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Economic Impact of Hydrogel Application in Cocoon Production Using Sensor-based Irrigation

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Authors' contributions

This work was carried out in collaboration among all authors. Author PHM conceptualization of research and Contribution of experimental materials and designing of the experiment. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out to study the economics of cocoon production as influenced by hydrogels under sensor-based irrigation. The experiment was laid out in Randomized Complete Block Design (RCBD) with nine treatment combinations and three replications by using two different types of hydrogels *viz.,* Pusa hydrogel (T_1- Pusa hydrogel @ 1 kg/ac, T_2- Pusa hydrogel @ 2 kg/ac, T_3- Pusa hydrogel @ 3 kg/ac and T_4- Pusa hydrogel @ 4 kg/ac) and Zeba hydrogel (T_5- Zeba hydrogel @ 3 kg/ac, T_6- Zeba hydrogel @ 4 kg/ac, T_7- Zeba hydrogel @ 5 kg/ac, and T_8- Zeba hydrogel @ 6 kg/ac), and T_9 was control without hydrogel. Total cost of cultivation was more (Rs. 83,173 ha^{-1} crop^{-1}) in treatment T_4 which received Pusa hydrogel @ 4 kg/ac followed by T_3 (Rs. 81,691 ha^{-1} crop^{-1}). The cost of cultivation was least (Rs. 77,245 ha^{-1} crop^{-1}) in T_9 - control plot. Among the different treatment combinations Zeba hydrogel @ 6 kg ac^{-1} (T_8) treated mulberry leaves fed double hybrid silkworms yielded maximum net returns (Rs. 1,48,812 ha^{-1} year-^{1}) followed by T_7 -

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Zeba hydrogel @ 5 kg ac^{-1} (Rs. 1,46,738 ha^{-1} year^{-1}) and least was recorded in T_9- Control plot without hydrogel (Rs. 1,13,681 ha^{-1} year^{-1}). However, Zeba hydrogel @ 6 kg ac^{-1} was found to be cost effective with higher B:C ratio (2.88) followed by T_7- Zeba hydrogel @ 5 kg/ac (2.86) as compared to control which recorded (2.47).

Keywords: Tree mulberry; sensor based irrigation; hydrogels; economics.

1. INTRODUCTION

The gap between the demand and supply of water is widening annually, and in the near future, declining availability will be a serious threat to the entire world. It is anticipated that the current 4500 km^3 worldwide withdrawal will rise to 6900 km^3. By 2030, the estimated availability of water will decline slightly to 4100 km3, resulting in a 40 per cent deficit. Meanwhile, India's annual demand forecast to rise to over 1500 km^3, compared to a projected availability of 744 km^3, with a 50 per cent deficit [1].

Among all other agronomic inputs, mulberry leaf quantity and quality are most influenced by irrigation water. In sensor-based drip irrigation system applying water to the soil at regular intervals irrigates a specific region surrounding the plant. An irrigation system controller that is already in place can be linked to soil moisture sensors. When an irrigation event is scheduled, the sensor determines the amount of moisture at the root zone. If the soil moisture exceeds a predetermined threshold, the cycle is skipped. The sensors help determine whether irrigation is acceptable and how deep to actually irrigate when they are implanted in the root zone at different places [2].

Depending on the soil type and season, mulberry requires 1.5 to 2.0 acres of water each irrigation at intervals of 6 to 12 days. Aiming for the optimum leaf yield in mulberry, about eight 65-70 day irrigations are needed every crop. Thus, approximately 75 acres of water, or 1875 mm of rainfall spread equally at 36 mm per week or 5–6 mm per day, are needed annually for irrigation water for five crops. However, in India, four to five months rains were received for about eighty percent of the 1,160 mm of annual rainfall on average [3,4]. Therefore, year-round access to water is a problem for producing mulberry leaf with quality and good crop output.

