament length (m)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
Interaction (M × F)																		
M ₁ x F ₁	361.8	393.3	377.5	15.7	19.0	17.3	13.2	15.6	14.4	2.5	3.4	3.0	16.1	17.8	16.9	793.5	865.9	829.7
M ₁ x F ₂	324.7	352.9	338.8	14.8	17.9	16.3	12.4	14.7	13.6	2.4	3.2	2.8	16.0	17.5	16.8	745.8	776.1	760.9
M ₁ x F ₃	393.6	430.0	411.8	16.6	20.1	18.3	13.9	16.5	15.2	2.7	3.6	3.2	16.2	18.1	17.1	843.3	886.3	864.8
M ₂ x F ₁	321.8	357.4	339.6	13.6	16.4	15.0	11.5	13.5	12.5	2.2	2.8	2.5	15.9	17.2	16.6	682.3	819.3	750.8
M ₂ x F ₂	295.5	325.8	310.6	12.8	15.3	14.0	10.8	12.7	11.7	2.0	2.6	2.3	15.7	17.0	16.3	636.4	738.9	687.6
M ₂ x F ₃	362.1	402.8	382.4	14.7	17.7	16.2	12.3	14.5	13.4	2.4	3.1	2.7	16.0	17.6	16.8	740.9	833.6	787.3
M ₃ x F ₁	278.1	304.9	291.5	12.3	14.6	13.4	10.3	12.1	11.2	1.9	2.5	2.2	15.6	16.8	16.2	608.1	753.3	680.7
M ₃ x F ₂	255.4	277.6	266.5	11.3	13.4	12.3	9.6	11.2	10.4	1.8	2.2	2.0	15.4	16.5	15.9	556.9	682.6	619.8
M ₃ x F ₃	292.6	328.1	310.4	13.2	15.8	14.5	11.1	13.1	12.1	2.1	2.7	2.4	15.7	17.0	16.3	654.4	770.4	712.4
S.Em ±	17.3	20.9	19.0	0.65	1.00	0.82	0.52	0.78	0.64	0.14	0.22	0.18	0.41	0.37	0.34	44.80	41.44	40.97
CD@5%	50.4	61.1	55.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (S × F)																		
S ₁ x F ₁	300.3	328.9	314.6	13.2	15.8	14.5	11.1	13.1	12.1	2.1	2.7	2.4	15.8	17.2	16.5	660.2	796.8	728.5
S ₁ x F ₂	280.2	304.8	292.5	12.6	15.0	13.8	10.6	12.4	11.5	2.0	2.5	2.3	15.7	16.9	16.3	623.1	716.5	669.8
S ₁ x F ₃	324.5	360.5	342.5	14.0	16.8	15.4	11.8	13.9	12.8	2.2	2.9	2.6	15.9	17.3	16.6	702.3	805.8	754.0
S ₂ x F ₁	340.8	374.8	357.8	14.5	17.5	16.0	12.2	14.4	13.3	2.3	3.1	2.7	15.9	17.4	16.6	729.0	828.9	778.9
S ₂ x F ₂	303.5	332.7	318.1	13.4	16.0	14.7	11.3	13.3	12.3	2.1	2.8	2.5	15.8	17.1	16.5	669.6	748.5	709.1
S ₂ x F ₃	374.3	413.4	393.9	15.6	18.9	17.2	13.1	15.5	14.3	2.5	3.4	2.9	16.1	17.8	16.9	790.2	854.4	822.3
S.Em ±	14.1	17.1	15.5	0.53	0.82	0.67	0.43	0.64	0.52	0.11	0.18	0.15	0.33	0.31	0.28	36.58	33.84	33.45
CD@5%	41.2	49.9	45.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

M₁: 100% RDF M₂: 75% RDF M₃: 50% RDF S₁: Jeevamrutha @ 500 L ha⁻¹ after pruning (45 days interval - 5 splits) S₂: Microbial consortia @ 7.5 L ha⁻¹ after pruning (45 days interval - 5 splits) F₁: Seriboost plus @ 0.7% (20 and 40 DAP) F₂: Panchagavya @ 5% (20 and 40 DAP) F₃: Humic acid + fulvic acid @ 3% (20 and 40 DAP)

Table 1c. Cocoon yield and quality parameters as influenced by different levels of RDF, fertigation and foliar spray of liquid nutrients

