EFFICACY OF HYDROGELS UNDER SENSOR BASED IRRIGATIONONBIOCHEMICALCONTENTSOFTREEMULBERRY LEAVES

Abstract

The efficacyofhydrogelsunder sensor-based irrigation onbiochemicalcontentsoftreemulberryleaveswasstudiedduring2022-23andtheexperimentwaslaidoutinRandomized Complete Block Design (RCBD) with nine treatment combinations and threereplications. The hydrogels were applied during beginning of first crop and the observationswere recorded at 45th Day After Pruning (DAP), the pooled data of five crops were analyzed.Main plot include two different types of hydrogels *viz.*, Pusa hydrogel (T_1- Pusa hydrogel @ 1kg/ac, T_2- Pusa hydrogel @ 2 kg/ac, T_3- Pusa hydrogel @ 3 kg/ac and T_4- Pusa hydrogel @ 4kg/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-control without hydrogel.The biochemical composition of leaf *viz*., total chlorophyll (2.59 mgg^{-1}), protein (20.32%),carbohydrates (20.29%), crude fibre (12.13%), fat (1.12%) and ash contents (9.54%) werefoundhighest in thetreatment which received Zebahydrogel @ 6 kg/ac.

Keywords:V_1TreeMulberry,SensorbasedIrrigation,Hydrogels, Leafnutrientstatus.

INTRODUCTION

"Mulberry foliage is the sole food for the silkworm (*Bombyx mori.* L). As mulberrybelongs to genus *Morus* is a perennial crop can be maintained for many years, selection ofland, recommended package of practices and water management are the primary factors forproducing quality leaves. Among these, irrigation water plays a significant role as one of thekey input in mulberry cultivation. The quality of mulberry leaves is critical to the performanceand determines its economics for the farmers. Moisture content in mulberry leaves improvesingestion,digestionandalsotheconversionofnutrientsinsilkworm.Watercontentinmulberryleavesisconsideredasoneofthecriteriainestimatingtheleafquality.Theimprovement of leaf quality and the productivity of leaves is immediately required for thesustainabilityof cocoon crops" (Seenappaand Devakumar, 2015).

At present, about 95.0 per cent of the mulberry region is under the irrigated conditionand borewell water is a common source of irrigation in South Indi. With change in climaticscenario,thewateravailabilityisgettingscarcedaybydayduetoquickgroundwaterdepletion whichoftenconstrainsthefarmerstoirrigatetheirmulberrygardensasperrequirements. In the soil-plant system, water is essential for the delivery of nutrients throughout the plant, serves as a solvent in biochemical reactions, distributes solutes, regulates temperature, and provides hydrogen for photosynthesis.

Among all the agronomic inputs, for the quantity and quality of mulberry leaf irrigationwaterpossesshighestimpact.Insensor-baseddripirrigationsystem,waterisappliedatfrequent intervals over the soil to irrigate a limited area around the plant and the soil moisturesensors can be connected to an existing irrigation system controller. Before a planned watering event, the sensor determines the amount of moisture in the root zone of the soil. If the soil moisture is higher than a certain threshold, the cycle is skipped. According to Hanson and Orloff's (2002) investigation, the sensors' placement at different places in the root zone helps determine whether irrigation is appropriate and how deep to apply it.

"Mulberryrequiresabout1.5-2.0acreinchesofwaterperirrigationatanintervalof6-12 days depending upon the type of soil and seasons. About eight numbers of irrigation isrequired per crop of 65-70 days duration to achieve the maximum leaf yield. Thus the annualrequirement of irrigation water for five crops is about 75 acre inches of water equal to 1875mmrainfalldistributedequally@36mmperweekor5-6mmperday.However,80percent of average annual rainfall of 1,160 mm is received in 4-5 months in our country" (Lal, 2001;Guptaand Deshpande, 2004).