The drip irrigation technique delivers nutrients and water straight to the plant's roots. Higher crop yields, water savings, enhanced fertilizer use efficiency, lower energy consumption, lower labour costs, better disease and pest management, and suitability for sloppy, undulating terrain are some of its main advantages over other approaches. Comparing drip irrigation to traditional flood irrigation techniques, water savings range from 70 to 80 per cent on average [5].

Hydrogels also known as hydrophilic gels or super absorbent polymers, fall into a few different categories, including synthetic, semi-synthetic and naturally occurring. In dry conditions with light soil, the majority of these polymers can hold 332-465 times the water content of their weight and release it gradually [6]. Because of their hydrophilic nature, hydrogels swell when they come into contact with water, releasing over 95 per cent of the water that has been stored for crop absorption. Depending on the soil conditions and growing method, the super absorbent gels' process of holding and releasing water may take ranging between two to five years. But eventually, without leaving any remnant, it decomposes into CO_2, water, ammonia, and potassium ions over time, making them ecofriendly [7].

2. MATERIALS AND METHODS

The experiment was conducted during 2022-23 in well-established V_1 tree mulberry garden at L-Block, Integrated Farming System Demonstration 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 laid out in Randomized Complete Block Design (RCBD) with nine treatment combinations and three replications (Plate 1).

2.1 Treatment Combinations

Pusa hydrogel is an indigenous cellulose based product designed and developed to enhance the crop productivity in moisture stress conditions. Whereas, Zeba hydrogel is an unique starch based soil amendment that absorbs water and releases it back to plants when they need it. The dosage of Pusa hydrogel is 1-2.5 kg/ac and Zeba hydrogel is 5 kg/ac.

T_1- Pusa hydrogel @ 1 kg/ac
T_2- Pusa hydrogel @ 2 kg/ac
T_3- Pusa hydrogel @ 3 kg/ac
T_4- Pusa hydrogel @ 4 kg/ac
T_5- Zeba hydrogel @ 3 kg/ac
T_6- Zeba hydrogel @ 4 kg/ac
T_7- Zeba hydrogel @ 5 kg/ac
T_8- Zeba hydrogel @ 6 kg/ac
T_9- Control (Without hydrogel)

Hydrogels are applied at the root zone of the tree mulberry immediately after pruning along with the recommended dose of NPK during March, 2022. The hydrogels were applied only once in the five crops. Irrigation is applied at 50 per cent DASM (Depletion of available soil moisture). All the other practices of mulberry cultivation followed as per standard package of practices [8].

Soil moisture in the soil was measured by using soil moisture indicator, moisture probe meter and single point sensors. Sensors were placed in each treatment such way to avoid the error. Single point sensors were placed at 15 cm depth to ensure enough water for crop growth. These were connected to the IoT based field controller in turn to the gateway through wireless connection in order to store the data in clouds to monitor the water stored in the soil outside the area that can be recharged by drip irrigation [9].

Soil moisture indicator was developed by Sugarcane Breeding Institute, Coimbatore which works on principle of resistance but, the depiction will be in the form of colour (https://sugarcane.icar.gov.in/index.php/soil-moisture-indicator/).

2.2 Economics of Applying Hydrogels under Sensor Based Irrigation to Mulberry and Cocoon Production

Cost of cultivation (Rs. / ha): The cost of cultivation was worked out treatment wise. The prices of the inputs that at the time of their use and selling prices of the cocoons on the basis of prevailing market rates were taken into account.

Plate 1. View of experimental plot

Net returns (Rs. / ha): The net returns per ha was calculated by deducting the cost of cultivation per hectare from gross returns per ha.

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

$$\text{Benefit: Cost ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

3. RESULTS AND DISCUSSION

Economics of applying hydrogels under sensor based irrigation to mulberry and cocoon production: The acceptance of any technology developed to the farmers ultimately depends on the economics of the crop production. Among the different indicators of monitory efficiency, the economics in terms of net returns and B:C ratio has greater impact on the practical utility and acceptance of technology. Economics of cocoon productivity as influenced by hydrogels under sensor based irrigation on mulberry and silkworm rearing is presented in Table 1.