Treatments	Cocoon yield (kg ha ⁻¹ crop ⁻¹)			Cocoon weight (g 10 ⁻¹ cocoons)			Pupal weight (g 10 ⁻¹ pupae)			Shell weight (g 10 ⁻¹ shell)			Shell ratio (%)			Filament length (m)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
Interaction (M × S × F)																		
M ₁ S ₁ F ₁	334.0	364.0	349.0	15.1	18.3	16.7	12.7	15.0	13.9	2.4	3.2	2.8	16.0	17.7	16.9	762.6	852.9	807.7
M ₁ S ₁ F ₂	318.9	345.9	332.4	14.4	17.3	15.8	12.1	14.3	13.2	2.3	3.0	2.7	16.0	17.4	16.7	721.9	763.9	742.9
M ₁ S ₁ F ₃	358.1	393.0	375.6	16.1	19.5	17.8	13.5	16.0	14.8	2.6	3.5	3.0	16.1	17.9	17.0	815.2	853.6	834.4
M ₁ S ₂ F ₁	389.6	422.7	406.1	16.3	19.7	18.0	13.7	16.2	14.9	2.6	3.5	3.1	16.1	17.9	17.0	824.3	879.0	851.7
M ₁ S ₂ F ₂	330.5	359.8	345.2	15.3	18.4	16.8	12.8	15.1	14.0	2.5	3.3	2.9	16.0	17.7	16.9	769.6	788.2	778.9
M ₁ S ₂ F ₃	429.1	467.0	448.1	17.0	20.7	18.9	14.3	16.9	15.6	2.8	3.8	3.3	16.3	18.2	17.3	871.4	918.9	895.2
M ₂ S ₁ F ₁	300.2	331.4	315.8	12.9	15.5	14.2	10.9	12.8	11.9	2.1	2.7	2.4	15.8	17.1	16.5	646.1	794.3	720.2
M ₂ S ₁ F ₂	273.9	299.9	286.9	12.4	14.8	13.6	10.5	12.3	11.4	1.9	2.5	2.2	15.6	16.9	16.3	616.0	718.7	667.4
M ₂ S ₁ F ₃	329.1	366.2	347.7	13.5	16.2	14.8	11.4	13.4	12.4	2.2	2.8	2.5	15.9	17.3	16.6	677.6	803.5	740.5
M ₂ S ₂ F ₁	343.5	383.4	363.4	14.3	17.2	15.8	12.0	14.2	13.1	2.3	3.0	2.7	15.9	17.3	16.6	718.4	844.3	781.3

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Treatments	Cocoon yield (kg ha ⁻¹ crop ⁻¹)			Cocoon weight (g 10 ⁻¹ cocoons)			Pupal weight (g 10 ⁻¹ pupae)			Shell weight (g 10 ⁻¹ shell)			Shell ratio (%)			Filament length (m)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
	Interaction(M × S × F)																	
M ₂ S ₂ F ₂	317.0	351.7	334.4	13.2	15.7	14.4	11.1	13.0	12.1	2.1	2.7	2.4	15.7	17.1	16.4	656.7	759.0	707.9
M ₂ S ₂ F ₃	395.0	439.4	417.2	15.8	19.1	17.5	13.3	15.7	14.5	2.6	3.4	3.0	16.2	18.0	17.1	804.3	863.8	834.0
M ₃ S ₁ F ₁	266.7	291.3	279.0	11.6	13.7	12.6	9.7	11.4	10.6	1.8	2.3	2.1	15.6	16.7	16.1	572.0	743.3	657.6
M ₃ S ₁ F ₂	247.8	268.5	258.2	10.8	12.8	11.8	9.2	10.7	9.9	1.7	2.1	1.9	15.4	16.3	15.8	531.3	667.0	599.2
M ₃ S ₁ F ₃	286.3	322.3	304.3	12.4	14.8	13.6	10.5	12.3	11.4	1.9	2.5	2.2	15.6	16.8	16.2	614.0	760.3	687.1
M ₃ S ₂ F ₁	289.4	318.5	303.9	13.0	15.5	14.2	10.9	12.8	11.9	2.0	2.7	2.4	15.6	16.9	16.3	644.3	763.3	703.8
M ₃ S ₂ F ₂	262.9	286.7	274.8	11.8	14.0	12.9	9.9	11.6	10.8	1.8	2.3	2.1	15.5	16.6	16.1	582.6	698.2	640.4
M ₃ S ₂ F ₃	298.8	334.0	316.4	13.9	16.7	15.3	11.7	13.8	12.8	2.2	2.9	2.6	15.8	17.2	16.5	694.9	780.5	737.7
SEm±	24.4	29.6	26.9	0.92	1.41	1.16	0.74	1.10	0.91	0.19	0.31	0.25	0.58	0.53	0.48	63.36	58.61	57.93
CD@5%	71.3	86.3	78.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

