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K Ranganatha
Department of Sericulture, College
of Agriculture, UAS, GKVK,
Bengaluru, Karnataka, India

KG Banuprakash
Department of Sericulture, College
of Agriculture, UAS, GKVK,
Bengaluru, Karnataka, India

KS Vinoda
Department of Sericulture, College
of Agriculture, UAS, GKVK,
Bengaluru, Karnataka, India

DC Hanumanthappa
Professor of Agronomy & OIC,
AICRP-Agroforestry, UAS,
GKVK, Bengaluru, Karnataka,
India

MS Varun
Department of Sericulture, College
of Agriculture, UAS, GKVK,
Bengaluru, Karnataka, India

GM Gaddi
Professor, Department of
Agricultural Economics, UAS,
GKVK, Bengaluru, Karnataka,
India

Corresponding Author:
K Ranganatha
Department of Sericulture, College
of Agriculture, UAS, GKVK,
Bengaluru, Karnataka, India

Economic evaluation of hydrogel and graded levels of fertiligation in mulberry cultivation and cocoon production

**K Ranganatha, KG Banuprakash, KS Vinoda, DC Hanumanthappa, MS
Varun and GM Gaddi**

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Abstract

A field experiment was conducted during 2025 to evaluate the economics of hydrogel application combined with graded levels of fertiligation in mulberry. Eight treatments comprising 50, 75 and 100% recommended dose of nitrogen and potassium (RDNK) through fertiligation, with and without starch-based hydrogel, along with conventional fertilizer practices, were laid out in a randomized complete block design with three replications. The total cost of leaf production ranged from Rs. 50,021/- to Rs. 53,360/- ha⁻¹ crop⁻¹, while cocoon production cost remained constant at Rs. 40,877/- ha⁻¹ crop⁻¹. Among the treatments, 75% RDNK through fertiligation combined with hydrogel recorded the highest gross returns (Rs. 2,84,180/- ha⁻¹ crop⁻¹), net returns (Rs. 1,90,425/- ha⁻¹ crop⁻¹) and benefit-cost ratio (3.03), compared to the control with regular RDF which recorded the lowest B:C ratio (2.70). The improved profitability was attributed due to the enhanced soil moisture retention, better nutrient use efficiency and increased leaf and cocoon productivity. The study demonstrated that integrating hydrogel with optimized fertiligation under sensor-based irrigation is an economically viable and resource-efficient strategy for sustainable mulberry cultivation and cocoon production.

Keywords: Mulberry, hydrogel, fertiligation, economics

Introduction

Mulberry (*Morus alba* L.) is the sole food plant for the silkworm (*Bombyx mori* L.) and forms the foundation of the sericulture industry, which supports millions of rural livelihoods in India. Productivity and quality of mulberry leaves directly influence silkworm growth, cocoon yield, and silk quality, making efficient crop management essential for sustaining sericulture profitability (Bongale *et al.*, 1997) [4]. Among the various agronomic factors, water and nutrient management play a decisive role in determining mulberry leaf yield and nutrient composition (Singh *et al.*, 2012) [13].

Traditional methods of irrigation and fertilizer application in mulberry are often characterized by excessive water use, uneven nutrient distribution, and substantial losses through leaching and volatilization, particularly in light-textured soils of dry and semi-arid regions (Thomas *et al.*, 2024) [14]. These inefficiencies not only reduce nutrient use efficiency but also increase the cost of cultivation, thereby lowering net returns to farmers. Micro-irrigation systems, particularly drip irrigation combined with fertiligation have shown to improve water use efficiency and fertilizer recovery by delivering nutrients directly to the root zone in precise quantities (Bandyopadhyay *et al.*, 2020) [3].

However, water stress remains a major constraint in mulberry cultivation, particularly under erratic rainfall and limited irrigation resources. In this context, super-absorbent polymers or hydrogels have emerged as promising soil amendments for improving soil moisture retention and reducing irrigation frequency. Hydrogels can absorb and store large quantities of water and gradually release it to plant roots, thereby mitigating moisture stress and enhancing water productivity (Neethu *et al.*, 2018) [11]. Starch-based hydrogels have been widely evaluated for their biodegradability, compatibility with crops and positive effects on soil physical properties,

(Ranganatha *et al.*, 2025) ^[12] demonstrated that hydrogel application and fertigation improve crop yield and water productivity in mulberry by reducing irrigation requirement and enhancing nutrient availability in the root zone. In mulberry, hydrogel application has been reported to increase leaf yield and profitability despite a marginal increase in cultivation cost, owing to better moisture conservation and improved plant growth.