"Hydrogelsarealsocalledashydrophilicgelsorsuperabsorbentpolymersarecategorised into different groups, such as naturally occurring, semi-synthetic or synthetic. Mostof these polymers can retain 332-465 times water to its weight and release it slowly duringdrought under light soil" (Dehkordi, 2016)."Hydrogels are subjected toswellingdue to itshydrophilic nature on coming in contact with water and release nearly 95 per cent of storedwater available for crop absorption. The process of retaining water and releasing the same bysuper absorbent gels may last for two to five years depending on the soil environment andcultivation process. Conclusively, it decomposes into CO2, water, ammonia, and potassium ions over time without leaving any trace, making it environmentally benign (Trenkel, 1997). By enhancing soil permeability, compaction, infiltration rate, bulk density, porosity, and other factors, hydrogels also serve as soil conditioners or ameliorants.

"When the super absorbent hydrogel polymers are incorporated in moist soil, it becomesswollen after absorbing and storing a large quantity of water and nutrients within a short periodandallowstheabsorbedwaterandnutrientswithinitslowlytothesoil,mitigatingthewaterandnutrientrequirementsof the plant especiallyduringthe drought stresscondition.Thepeculiar water-nutrient reservoir and lending characteristics of the hydrogel polymers for thesoil-plant system have been widely applied in the agricultural domain for substantial water andnutrientsaving and ecological restoration"(Li*etal.*, 2014).

MATERIALANDMETHODS

The experiment was conducted during 2022-23 in well-established V1 tree mulberrygarden at L- Block, IFS Demonstration Unit, University of Agricultural Sciences, GandhiKrishi Vigyan Kendra, Bengaluru. The field is located at a latitude of 12°58′ N and longitudeof 77°35′ East and at an altitude of 930 m above mean sea level in the Eastern Dry Zone(Zone-5)ofKarnataka.ThetreatmentswereplannedinaccordancewithregularrecommendeddosageofPusahydrogelis1-2.5kgperacreandZebahydrogelis5kgperacre, in view that to access hydrogels at varied dosages. The experiment was established withnine treatment combinations *viz.,* Pusa hydrogel (T_1- Pusa hydrogel @ 1 kg/ac, T_2- Pusahydrogel @ 2 kg/ac, T_3- Pusa hydrogel @ 3 kg/ac and T_4- Pusa hydrogel @ 4 kg/ac) and Zebahydrogel (T_5- Zeba hydrogel @ 3 kg/ac, T_6- Zeba hydrogel @ 4 kg/ac, T_7- Zeba hydrogel @ 5kg/ac and T_8- Zeba hydrogel @ 6 kg/ac)and

T_9-control without hydrogel, were laid out inRCBDdesign with threereplications.

Hydrogelswereappliedattherootzoneofthetreemulberryimmediatelyafterpruning. Irrigation was allowed at 50 per cent DASM (Depletion of available soil moisture).All the other practices of mulberry cultivation followed as per standard package of practices(Dandin and Giridhar, 2014). Observations recorded at regular intervals till 60th day afterpruning (DAP). The data on leaf parameters at 45th DAP of mulberry crop were recorded ineach treatment on randomly selected five plants from each net plot and mean value wasworkedout.Theexperimentaldatacollectedongrowthcomponentsofplantweresubjectedto Fisher's method of Analysis of Variance (ANOVA) as outlined by Panse and Sukhatme(1967).

Estimationofbiochemicalparametersinmulberryleaf

Quality parameters of mulberry leaf such as total chlorophyll, total carbohydrates,proteins, crude fibre, fat and ash contents of the leaf wereestimated at 45 days after treatmentimposition in each crop (total five crops) and the pooled data is presented in the experimentalresults.

Chlorophyllestimation

The content of chlorophyll in mulberry leaf was calculated by following proceduredefined by Hiscox and Isrealstam (1979). The total leaf chlorophyll content was determinedusingthe formulaproposed by Arnon(1949).

$$\text{Totalchlorophyll (mg/g)freshweight} = \frac{20.2(\text{O.D.}645)+8.02(\text{O.D.}663)\times\text{Volume}}{1000\text{gweight ofleaves}}$$

Estimationofcrudeprotein

Protein content of the leaf was assessed after determining the total nitrogen contentinthe leaf (0.5 g leaf sample) using Macro-Kjeldhal method. The protein content of the leafwascomputed by multiplying the per cent nitrogen of the sample with the factor 6.25 (A.O.A.C.,1980).