M₁: 100% RDF M₂: 75% RDF M₃: 50% RDF S₁: Jeevamrutha @ 500 L ha⁻¹ after pruning (45 days interval – 5 splits) S₂: Microbial consortia @ 7.5 L ha⁻¹ after pruning (45 days interval – 5 splits) F₁: Seriboost plus @ 0.7% (20 and 40 DAP) F₂: Panchagavya @ 5% (20 and 40 DAP) F₃: Humic acid + fulvic acid @ 3% (20 and 40 DAP)

Results and discussion

Effect of RDF levels, fertigation and foliar spray of liquid nutrients on cocoon yield (kg ha⁻¹ crop⁻¹) (Table 1a, 1b and 1c)

The cocoon yield was significantly influenced by RDF levels, fertigation with liquid organic manures and foliar application of liquid nutrients during both the years of experimentation as well as in pooled analysis.

Effect of RDF levels on cocoon yield

Among the RDF levels, 100% RDF (M₁) recorded significantly highest cocoon yield of 360, 392 and 376 kg ha⁻¹ crop⁻¹ during 2024, 2025 and pooled analysis, respectively. The lowest cocoon yield was recorded with 50% RDF (M₃), with values of 275, 304 and 289 kg ha⁻¹ crop⁻¹, respectively. The treatment receiving 75% RDF (M₂) recorded 326, 362 and 344 kg ha⁻¹ crop⁻¹, respectively.

In pooled analysis, M₁ was significantly superior to M₂ and M₃, indicating the beneficial effect of adequate nutrient supply on mulberry productivity and subsequent cocoon production.

Effect of fertigation with liquid organic manures on cocoon yield

Fertigation with liquid organic manures significantly affected cocoon yield. Microbial consortia @ 7.5 L ha⁻¹ (S₂) recorded significantly highest cocoon yield of 340, 374 and 357 kg ha⁻¹ crop⁻¹ in 2024, 2025 and pooled analysis, respectively. The lowest yield was recorded with Jeevamrutha @ 500 L ha⁻¹ (S₁), with corresponding values of 302, 331 and 317 kg ha⁻¹ crop⁻¹. The superiority of S₂ may be attributed to improved nutrient mineralization, microbial activity and nutrient availability, which favoured better mulberry growth and leaf production.

Effect of foliar application of liquid nutrients on cocoon yield

Among the foliar treatments, humic acid + fulvic acid @ 3% (F₃) recorded significantly superior cocoon yield of 349, 387 and 368 kg ha⁻¹ crop⁻¹ during 2024, 2025 and pooled analysis, respectively. The lowest yield was recorded with Panchagavya @ 5% (F₂), with values of 292, 319 and 305 kg ha⁻¹ crop⁻¹, respectively, while seriboost Plus @ 0.7% (F₁) recorded intermediate values of 321, 352 and 336 kg ha⁻¹ crop⁻¹. The higher cocoon yield under F₃ could be attributed to the beneficial effect of humic and fulvic substances on nutrient uptake and physiological activity of mulberry.

Interaction effect of RDF levels and fertigation (M × S) on cocoon yield

The interaction between RDF levels and fertigation (M × S) was significant. The highest pooled cocoon yield of 400 kg ha⁻¹ crop⁻¹ was recorded with 100% RDF + microbial consortia (M₁S₂), followed by 75% RDF + microbial consortia (M₂S₂) with 372 kg ha⁻¹ crop⁻¹. The lowest pooled yield of 280 kg ha⁻¹ crop⁻¹ was recorded with 50% RDF + Jeevamrutha (M₃S₁). The higher yield under M₁S₂ indicates the complementary effect of adequate mineral nutrition and microbial-mediated nutrient availability, resulting in improved mulberry productivity and subsequent cocoon production.