The integration of fertigation with hydrogel application improves water and nutrient use efficiency by enhancing soil moisture retention and reducing nutrient losses in the root zone. While both fertigation and hydrogels individually enhance crop productivity, studies evaluating their combined effects on mulberry growth, leaf yield, economic returns and subsequent silkworm performance remain limited.

In this background, the present study was undertaken to assess the impact of hydrogel application and graded levels of fertigation on profitability of mulberry leaf and cocoon production. The study aims to identify economically optimal fertigation levels and evaluate whether hydrogel application can reduce input costs and help earn enhanced returns, thereby providing a sustainable and profitable strategy for mulberry-sericulture.

Materials and Methods

The experiment was conducted during 2025 in well-established V1 mulberry garden at L-block, Agroforestry based Integrated Farming System demo unit, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru. The field is located at a latitude of 12°58' N and longitude of 77°35' east and at an altitude of 930 m above mean sea level in the Eastern Dry Zone (Zone 5) of Karnataka. The experiment was conducted with eight treatment combinations viz.,

T₁-50% RDNK through fertigation

T₂-50% RDNK through fertigation + hydrogel® @ 6 kg ac⁻¹

T₃-75% RDNK through fertigation

T₄-75% RDNK through fertigation + hydrogel® @ 6 kg ac⁻¹

T₅-100% RDNK through fertigation

T₆-100% RDNK through fertigation + hydrogel® @ 6 kg ac⁻¹

T₇-RDNK as per Package of Practice and

T₈-Control (RDF as per Package of Practice)

Note:® Starch-based Zeba hydrogel

These treatments were laid out in RCBD design with three replications.

Hydrogel application was carried out only once for first crop

after the pruning (as used by Harshita Mala *et al.*, 2023) ^[6] Fertigation (T₁ to T₆) application was carried out in three equal splits at weekly intervals (15th to 29th days after pruning) for both first and second crop (similar to those carried out by Mahesh *et al.*, 2022) ^[10], T₇ (without P for second crop) and T₈ (with P for both crops) were acted as control treatments. The fertilizers for T₇ and T₈ were applied at 20 days after pruning as per Dandin and Giridhar (2014) ^[5]. FYM @ 20 t ha⁻¹ yr⁻¹ was applied after pruning of mulberry and irrigation was given based on soil moisture content for all the treatments. N (Urea) and K (Muriate of potash) were applied through fertigation for both the crops. Phosphorus is immobile in soil, while is mainly responsible for root growth, so applied only once as basal dose for all the treatments except T₈ (Arunadevi and Selvaraj, 2013) ^[2].

Single point sensors were placed at 15 cm depth to ensure enough water for crop growth. Soil moisture indicator developed by Sugarcane Breeding Institute, Coimbatore was used which works on principle of resistance but, the depiction will be in the form of colour.

Economics of Applying Hydrogel and fertigation under Sensor Based Irrigation to Mulberry and Cocoon Production

Cost of cultivation (Rs. /ha): The treatment-wise cost of cultivation was worked out by considering the cost of all the labour and material inputs including the imputed values for land, depreciation of various machinery and equipment used in mulberry cultivation and cocoon production. The prices of the inputs that at the time of their use and value of the cocoons produced on the basis of prevailing market rates were considered.

Net returns (Rs. /ha): The net returns per ha were calculated by deducting the total cost of cultivation (consisting of variable cost and fixed cost items) per hectare from gross returns realised per ha.

Benefit: Cost ratio: Benefit cost ratio was worked out by using following formula:

Benefit: Cost ratio= Gross returns/Cost of cultivation

Results and Discussion

The results and discussion on economics of mulberry cultivation and cocoon production under hydrogel and graded levels of fertigation are presented in the following sections:

Table 1: Particulars of different inputs used for irrigated mulberry garden (Rs. ha⁻¹crop⁻¹)

Sl. No.	Particulars	Unit	Requirements	Rate (Rs. Unit)	Total amount (Rs.)	% share
A	Operational / Variable costs					
I	Labour cost					
1	Human labour	md	39	-	18600	39.30
	a. Men		7	600	4200	8.87
	b. Women		32	450	14400	30.43
2	Bullock labour	bp	6	1200	7200	15.21
3	Machine labour	mh	2	700	1400	2.96
II	Material cost					
1	FYM	Tonnes	4	1150	4600	9.72
2	Apportioned drip system cost	Rs.	-	-	8333	17.61
	Sub total	Rs.			40133	84.80
	Interest on working capital @ 10%	Rs.	-	-	478	1.01
	Total Variable Cost (A)	Rs.			40611	85.81
B	Fixed costs					
1	Land revenue	Rs.	-	-	100	0.21

