

EFFICACY OF HYDROGELS UNDER SENSOR BASED IRRIGATION ON SOIL NUTRIENT STATUS OF TREE MULBERRY

Comment [H1]: You can remove

ABSTRACT

A field experiment was carried out to study the efficacy of hydrogels under sensor-based irrigation on soil nutrient status of tree mulberry during 2022-23. The experiment was laid out in Randomized Complete Block Design (RCBD) with nine treatment combinations and three replications, observations were recorded at 30th, 45th and 60th Days after Pruning (DAP) and pooled data of five crops were analyzed. The hydrogels were applied during beginning of first crop. Main plot included two different types of hydrogels viz., Pusa hydrogel (T₁- Pusa hydrogel @ 1 kg/ac, T₂- Pusa hydrogel @ 2 kg/ac, T₃- Pusa hydrogel @ 3 kg/ac and T₄- Pusa hydrogel @ 4 kg/ac) and Zeba hydrogel (T₅- Zeba hydrogel @ 3 kg/ac, T₆- Zeba hydrogel @ 4 kg/ac, T₇- Zeba hydrogel @ 5 kg/ac, and T₈- Zeba hydrogel @ 6 kg/ac) and T₉- control without any hydrogel. Among hydrogels, Zeba hydrogel @ 5 & 6 kg/ac (T₇ and T₈) exhibited ideal pH (6.73), EC (0.27 d Sm⁻¹) and OC (0.43 %). The major nutrients viz Nitrogen, Phosphorus and Potassium (282.03, 40.78 and 231.35 kg/ha) and secondary nutrients viz Calcium, Magnesium and Sulphur (2.87 c. mol/kg, 2.32 c. mol/kg and 7.68 mg/kg) has recorded significantly on the application of Zeba hydrogel @ 6 kg/ac. The micronutrient content was significantly higher in soil collected from T₈ which received Zeba hydrogel @ 6 kg/ac with Zn, Fe, Cu and Mn of 2.50, 20.97, 3.80 and 23.78 mg/kg respectively,

Keywords: Tree Mulberry, Sensor based Irrigation, Hydrogels, Soil nutrient status.

Comment [H2]: You can remove

INTRODUCTION

Mulberry foliage is the sole food for the silkworm (*Bombyx mori*, L.) is a perennial crop which can be maintained for many years and following the recommended package of practices and water management are the imperial factors for producing quality leaf. The quality of mulberry leaves is critical to the sericulture industry's performance as it determines the economics. Moisture content in mulberry leaves improves ingestion, digestion and also the conversion of nutrients in silkworm, and provide the maximum output. Water content in mulberry leaves is considered as one of the criteria in estimating the leaf quality. The improvement of leaf quality and the productivity of leaves is immediately required for the sustainability of cocoon crops (Seenappa and Devakumar, 2015).

In Karnataka, about 95.0 percent of the mulberry gardens are under the irrigated condition, even though borewell water is a common source of irrigation, its availability is getting scarce day by day due to quick groundwater depletion which often leads to the difficulty to irrigate their mulberry gardens according to the requirements. Water in the soil-plants system is a necessary medium for the distribution of nutrients through the plant, works as a solvent for biochemical reactions, represents a medium of distribution for solutes and helps in temperature regulation as well as a source of hydrogen in photosynthesis (Anon., 2018).

Comment [H3]: Please add references

Among all the agronomic inputs, irrigation water has highest impact on mulberry leaf quantity and quality. In sensor-based drip irrigation system, water is applied at frequent intervals over the soil to irrigate a limited area around the plant. Soil moisture sensors can be connected to the existing irrigation system controller. The sensor measures the soil moisture content in the targeted root zone before scheduled irrigation event and bypasses the cycle if the soil moisture is above the specific threshold. Hanson and Orloff (2002), examined that when the sensors are in the root zone at various points they aid in determining the acceptability of irrigation and actual depth of irrigation to be given.

Comment [H4]: Add references

Mulberry requires about 1.5-2.0 acre inches of water per irrigation at an interval of 6-12 days depending upon the type of soil and seasons. About eight numbers of irrigations are required per crop of 65-70 days' duration to achieve the maximum leaf yield. Thus counting the annual requirement of irrigation water for five crops is about 75 acre inches of

waterequalto1875mmrainfalldistributedequally@36mmperweekor5-
6mmperday.But80percent

UNDER PEER REVIEW

of average annual rainfall of 1,160 mm is received in 4-5 months in our country (Lal, 2001; Gupta and Deshpande, 2004).