Interaction between RDF levels and foliar sprays (M × F) on cocoon yield

The interaction between RDF levels and foliar sprays (M × F), significantly influenced cocoon yield. The highest pooled cocoon yield of 412 kg ha⁻¹ crop⁻¹ was recorded with 100% RDF + Humic acid + Fulvic acid @ 3% (M₁F₃), with corresponding yields of 394 and 430 kg ha⁻¹ crop⁻¹ during 2024 and 2025, respectively. The lowest pooled cocoon yield of 266 kg ha⁻¹ crop⁻¹ was recorded with 50% RDF + Panchagavya @ 5% (M₃F₂). The superiority of M₁F₃ indicates the complementary effect of adequate mineral nutrition and foliar application of Humic and Fulvic substances in enhancing mulberry growth and cocoon production.

Interaction between fertigation and foliar sprays (S × F) on cocoon yield

The interaction between fertigation and foliar application significantly affected cocoon yield. The highest pooled cocoon yield of 394 kg ha⁻¹ crop⁻¹ was recorded with Microbial consortia + Humic acid and Fulvic acid @ 3% (S₂F₃), with yields of 374 and 413 kg ha⁻¹ crop⁻¹ during 2024 and 2025, respectively. The lowest pooled yield of 292 kg ha⁻¹ crop⁻¹ was recorded with Jeevamrutha + Panchagavya (S₁F₂). The higher response under S₂F₃ may be attributed to the combined influence of microbial-mediated nutrient availability and improved foliar nutrient utilization.

Interaction among RDF levels, fertigation and foliar sprays (M × S × F) on cocoon yield

The three-way interaction among RDF levels, fertigation and foliar sprays significantly influenced cocoon yield. The highest pooled cocoon yield of 448 kg ha⁻¹ crop⁻¹ was recorded with the combination of 100% RDF + Microbial consortia @ 7.5 L ha⁻¹ + Humic acid + Fulvic acid @ 3% (M₁S₂F₃). The corresponding cocoon yields were 429 and 467 kg ha⁻¹ crop⁻¹ during 2024 and 2025, respectively. The next higher pooled yield was recorded with 75% RDF + microbial consortia + humic acid and fulvic acid (M₂S₂F₃) with 417 kg ha⁻¹ crop⁻¹.

The lowest pooled cocoon yield of 258 kg ha⁻¹ crop⁻¹ was recorded with 50% RDF + Jeevamrutha + Panchagavya (M₃S₁F₂), with corresponding values of 244 and 269 kg ha⁻¹ crop⁻¹ during 2024 and 2025, respectively. The substantially higher cocoon yield under M₁S₂F₃ may be attributed to the synergistic effect of adequate mineral nutrition, microbial-mediated nutrient availability and foliar ap-

sulting in higher cocoon production. Similar synergistic effects were reported by Banu Priya (2021) [5], Hemavathi (2021) [6] and Shashidhar *et al.* (2026) [7].

Effect of RDF levels, fertigation and foliar spray of liquid nutrients on cocoon parameters (Table 1a, 1b and 1c)

The data pertaining to the effect of different levels of recommended dose of fertilizers (RDF), fertigation with liquid organic manures and foliar application of liquid nutrients on important cocoon parameters of silkworm *viz.*, cocoon weight (g), pupal weight (g), shell weight (g), shell ratio (%) and filament length (m) are presented in Tables 1a, 1b and 1c. The observations revealed considerable variation among the RDF levels, fertigation treatments and foliar sprays. The cocoon characters were superior under higher RDF, microbial consortia fertigation and foliar application of humic acid + fulvic acid. The response was more pronounced when these components were combined, indicating the importance of integrated nutrient management in improving the quality of cocoons.

Cocoon weight (g 10-1 cocoons)

Cocoon weight is an important economic trait in sericulture because it reflects the quantity of biomass accumulated by the silkworm during larval development and is closely associated with pupal and shell weights. The results presented in Table 17a showed that RDF levels significantly influenced cocoon weight during both the years of experimentation.