2	Depreciation	Rs.	-	-	2202	4.65
3	Rental value of land (Opportunity cost of owned land)	Rs.	-	-	3000	6.34
	Apportioned establishment cost of Mulberry garden	Rs.	-	-	1278	2.70
	Sub total	Rs.			6580	13.90
	Interest on fixed capital @ 12%	Rs.	-	-	134	0.28
	Total Fixed Cost (B)	Rs.			6714	14.19
	Total Cost of Cultivation (A+B)	Rs.			47325	100.00

The cost structure of maintaining an irrigated mulberry garden on a per hectare per crop basis indicates that the total cost of cultivation was Rs. 47,325/-, comprising of majorly variable costs (85.81%) and about 14.19% fixed costs. Variable costs formed the major share at Rs. 40,611/-, showing that mulberry cultivation is largely labour-intensive and input-intensive as well. Among labour components, human labour accounted for the highest expenditure (Rs. 18,600/-), with women labour contributing for a relatively larger share (Rs. 14,400/-) than men labour (Rs.4,200/-), followed by bullock labour (Rs.7,200/-) while accounted for about 15.21% and machine labour accounted for just about three% (Rs. 1,400/-) in the total cost of cultivation. Material costs consisted of expenditure on FYM (Rs.

4,600/-) and amortised cost of drip irrigation system (Rs. 8,333/-), reflecting the importance of nutrient management and irrigation infrastructure. Interest on working capital at 10% (Rs. 478/-) increased the operational cost, bringing total variable cost to Rs. 40,611/-. Fixed costs were comparatively lower at Rs. 6,714/-, comprising land revenue, depreciation, imputed rental value of land, apportioned establishment cost, and interest on fixed capital accounted at 12% (Rs. 134/-) considering the prevailing term loan interest rate. Overall, variable costs dominated total expenditure, with labour and drip irrigation being the major cost components in irrigated mulberry cultivation.

Table 2: Cost of chemical fertilizers and hydrogel (Rs. ha⁻¹ yr⁻¹)

Sl. No.	Particulars	Unit	Requirements	Rate (Rs. Unit)	Total amount (Rs.)
A	Operational / Variable costs				
1	Nitrogen @ 350 kg	(Urea, kg)	760	Rs. 300 per 50 kg bag	4560
2	Phosphorus @ 140 kg	(SSP, kg)	875	Rs. 450 per 50 kg bag	7875
3	Potassium @ 140 kg	(MoP, kg)	233	Rs. 900 per 50 kg bag	4194
	Total Chemical Fertilizer cost	Rs.	-	-	16629
	Interest on working capital @ 10%	Rs.	-	-	1663
	Total fertilizer cost	Rs.			18292
4	Hydrogel	kg	30	360	10800
	Interest on working capital @ 10%	Rs.			1080
	Total hydrogel cost	Rs.			11880

The cost details of chemical fertilizers and hydrogel applied in mulberry cultivation on a per hectare per year basis is depicted in Table 2. The expenditure on chemical fertilizers included expenditure on nitrogen, phosphorus and potassium, with costs of Rs. 4,560/-, Rs. 7,875/- and Rs. 4,194/-, respectively. The total fertilizer cost was Rs. 16,629/-, and interest on working capital at 10% added Rs. 1,663/-, resulting in a total fertilizer

expenditure of Rs. 18,292/-. The cost of Hydrogel amounted to Rs. 10,800/-, including the interest on this working capital (Rs.1,080/-) stood at total hydrogel cost to Rs. 11,880/-. Thus, in addition to the fertilizer input cost a major recurring cost, including hydrogel cost represented a substantial supplementary investment in the mulberry cultivation.