Crudeprotein (%)=N(%)x6.25

Estimationoftotalcarbohydrate

Totalcarbohydrateofmulberryleafwasestimatedbyfollowingthemethodof(Dubois*etal*.,1956)usingglucoseasstandard.Thetotalanthronepositivesubstanceswere expressedasmgofcarbohydrate/g dryweightofleafsample.

Estimationofcrudefibrein plantsample

The crude fibre of the sample was estimated by taking 2g sample with ether orpetroleumetherandboiled(initialboilingtemperatureof35-38°Candfinaltemperatureof52 °C). Then 200 ml of sulphuric acid was added and boiled for 30 min. Filtered throughmuslinclothandwashed withboilingwateruntilwashingswerefreeofacid.Again,boiledtheresiduewith 200 ml of sodium hydroxide for 30 min. Filtered thorough muslin cloth, again washedwith 25 ml of boiling sulphuric acid, three 50 ml portions of water and 25 mlof alcohol. Theresidue was removed and transferred to pre-weighed ashing crucible (W1, g). The residue wasdriedfor2hr at130°C,cooledinadesiccatorandweighed(W2,g),Ignitedfor30minsat600 °C and then cooled in a desiccator and reweighed (W3, g). The fibre content of sample wascalculatedby:

$$\text{CrudeFibre}(\%) = \frac{(W2-W1)-(W3-W1)}{\text{weight ofthesample(g)}} \times 100$$

Estimationofash(%)

Theashcontentinselectedleavesofmulberrywereestimatedbyadoptingbyusing A.O.A.C(1980)methodandexpressedinpercentage.

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RESULTSANDDISCUSSION

Totalchlorophyll(mgg^{-1})

Application of differentlevels of hydrogels to tree mulberry exhibited significantinfluence in the chlorophyll content of leaf estimated on 45th day after hydrogel application.Maximum chlorophyll content (2.59 mg/g) was recorded in mulberry leaf raised with Zebahydrogel @ 6 kg ac^{-1}, which was on par with that of T_7 (2.52 mg/g) and T_6 (2.46 mg/g).Whereas, minimum total chlorophyll content (1.83 mg/g) was recorded in leaves harvestedfrommulberrytreeraisedwithoutanyhydrogelapplication(T_9),whichwasonparwithT_1

(2.02 mg/g). The enhancement in chlorophyll content in mulberry leaves might be due to byproviding a conducive environment for water retention and nutrient absorption by hydrogels.They act as a water reservoir, ensuring a consistent and optimum moisture level for plantgrowth. Additionally, hydrogels can improve soil structure, promoting root development andoverall plant health, leading to increased chlorophyll production in leaves. The present resultsare in close agreement with the findings of Singhal *et al*. (1999) reported that nitrogen is anessential constituent of chlorophyll, nitrogen harvests solar energy and aids in the synthesis ofchlorophyll. Photosynthetic efficiency is indicated by the increased amount of chlorophyllcontentinleaves;thus,itcanbeusedasoneofthecriteriaforphotosyntheticratequantification in mulberry (Sujathamma and Dandin, 2000). Nalborczyk*et al*. (1994) reportedthatthenitrogenfertilizerapplicationaffectschlorophyllcontentinplants.

Janardhan *et al*. (2008) reported that more amount of nitrogen (614 kg/ha) combinedwith recommended dose of farm yard manure and fertilizers compared to other treatments (0to250 kg ha^{-1}) lead to more chlorophyll content and higher mulberry leaf yield. The enhancedcarbohydrate status also may be attributed to higher photosynthetic efficiency due to presenceof higher chlorophyll levels (Ramachandra *et al*., 2008).The applicationof hydrogel avoidsthestressofhumidityfluctuationsandprotectsthedurabilityofchlorophyll.Instressconditions the protection of durability of chlorophyll by super absorbent polymer materialswereshownin sunflower(Nazarli *et al*., 2010)and corn(Khadem*et al.*, 2010).