Among the RDF levels, M₁ (100% RDF) recorded the highest cocoon weight of 15.7, 19.0 and 17.3 g 10⁻¹ cocoons during 2024, 2025 and pooled, respectively, and was significantly superior to M₂ (75% RDF) and M₃ (50% RDF). The lowest values were recorded in M₃ (50% RDF), with 12.2, 14.6 and 13.4 g 10⁻¹ cocoons, respectively. The higher cocoon weight under M₁ may be attributed to better nutritional availability resulting from adequate and balanced supply of N, P and K, which favoured vigorous larval growth and efficient conversion of mulberry leaf nutrients into cocoon biomass.

Among fertigation treatments, S₂ (microbial consortia @ 7.5 L ha⁻¹ after pruning at 45 days interval in 5 splits) recorded the highest cocoon weight of 14.5, 17.5 and 16.0 g 10⁻¹ cocoons in 2024, 2025 and pooled, respectively, and was significantly superior to S₁ (Jeevamrutha @ 500 L ha⁻¹ after pruning at 45 days interval in 5 splits), which recorded 13.3, 15.9 and 14.6 g 10⁻¹ cocoons.

Among foliar treatments, F₃ (humic acid + fulvic acid @ 3% at 20 and 40 DAP) recorded the highest cocoon weight of 14.8, 17.8 and 16.3 g 10⁻¹ cocoons, respectively, and was significantly superior to F₁ (seriboost plus @ 0.7% at 20 and 40 DAP) and F₂ (Panchagavya @ 5% at 20 and 40 DAP). The lowest value was observed with F₂ (Panchagavya @ 5%). The favourable response to humic and fulvic acids could be associated with enhanced nutrient absorption, improved physiological activity and better quality of mulberry foliage, ultimately contributing to greater cocoon biomass.

The $M \times S$ and $M \times F$ interactions were non-significant. Numerically, M₁S₂ recorded the highest pooled cocoon weight (17.9 g 10⁻¹ cocoons), while among $M \times F$ combinations M₁F₃ recorded the highest pooled value (18.3 g 10⁻¹ cocoons).

At the three-way interaction level, M₁S₂F₃ recorded the numerically highest pooled cocoon weight (18.9 g 10⁻¹ cocoons), whereas M₃S₁F₂ recorded the lowest (11.8 g 10⁻¹ cocoons). These values represent numerical trends because the interaction effects were non-significant.

Pupal weight (g 10-1 pupae)

Pupal weight followed a trend similar to that observed for cocoon weight. Significant differences were observed among RDF levels, fertigation treatments and foliar sprays. The highest pupal weight was recorded in M₁ (100% RDF), with a value of 14.4 g 10⁻¹ pupae. The lowest value was recorded in M₃ (50% RDF), with 11.2 g 10⁻¹ pupae. The superior performance under full RDF indicates that adequate nutrient availability supported better larval development and accumulation of biomass within the pupae.

Among fertigation treatments, S₂ (microbial consortia @ 7.5 L ha⁻¹ after pruning at 45 days interval in 5 splits) recorded the highest pupal weight of 13.3 g 10⁻¹ pupae and was significantly superior to S₁ (Jeevamrutha @ 500 L ha⁻¹ after pruning at 45 days interval in 5 splits).

Among foliar treatments, F₃ (Humic acid + fulvic acid @ 3% at 20 and 40 DAP) recorded the highest pupal weight of 13.6 g 10⁻¹ pupae, while F₂ (Panchagavya @ 5% at 20 and 40 DAP) recorded the lowest values of 11.9 g 10⁻¹ pupae. The improved pupal weight with microbial consortia and humic + fulvic acid may be related to improved nutrient availability and physiological efficiency of the mulberry plant, resulting in nutritionally superior leaves for silkworm feeding.

The interaction effects were non-significant. Numerically, M₁S₂ recorded the highest pooled pupal weight (14.8 g 10⁻¹ pupae), while M₁F₃ recorded 15.2 g 10⁻¹ pupae. At the $M \times S \times F$ level, M₁S₂F₃ recorded the highest value of 15.6 g 10⁻¹ pupae, whereas M₃S₁F₂ recorded the lowest value of 9.9 g 10⁻¹ pupae. These differences should be interpreted only as numerical trends in view of the non-significant interaction effects.