Table 3: Total cost of mulberry cultivation for different treatments (Rs. ha⁻¹ crop⁻¹)

Treatments	Cost of mulberry cultivation excluding cost of treatment (Rs.)	Cost of fertilizers (Rs.) #	Cost of hydrogel (Rs.)	Total cost of mulberry cultivation (Rs.)
T ₁	47325	2695	0	50021
T ₂	47325	2695	2376	52397
T ₃	47325	3177	0	50502
T ₄	47325	3177	2376	52878
T ₅	47325	3658	0	50984
T ₆	47325	3658	2376	53360
T ₇	47325	3658	0	50984
T ₈	47325	3658	0	50984

Inclusive of phosphorous application as basal dose

The total cost of mulberry cultivation under different treatments on a per hectare per crop basis by combining the base cultivation cost with treatment-specific inputs is presented in Table 3. The cost of cultivation excluding cost of treatment remained constant across all treatments (Rs. 47,325/-), representing the common operational and fixed costs of mulberry cultivation. Variations in total cost were mainly due to differences in fertilizer application rates and the inclusion of hydrogel. Fertilizer costs ranged from

Rs. 2,695/- in T₁ and T₂ to Rs. 3,658/- in treatments receiving higher fertilizer levels. Treatments with hydrogel (T₂, T₄ and T₆) resulted in an additional cost of Rs. 2,376/-, taking to higher total cost. Consequently, the total cost varied from Rs. 50,021/- (T₁) to a maximum of Rs. 53,360/- (T₆). Thus, results presented in table indicated that the inclusion of hydrogel and higher fertilizer doses increased production costs, while the baseline cost of cultivation remained unchanged. The fertilizer cost values included phosphorus applied as a basal dose.

Table 4: Cost of cocoon production (650 DFLs)

Sl. No.	Particulars	Unit	Requirements	Rate (Rs. Unit)	Total amount (Rs.)
A	Operational / Variable costs				
I	Labour cost				
1	Human labour	md	17	-	7950
	a. Men		2	600	1200
	b. Women		15	450	6750
3	Machine labour	mh	1	700	700
II	Material cost				
1	Chawki worms	Rs.	-	-	26000
2	Paraffin paper, foam rubber, etc.,	Rs.	-	-	800
3	Disinfectants	Rs.	-	-	500
4	Marketing cost (packing, transportation and commission)	Rs.	-	-	3230
5	Electricity cost	Rs.	-	-	120
	Sub total	Rs.			39300
	Interest on working capital @ 10%	Rs.	-	-	314
	Total Variable Cost (A)	Rs.			39615
B	Fixed costs				
1	Depreciation on building, utensils and equipment	Rs.	-	-	1250
	Interest on fixed capital @ 12%	Rs.	-	-	12
	Total Fixed Costs (B)	Rs.			1262
	Total Cost of 650 DFLs Production (A+B)	Rs.			40877

The cost of cocoon production from rearing 650 DFLs, consisted of both variable cost and fixed cost components. The total cost of cocoon production excluding the cost of Mulberry leaves was estimated at Rs. 40877/-, of which variable costs contributed for the major share (Rs. 39,615/-). Labour expenditure accounted for Rs. 8,650/-, with human labour forming the major component (Rs. 7,950/-), as expected the proportion of women labour (Rs. 6,750/-) exceeded men labour (Rs. 1,200/-). Machine labour cost was Rs. 700 towards disinfection of rearing house. Material costs were dominated by chawki worms, which accounted for the highest expenditure (Rs. 26,000/-), indicating

that seed cost is the major cost driver in cocoon production. Other supporting expenses included paraffin paper and accessories, disinfectants, marketing charges and electricity, together contributing a smaller share to the total. Interest on working capital at 10% added Rs. 314/-, increasing the operational cost. Fixed costs were minimal (Rs. 1,262/-) and mainly comprised depreciation on building and equipment along with interest on fixed capital. Overall, the table highlights that variable costs, particularly chawki worms and labour, constitute the major share of total cocoon production cost.

Table 5: Economics of mulberry and cocoon production with hydrogel and graded levels of fertigation

Treatments	Cost of cultivation		Total cocoon production cost (Rs. ha ⁻¹ crop ⁻¹)	Cocoon production (kg ha ⁻¹ crop ⁻¹)	Gross returns (Rs. ha ⁻¹ crop ⁻¹)	Net profit (Rs. ha ⁻¹ crop ⁻¹)	B:C Ratio
	Total cost of leaf production (Rs. ha ⁻¹ crop ⁻¹)	Total cost of cocoon production except leaf cost (Rs. ha ⁻¹ crop ⁻¹)					
T ₁	50021	40877	90897	523	261560	170663	2.88
T ₂	52397	40877	93273	540	269750	176477	2.89
T ₃	50502	40877	91379	534	266760	175381	2.92
T ₄	52878	40877	93755	568	284180	190425	3.03
T ₅	50984	40877	91860	543	271440	179580	2.95
T ₆	53360	40877	94236	563	281450	187214	2.99
T ₇	50984	40877	91860	496	248040	156180	2.70
T ₈	50984	40877	91860	507	253370	161510	2.76