Hydrogels are also called as hydrophilic gels or super absorbent polymers and they are categorized into different groups, such as naturally occurring, semi-synthetic or synthetic. Most of these polymers can retain 332-465 times of water to its weight and release them slowly during stress under soil (Dehkordi, 2016). Hydrogels are subjected to swelling due to its hydrophilic nature on coming in contact with water and release nearly 95 per cent of stored water available for crop absorption. The process of retaining water and releasing the same by super absorbent gels may last for two to five years depending on the soil environment and cultivation process. However, ultimately in due course of time, they break down into CO₂, water, ammonia and potassium ions without any residue, thus making it environment friendly (Trenkel, 1997). Hydrogels also act as soil ameliorant or conditioner by improving porosity, bulk density, soil permeability, compaction, infiltration rate, etc.

When the superabsorbent hydrogel polymers are incorporated in moist soil, it becomes swollen after absorbing and storing a large quantity of water and nutrients within a short period, and allows the absorbed water and nutrients within it slowly to the soil, mitigating the water and nutrient requirements of the plant especially when the drought stress condition around the root zone periphery prevails. The peculiar water-nutrient reservoir and lending characteristics of the hydrogel polymers for the soil-plant system have been widely applied in the agricultural domain for substantial water and nutrient saving and ecological restoration (Li et al., 2013).

MATERIAL AND METHODS

The experiment was conducted during 2022-23 in well-established V1 tree mulberry garden at IFS demonstration plot, AICRP- Agroforestry Unit, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru. The field is located at latitude of 12°58'N, and longitude of 77°35'E and at an altitude of 930 m above mean sea level in the Eastern Dry Zone (Zone-5) of Karnataka. For all other perennial crops, the recommended dosage of Pusa hydrogel is 1-2.5 kg per acre (<https://vikaspedia.in/agriculture/crop-production/advanced-technologies/applications-of-super-absorbent-polymers-in-agriculture>) and Zeba hydrogel is 5 kg per (<https://www.upltd.com/in/crop-protection/water->

Comment [H5]: Add full name

conservation/zeba).Basedonthat,theexperimentwasestablishedwithninetreatmentcombinations viz.,Pusahydrogel(T₁-Pusahydrogel@1kg/ac,T₂-Pusahydrogel@2kg/ac,T₃-Pusahydrogel@3kg/acandT₄-Pusahydrogel@4kg/ac)andZebahydrogel(T₅-

UNDER PEER REVIEW

Zebahydrogel@3kg/ac, T₆-Zebahydrogel@ 4kg/ac, T₇-Zebahydrogel@5kg/ac and T₈-Zebahydrogel@6kg/ac) and T₉-control without hydrogel, were laid out in RCBD design with three replications.

Hydrogels are applied at the root zone of the tree mulberry immediately after pruning. 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 (Dandin and Giridhar, 2014). Observations recorded at regular interval still 60th day after pruning.

Soil moisture content in the soil was measured by using soil moisture indicator, moisture probe meter and single point sensors. 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 cloud to monitor the water stored in the soil outside the area (Li *et al.*, 2020).

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 as given in Table 1 (<https://sugarcane.icar.gov.in/index.php/soil-moisture-indicator/>).

Table 1: Indicator readings and soil moisture status

Colour of LED	Soil moisture percentage	Soil moisture status	Inference
Blue	75-100%	Ample moisture	No need of irrigation
Green	50%	Sufficient moisture	Immediate irrigation not required
Yellow	25%	Low moisture	Irrigation advisable
Red	<25%	Very low moisture	Immediate irrigation necessary

The data on growth parameters at 30th, 45th and 60th DAP of mulberry crop were recorded in each treatment on randomly selected five plants from each net plot and mean value was worked out. The experimental data collected on growth components of plant were subjected to Fisher's method of Analysis of Variance (ANOVA) as outlined by Panse and Sukhatme (1967).

Estimation of chemical properties of soil

The chemical properties in soil and plant were determined by following the standard procedure as follows

List 1. Chemical properties in soil and plant

Parameters

Methods

References

UNDER PEER REVIEW

Soil analysis		
pH(1:2.5)	Potentiometric method	Jackson(1973)
EC (dS m ⁻¹)	Conductometric method	Jackson(1973)
Organic carbon(%)	Wet oxidation method	Walkley and Black(1934)
Available N(kg ha ⁻¹)	Alkaline permanganate method	Subbiah and Asija(1956)
Available P ₂ O ₅ (kg ha ⁻¹)	Olsen's Method	Jackson(1973)
Available K ₂ O(kg ha ⁻¹)	Flame photometer Method	Jackson(1973)
Exchangeable Ca(c.mol/kg)	Versenate titration Method	Jackson(1973)
Exchangeable Mg(c.mol/kg)	Versenate titration Method	Jackson(1973)
Available S(mg kg ⁻¹)	Turbidometric Method	Black(1965)
DTPA extractable Fe, Mn, Zn and Cu (mg kg ⁻¹)	Atomic absorption spectro photometry	Lindsay and Norwell(1978)

Soil pH and Electrical conductivity

Soil pH was estimated in 1:2.5 soil water-suspension, using pH meter (Jackson, 1973). The clear supernatant of the soil water suspension was removed and the Electrical conductivity (EC) was measured using conductivity bridge (Jackson, 1973).