Total cost of cultivation (Rs. ha^{-1} crop^{-1}): Total cost of cultivation was higher (Rs. 83,173 ha^{-1} crop^{-1}) in treatment T_4 which received Pusa hydrogel @ 4 kg ac^{-1} followed by T_3 (Rs. 81,691 ha^{-1} crop^{-1}). The cost of cultivation was least (Rs. 77,245 ha^{-1} crop^{-1}) in T_9 control plot (without hydrogel) (Table 1).

Net returns (Rs. ha^{-1} crop^{-1}): The net returns earned ranged from 1,48,812 Rs. ha^{-1} crop^{-1} in treatment T_8 to 1,13,681 Rs. ha^{-1} crop^{-1} in T_9. Among the different treatment combinations, mulberry leaves from Zeba hydrogel @ 6 kg ac^{-1} (T_8) treated tree mulberry fed leaves double hybrid silkworms yielded maximum net returns (Rs. 1,48,812 ha^{-1} crop^{-1}) followed by T_7 - Zeba hydrogel @ 5 kg ac^{-1} (Rs. 1,46,738 ha^{-1} crop^{-1}), T_6 - Zeba hydrogel @ 4 kg ac^{-1} (Rs. 1,35,644 ha^{-1} crop^{-1}) and least was recorded in T_9- Control plot without hydrogel (Rs. 1,13,681 ha^{-1} crop^{-1}) (Table 1).

Benefit: Cost ratio: The highest B:C ratio of 2.88 was recorded in Zeba hydrogel @ 6 kg ac^{-1} (T_8) followed by T_7- Zeba hydrogel @ 5 kg ac^{-1} (2.86) among the hydrogels lowest was recorded in T_9- (control plot) which is without hydrogel (2.47) presented in Table 1.

The present study is in partial agreement with the findings of Imamsaheb et al. [10] who revealed that higher yield (63.78 t/ ha) and net income (Rs.1,14,470.91 / ha / crop), gross income (Rs.1,59,450 / ha / crop) and B: C ratio (3.22) was observed in mulberry genotypes when 100 per cent recommended NPK fertilizers was applied through fertigation. Further, Khan et al. [11] found that drip fertigation was found to have a higher net benefit of Rs. 38,742 ha per crop with 100 per cent water-soluble fertilizers compared to drip fertigation with 100 per cent fertilizer (Rs. 33,604 ha / crop).

Table 1. Economics of mulberry and cocoon production with hydrogel application under sensor based irrigation

Treatments	Cost of cultivation (Rs. ha^{-1} crop^{-1})		Total production cost (Rs. ha^{-1} crop^{-1})	Gross profit (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 (Rs. ha^{-1} crop^{-1})				
T_1	52,477	26,250	78,727	1,94,935	1,16,208	2.47
T_2	53,959	26,250	80,209	1,99,492	1,19,283	2.48
T_3	55,441	26,250	81,691	2,06,874	1,25,183	2.53
T_4	56,923	26,250	83,173	2,14,894	1,31,721	2.58
T_5	51,884	26,250	78,134	2,11,157	1,33,023	2.70
T_6	52,180	26,250	78,430	2,14,074	1,35,644	2.72
T_7	52,477	26,250	78,727	2,25,465	1,46,738	2.86
T_8	52,773	26,250	79,023	2,27,835	1,48,812	2.88
T_9	50,995	26,250	77,245	1,90,926	1,13,681	2.47

4. CONCLUSION

To conclude, the application of Zeba hydrogel @ 6 kg ac^{-1} (T8) has shown better results on economics of cocoon production under sensor based irrigation. Starch-based hydrogels can absorb and retain water effectively. They can help in maintaining soil moisture and provide a continuous water supply to plants. Hence, starch based hydrogels like Zeba may serve as best choice for use in mulberry cultivation. Hydrogels play a crucial role in sensor-based irrigation systems by efficiently managing water resources, preventing water wastage and promoting sustainable agricultural practices. Integrating these technologies can help address water scarcity challenges and contribute to more efficient and environmentally friendly irrigation practices.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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