Total cost of cultivation (Rs. ha⁻¹ crop⁻¹): The results on economics of mulberry leaf production and cocoon production under hydrogel application and graded levels of fertigation are presented in Table 5. The total cost of leaf production ranged from Rs. 50,021/- to Rs 53,360/- ha⁻¹ crop⁻¹, whereas the cost of cocoon production remained constant at Rs. 40,877/- ha⁻¹ crop⁻¹ across all the treatments. Consequently, the total production cost varied from Rs. 90,897/- to Rs. 94,236/- ha⁻¹ crop⁻¹, depending on the fertigation level and inclusion of hydrogel in the treatment.

Gross returns and net returns (Rs. ha⁻¹ crop⁻¹) from cocoon production: Gross returns differed considerably among treatments, indicating the influence of fertigation levels and hydrogel application on cocoon productivity. The highest gross return (Rs. 2,84,180/- ha⁻¹ crop⁻¹) was recorded in T₄, followed

by T₆ (Rs. 2,81,450/- ha⁻¹ crop⁻¹) and T₅ (Rs. 2,71,440/- ha⁻¹ crop⁻¹). A similar trend was observed for net returns, with T₄ registering the maximum net profit of Rs. 1,90,425/- ha⁻¹ crop⁻¹, followed by T₆ (Rs. 1,87,214/- ha⁻¹ crop⁻¹) and T₅ (Rs. 1,79,580/- ha⁻¹ crop⁻¹). This clearly indicates the economic advantage of hydrogel integration with optimized fertigation levels.

The returns per rupee of expenditure (Benefit: cost ratio): The returns per rupee of expenditure (B:C ratio) ranged from 2.70 to 3.03, reflecting variations in economic efficiency among treatments. The highest B:C ratio (3.03) was recorded in T₄, indicating superiority of the treatment and profitability due to higher cocoon yield and net return realisation. The lowest B:C ratio (2.70) was observed in T₇, suggesting comparatively lower economic performance. Overall, the results demonstrated that the combined application of hydrogel with an appropriate

fertigation level substantially improved profitability due to increased mulberry yield and cocoon production and economic efficiency compared to treatments without hydrogel or with suboptimal fertigation.

The maximum economic returns with hydrogel and graded fertigation were due to improved soil moisture retention, nutrient use efficiency and higher mulberry yields. Hydrogels store water in the root zone and release it gradually, reducing water stress, enhancing leaf growth and biomass, and increasing productivity compared to treatments without hydrogel (Agbna *et al.*, 2025)^[1]. Although hydrogels add towards production cost, multiple studies on hydrogels have indicated that crop yield and savings in water and fertilizer use, respectively often outweigh these costs. For example, hydrogel application in wheat resulted in higher gross and net monetary returns and improved benefit-cost ratios compared to control treatments without hydrogel, demonstrating its positive economic impact through yield and water productivity gains (Waghmare *et al.*, 2025)^[15]. Another study in mulberry itself revealed that 100% RDNK + starch-based hydrogel @ 6 kg⁻¹ resulted in maximum leaf yield (8116 kg ha⁻¹ crop⁻¹), water productivity (611.61 kg ha-cm⁻¹) with saving 21.43% of water (Ranganatha *et al.*, 2025)^[12], which all can suffice the usage of hydrogel though it is added expenditure in the production cost.

The present study is in partial agreement with the findings of Harshitha Mala *et al.* (2024)^[7] who revealed that the highest cultivation cost (Rs. 83,173/- ha⁻¹) for pusa hydrogel @ 4 kg treated plots and the lowest cultivation cost (Rs. 77,245/- ha⁻¹) for control plots, while net returns (Rs. 1,48,812/- ha⁻¹) and B:C ratio (2.88) were highest in Zeba hydrogel @ 6 kg ac⁻¹, highlighting improved profitability with hydrogel in mulberry. Madhu *et al.* (2024)^[9] reported the cost of cocoon production of small farmer per batch was Rs. 48,988/- with highest gross returns (63,240/-) and net returns (14,150/-). A study by Imamsaheb *et al.* (2011)^[8] revealed that higher yield (63.78 t/ha) and net income (Rs.1,14,471/- ha⁻¹ crop⁻¹), gross income (Rs.1,59,450/- ha⁻¹ crop⁻¹) and B:C ratio (3.22) was observed in tomato genotypes when 100% recommended NPK fertilizers was applied through fertigation.