Kargar *et al*. (2017) reported that addition of 0.5 per cent hydrogel to potting mediaofSiberianelm(*Ulmuspumila*)andsilvermaple(*Acersaccharium*)hadsignificantinfluenceonchlorophyllconcentrationby improvingphotosyntheticactivitiesovercontrol.

Protein(%)

The current results revealed significant variations with respect to protein content oftreemulberry leaf. Higher protein content (20.32 %) was found in the leaves obtained fromthetreatment T_8 (Zeba hydrogel @ 6 kg ac^{-1}) which was on par with that of T_7 (Zeba hydrogel @5 kg ac^{-1}) (20.07 %),T_6(Zeba hydrogel @ 4 kg ac^{-1})(19.75 %) andT_4 (Pusa hydrogel @ 4kg ac^{-1}) (19.51%). The lowest protein content was registered in leaves harvested from the treemulberry without hydrogel application T_9(17.75%). Hydrogels can help plants withstandstress. When plants are less stressed, they can allocate more resources to metabolic processeslikeprotein synthesis.

The findings at CSR&TI, Mysore indicated that application of higher dose of nitrogen incombination with phosphorous and potassiumincreased the crude protein content in mulberryleaf from 15 to 23 per cent (Anon., 1976). It was also reported that irrigation withholdingconditions with hydrogel at different growth stages increased protein percentage in soyabean(Ashkiani*etal*., 2013).

Hafiz *et al.* (2014) reported on the impact of hydrogels in potato (*Solanum tuberosum*L.) and concluded that the protein content (3.46 µg) was recorded in the treatment withapplication of hydrogel (80 mg Hydrogel / treatment (two doses) + NPK (250:150:150 per ha)which was followed by the application of hydrogel(40 mg Hydrogel/treatment (one dose) +NPK (250:150:150 per ha) which recorded (3.40 µg) over the control which reported lesserattributes(3.06 µg) and thesearein conformitywith present findings.

Carbohydrate(%)

Thecarbohydratecontentinleaveswasnon-significantwithvariouslevelsofhydrogelapplication.Therelativelyhighercarbohydratecontentof20.29percentwasrecorded in tree mulberry leaves harvested raised with the application of Zeba hydrogel @ 6kg ac^{-1}followed by T_7 (Zeba hydrogel @ 5 kg ac^{-1}) (19.84 %). The lowest carbohydratecontent(18.13%)wasobservedintheleavesobtainedfromtheplantsraisedwithouthydrogelapplicationT_9.Hydrogelsmightprobablypromotesustainedphotosyntheticactivitybyenhancingwaterretentionleading toincreasedcarbohydrate synthesisinmulberry leaves.

Rajanna *et al.* (2000) reported that mulberryraised with recommended NPKhadsignificantlyhighertotalsolublecarbohydrates(17.61%)andcrudeproteincontent(17.89 %). Similarly, Suresha (2004) opined that the treatment of nitrogen and potassium(300:200kg/h/yr)recordedhigherbiochemicalconstituentsinmulberryleafwhichindicatedasignificantdifferenceintotal solubleprotein,total reducingsugarsandtotalchlorophyll.

Crudefibre(%)

Significant variation was noticed among different treatments with regard to crude fibrecontent of leaf harvested from tree mulberry on 45th day after hydrogel application and wassignificantly higher in leaves from the plot that received Zeba hydrogel @ 6 kg ac^{-1}(12.13 %)which was on par with that of T7 (Zeba hydrogel @ 5 kg ac^{-1}) (11.70 %) and T6(Zebahydrogel@4kgac^{-1})(11.30%).However,thelowestcrudefibercontent(9.85%)was registeredintheleavesobtainedfromthetreatmentT_9(control).