Shell weight (g 10-1 shell)

Shell weight was significantly influenced by RDF levels, fertigation and foliar application. The highest shell weight was recorded under M₁ (100% RDF), with 3.0 g 10⁻¹ shell whereas M₃ (50% RDF) recorded the lowest value of 2.2 g 10⁻¹ shell. The significantly higher shell weight under M₁ may be attributed to improved nutritional status of the mulberry leaves, which favoured greater silk protein synthesis and deposition during cocoon formation.

Among fertigation treatments, S₂ (microbial consortia @ 7.5 L ha⁻¹ after pruning at 45 days interval in 5 splits) recorded the highest shell weight of 2.7 g 10⁻¹ shell and was significantly superior to S₁ (Jeevamrutha @ 500 L ha⁻¹ after pruning at 45 days interval in 5 splits). Among foliar treatments, F₃ (Humic acid + fulvic acid @ 3% at 20 and 40 DAP) recorded the highest shell weight of 2.8 g 10⁻¹ shell, while F₂ (Panchagavya @ 5% at 20 and 40 DAP) recorded the lowest value of 2.4 g 10⁻¹ shell. The enhanced shell weight under F₃ may be associated with improved nutrient assimilation and photosynthetic efficiency, thereby increasing the availability of assimilates for silk gland activity and shell formation.

The $M \times S$ and $M \times F$ interactions were non-significant. Numerically, M₁S₂ recorded the highest shell weight (3.1 g 10⁻¹ shell), while M₁F₃ recorded the highest value (3.2 g 10⁻¹ shell). Among the three-way combinations, M₁S₂F₃ recorded the numerically highest pooled shell weight (3.3 g 10⁻¹ shell), whereas M₃S₁F₂ recorded the lowest (1.9 g 10⁻¹ shell).

Shell ratio (%)

Shell ratio was not significantly influenced by RDF levels, fertigation, foliar sprays or their interactions during either year or in the pooled analysis. Nevertheless, numerical differences were evident. Among RDF levels, M₁ (100% RDF) recorded the highest pooled shell ratio (16.9%), followed by M₂ (75% RDF) (16.6%) and M₃ (50% RDF) (16.2%), while M₃ recorded the lowest value.

Among fertigation treatments, S₂ (microbial consortia @ 7.5 L ha⁻¹) recorded the highest pooled shell ratio (16.7%), compared with 16.4 per cent under S₁ (jeevamrutha @ 500 L ha⁻¹). Among foliar treatments, F₃ (humic + fulvic acid @ 3%) recorded the highest pooled shell ratio (16.8%), whereas F₂ (Panchagavya @ 5%) recorded the lowest (16.4%).

At the interaction level, the numerical differences were also small and statistically non-significant. The highest pooled shell ratio among $M \times S$ combinations was recorded with M₁S₂ (17.0%), while among $M \times F$ combinations M₁F₃ recorded 17.1 per cent.

At the $M \times S \times F$ level, M₁S₂F₃ recorded the highest pooled shell ratio (17.3%), whereas M₃S₁F₂ recorded the lowest (15.8%). The absence of significant differences suggests that shell formation increased largely in proportion to cocoon and pupal development, resulting in relatively stable shell ratios across treatments.

Filament length (m)

Filament length was significantly influenced by RDF levels, fertigation and foliar sprays. Among RDF levels, M₁ (100% RDF) recorded the highest filament length of 794.2, 842.8 and 818.5 m in 2024, 2025 and pooled, respectively, and was significantly superior to the reduced RDF levels. The lowest filament length was recorded under M₃ (50% RDF), with 606.5, 735.4 and 671.0 m, respectively. The increase in filament length with higher RDF may be attributed to improved nutritional status of mulberry, particularly adequate N and K availability, which promoted better leaf quality and consequently improved silk gland development and silk secretion.

Among fertigation treatments, S₂ (microbial consortia @ 7.5 L ha⁻¹) recorded the highest filament length of 770.1 m and was significantly superior to S₁ (Jeevamrutha @ 500 L ha⁻¹). Among foliar treatments, F₃ (humic acid + fulvic acid @ 3%) recorded the highest filament length of 788.2 m, and was significantly superior to F₁ (seriboost plus @ 0.7%) and F₂ (Panchagavya @ 5%). The lowest filament length was recorded with F₂. The superior performance of F₃ may be due to the role of humic and fulvic substances in improving nutrient uptake, plant metabolic activity and leaf quality, thereby providing a favourable nutritional substrate for silkworm growth and silk production.