The study concludes that integrating hydrogel application with optimized fertigation significantly improve the profitability of mulberry leaf production and cocoon production. Application of 75% recommended dose of nitrogen and potassium through fertigation combined with hydrogel recorded the highest net returns and benefit-cost ratio, owing to improved soil moisture retention, enhanced nutrient use efficiency and higher productivity. Although hydrogel application slightly increases the cultivation cost, the additional expenditure was offset by good yields and profitability. Hence, the combined use of hydrogel and optimized fertigation emerged as a viable and sustainable strategy for enhancing resource-use efficiency and economic returns in mulberry sericulture.

References

1. Agbna GH, Shahab A, Zaidi SJ. Multifunctional hydrogel systems: integrating nutrient delivery, soil enhancement, and climate resilience in modern agriculture. *Desalin Water Treat.* 2025;101372.
2. Arunadevi K, Selvaraj PK. Moisture distribution and fertilizer mobility under drip fertigation in mulberry. *J Soil Water Conserv.* 2013;12(2):123-129.
3. Bandyopadhyay A, Ghosh DK, Biswas B, Parameswarappa MH, Timsina J. Fertigation effects on nutrient use efficiency, energy productivity, and economics of coconut

- (*Cocos nucifera* L.) cultivation in the eastern Indo-Gangetic Plains of South Asia. *Int J Fruit Sci.* 2020;20(Suppl 3):1483-1494.
4. Bongale UD, Chaluvachari, Mallikarjunappa RS, Narahari Rao BV, Anantharaman MN, Dandin SB. Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (*Morus* spp.). *Sericologia.* 1997;37(1):71-81.
5. Dandin SB, Giridhar K. Handbook of sericulture technologies. Bangalore: Central Silk Board; 2014. p. 427.
6. Harshitha Mala P, Banuprakash KG, Hanumanthappa DC, Vinoda KS. Efficacy of hydrogels under sensor-based irrigation on growth and productivity of tree mulberry. *Mysore J Agric Sci.* 2023;57(4):135-144.
7. Harshitha Mala P, Banuprakash KG, Vinoda KS. Economic impact of hydrogel application in cocoon production using sensor-based irrigation. *Int J Environ Clim Change.* 2024;14(9):159-163.
8. Imamsaheb SJ, Patil MG, Naik MK, Hussain Abbas S, Ayyangoudar MS. Yield, yield components and quality of processing tomato (*Solanum lycopersicum* L.) genotypes as influenced by different levels of fertigation. *Environ Ecol.* 2011;29(1):229-232.
9. Madhu DM, Sinha DK, Gowda H, Haripriya S, Kumari T. An economic analysis of mulberry silk production in Chikkaballapur district of Karnataka. *Agric Res J.* 2024;61(2):203-217.
10. Mahesh R, Anil P, Debashish C, Sivaprasad V. Improved mulberry productivity and resource efficiency through low-cost drip fertigation. *Arch Agron Soil Sci.* 2022;68(6):749-763.
11. Neethu TM, Dubey PK, Kaswala AR. Prospects and applications of hydrogel technology in agriculture. *Int J Curr Microbiol Appl Sci.* 2018;7(5):3155-3162.
12. Ranganatha K, Hanumanthappa DC, Vinoda KS, Banuprakash KG, Nisarga K. Influence of hydrogel and graded levels of fertigation on growth and productivity of mulberry. *Int J Res Agron.* 2025;8(12):1130-1135.
13. Singh MK, Chowdhuri RS, Naqvi AH, Ghosh MK, Bindroo BB. Studies on integrated nutrient management on leaf yield and quality of silk of mulberry (*Morus alba* L.) grown under rainfed situation. *J Crop Weed.* 2012;8(2):80-82.
14. Thomas SL, Bindhu JS, Pillai SP, Beena R, Biju J, Sarada S. Nutrient dynamics and moisture distribution under drip irrigation system. *J Exp Agric Int.* 2024;46(10):485-493.
15. Waghmare SR, Patil PR, Surve US, Shendage GB, Sonwalkar TT, More NS. Effect of irrigation and hydrogel levels on yield and economics of wheat (*Triticum aestivum* L.). *Int J Res Agron.* 2025;8(8):459-463.