Fat(%)

The results revealed significant variations with respect to fat content of tree mulberryleaf. Higher fat content (1.12 %) was found in the leaves obtained fromthe treatment T_8(Zebahydrogel @ 6 kg ac^{-1}) which was on par with that of T_7 (Zeba hydrogel @ 5 kg ac^{-1}) (0.89 %),T_6 (Zeba hydrogel @ 4 kg ac^{-1}) (0.85 %) and T_4(Pusa hydrogel @ 4 kg ac^{-1}) (0.83 %). Thelowest fat content (0.74 %) was registered in leaves harvested from the plants raised withouthydrogelapplicationT_9.

Fertilizers provide essential nutrients for plant growth, including proteins, fats, ash,fibre, and carbohydrates. When hydrogels are combined with fertilizers, they can help controlthe release of these nutrients. This controlled release ensures that nutrients are available to theplants over an extended period, reducing the risk of nutrient leaching and waste. This steadynutrient supply can support the synthesis of proteins, fats, and carbohydrates in plant tissues.Hydrogels can minimize nutrient runoff, as they can retain water and nutrients in the rootzone, preventing them from being washed away by rain or irrigation. This helps the plant totake up more of the applied nutrients, which can lead to improved biochemical contents in theleaves(Bai*et al*. 2010).

Ash(%)

Theashcontentinleavesvariedsignificantlyduetovariouslevelsofhydrogelapplication. Significantly higher ash content of 9.54 per cent was recorded in leaves harvestedfrom tree mulberry raised with the application ofZeba hydrogel @ 6 kgac^{-1}, which was onpar with T_7 (Zeba hydrogel @ 5 kg/ac) (9.26 %). The lowest ash content (7.28 %) wasobservedintheleavesobtainedfromthetreesraisedwithouthydrogel applicationT_9.

Table1:Biochemicalconstituentsintreemulberryleavesasinfluencedbyhydrogelsundersensorbased irrigation

Treatments	Totalchlorophyll (mgg^{-1})	Protein (%)	Carbohydrate (%)	Crude fibre(%)	Fatcontent(%)	Ashcontent(%)
T_1	2.02	18.25	18.29	10.16	0.75	7.85
T_2	2.11	18.56	18.76	10.26	0.78	7.96

T_3	2.25	19.00	18.99	10.49	0.80	8.16
T_4	2.38	19.51	19.15	10.87	0.83	8.50
T_5	2.29	19.23	19.08	10.63	0.81	8.32
T_6	2.46	19.75	19.53	11.30	0.85	8.89
T_7	2.52	20.07	19.84	11.70	0.89	9.26
T_8	2.59	20.32	20.29	12.13	1.12	9.54
T_9	1.83	17.75	18.13	9.85	0.74	7.28
F-test	*	*	**NS**	*	*	*
S. Em±	0.07	0.35	0.52	0.48	0.03	0.29
$CD_{0.05}$	0.21	1.01	-	1.41	0.09	0.84
CV	7.31	4.09	6.07	10.08	9.10	7.76

The quality of leaf is dependent on its biochemical contents. Nitrogen is a majorcomponent of amino acids, the building blocks of proteins. Nitrogen deficiency reduces theprotein and water content of the leaves, thereby reducing the nutritive value of the leaves.Phosphorus helps in early root development and growth of plants. It is constituent of manycompounds in plants such as nucleic acids, phospholipids, coenzymes, NAD,NAPDandATP. It has close relationship with the metabolism of fats and carbohydrates, synthesis ofproteins,respiration, photosynthesisand other metabolicactivities (Shankar,1997).

CONCLUSION

It can be concluded that climate change affected the distribution of rainfall affecting the plantgrowth due to unavailability of moisture andnutrientsduring critical stages, especially in drylandareas.Hence,thereisaneedtocultivatecropswithgoodagriculturalpractices.Applicationofhydrogelincreasesmaximumwaterholdingcapacity,preventrunoffandevaporationlossofwaterfromthesoil.Besides,lossofnutrientthroughleachingandvolatilizationcanbepreventedwhichintermplantsarebenefitedfortheirgrowthanddevelopment.

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