The interaction effects of M×S, M×F and M×S×F were non-significant. However, M₁S₂ recorded the numerically highest pooled filament length among M×S combinations (841.9 m), while M₁F₃ recorded the highest value among M×F combinations (864.8 m).

At the three-way interaction level, M₁S₂F₃ recorded the numerically highest pooled filament length of 895.2 m, whereas M₃S₁F₂ recorded the lowest value of 599.2 m. Thus, although the three-way interaction was statistically non-significant, the numerical trend indicated that full RDF combined with microbial consortia fertigation and humic + fulvic acid foliar application favoured superior cocoon quality and silk productivity.

Overall, the results demonstrated that 100% RDF (M₁), microbial consortia fertigation (S₂) and humic acid + fulvic acid foliar spray (F₃) consistently recorded the highest values for cocoon weight, pupal weight, shell weight and filament length. The overall superiority of these treatments indicates the importance of maintaining adequate soil nutrient supply along with biologically active nutrient management and foliar application of humic substances for improving mulberry leaf quality and, consequently, silkworm cocoon performance.

These findings corroborate reports of Mallappa (2014) [8], Pavankumar *et al.* (2020) [9] and Vidyashree *et al.* (2026) [10], who reported higher profitability from integrated nutrient management practices in mulberry.

Conclusion

The results clearly indicated that the application of 100% RDF, fertigation with microbial consortia, and foliar spray of humic acid + fulvic acid resulted in superior cocoon yield and improved cocoon quality parameters. The interactions among RDF levels, fertigation and foliar application were significant, with the combined application of 100% RDF + microbial consortia + humic acid + fulvic acid consistently recording superior cocoon yield, cocoon weight, pupal weight, shell weight, shell ratio and filament length. In contrast, reduced RDF level in combination with jeevamrutha and panchagavya resulted in comparatively lower values for yield and cocoon quality attributes.

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Overall, the findings demonstrated that integrated nutrient management through adequate RDF supplemented with microbial consortia fertigation and humic acid + fulvic acid foliar application enhanced cocoon productivity and quality under tree mulberry cultivation.

Declaration of AI use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing interests

Authors have declared that no competing interests exist.

References

1. Tahia F, Rania G. Foliar fertilizers impact on biochemical analysis on silkworm, *Bombyx mori* L. J. Entomolo. 2022;15(3):55-61.
2. Dandin SB, Giridhar K. Handbook of Sericulture Technologies. Central Silk Board, Bangalore, India. 2014:427.
3. Handreck K, Black ND. Growing media for ornamental plants and turf. University of New South Wales. 1994:23-26.
4. Dandin SB, Jayanth Jayaswal, Giridhar K. Handbook of Sericulture Technologies. Central Silk Board, Bangalore. 2003:284.
5. Banu Priya GM. Studies on yield and income maximisation in tree mulberry based legume intercropping system. M. Sc. Thesis, UAS, Bengaluru. 2021:98-99.
6. Hemavathi SU. Influence of liquid organic manures on growth, yield and quality of mulberry leaf and rearing performance of silkworm (*Bombyx mori* L.). M.Sc. (Seri) Thesis, UAS, Bangalore. 2021:103.
7. Shashidhar KR, Noorulla Haveri, Manjunatha Reddy TB, Thulasiram K. Efficacy of varied liquid microbial formulations on growth and yield performance of mulberry (*Morus indica* L.). Pl. Cell Biotech, Molecu. Bio. 2026;27(9):147-153.
8. Mallappa. Influence of integrated nutrient management on yield and economics of Mulberry (*Morus alba* L.). M.Sc. (Agri) Thesis, UAS, Bangalore. 2014:100.
9. Pavankumar S, Bali K, Chanotra S. Impact of organic based nutrient management on growth and yield parameters of mulberry (*Morus sp.*). Intl. J. Chem. Stud. 2020;8(4):1036-1039.
10. Vidyashree S, Ramakrishna Naika, Shyla PN, Srinivas Raju KV, Naveen DV, Harish Babu S. Impact of water-soluble fertilizers on growth and yield of mulberry. Int. J. Res. Agron. 2026;9(3):264-269.

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