Soil organic carbon

The wet oxidation process was used to estimate soil organic carbon (Walkley and Black, 1934).

Available nitrogen

Soil of 5 g was distilled with 25 ml of 0.1N KMnO₄ and 25 ml of 2.5 per cent NaOH. During distillation the ammonia released was trapped in 4 percent boric acid containing mixed indicator and titrated against standard H₂SO₄ and the available nitrogen was expressed in kg/ha (Subbiah and Asija, 1956).

Available phosphorus

The available phosphorus present in the soil was extracted with Olsen's reagent. The extracted phosphorus content was then estimated by Ascorbic acid reduced blue color method. The intensity of blue color was read in spectrophotometer (Jackson, 1973).

Available potassium

The available potassium in the soil was extracted with neutral normal ammonium acetate solution and was estimated using flame photometer as described by (Jackson, 1973).

Secondary nutrients

Calcium and magnesium were determined by the EDTA titration or Versenate-titration method (Jackson 1973). Sulphur content in the di acid digested sample was estimated by turbidometric method as outlined by Black (1965).

DTPA extractable micronutrients

The content of Zn, Fe, Cu, and Mn determined by using atomic absorption spectrophotometer with appropriate hollow cathode lamps (Lindsey and Norwell, 1978).

RESULTS AND DISCUSSION

Soil pH

Soil pH was measured in tre mulberry garden after the completion of experiment. There was no significant difference among the treatments. However, lower pH (6.72) was observed in T₇ and T₈ among the treatment which received Zeba hydrogel @ 5 & 6 kg/ac, followed by T₆ (6.73) and highest pH (7.80) was recorded in control plot (T₉) (Table 2). Trung *et al.* (2009) found that pH was unchanged in composted pine bark amended with PAG, but was reduced by UFRF (urea-formaldehyde resin foam) alone and UFRF plus PAG (Artificial polyacrylamide gel). The addition of FYM and integrated use of FYM with chemical fertilizers resulted in significantly higher organic carbon accumulation over inorganic fertilizers alone after harvest of maize in an alfisol (Kumari *et al.*, 2013), which could be correlated to the present

findings.

UNDER PEER REVIEW

Soil EC (dSm⁻¹)

Significantly higher EC (0.27 dS m⁻¹) was observed in T₈ (Zeba hydrogel @ 6kg/ac) and T₇ (Zeba hydrogel @ kg/ac), whereas, the value was also on par with that of T₆ (0.26 dSm⁻¹), T₄ (0.26 dSm⁻¹) and T₅ (0.25 dS m⁻¹). The lowest EC (0.25 dS m⁻¹) was found in Control (T₉) (Table 2). The increase in EC (dSm⁻¹) might be due to increased amount of K application which might have accounted for more K⁺ ions in solution. The increase in electrical conductivity of soil with the increase in N and K fertigation levels was reported also by Goha and Malkout (1992). Khanday and Ali (2012), revealed that amongst interactions S1F1 (flood irrigation + soil application of the 100 % NPK) and S2F1 (drip irrigation + soil application of 100 % NPK) resulted in the highest pH in surface and sub-surface soils, respectively. S2F4 (drip irrigation + soil application of 150% NPK) and S1F6 (flood irrigation + biofertilizer and FYM) resulted in the highest EC in 0-15 and 15-30 cm. A similar effect on CEC in the surface and sub-surface soil was shown by S2F4 (drip irrigation + soil application of 150% NPK) and S3F4 (drip Fertigation with 150% NPK + FYM) respectively. Here also the availability of more moisture in several treatments resulted in good EC, which means usage of hydrogels has succeeded in maintaining good EC at the applied soil.

Organic carbon (%)

Organic carbon content in soil at the completion of the experiment in tree mulberry garden was significantly higher in T₈ and T₇ (0.43 %) which received Zeba hydrogel @ 5 & 6 kg/ac. However, significantly lower organic carbon (0.42 %) content was found in control (T₁) (Table 2). The addition of FYM and its integrated usage with chemical fertilizers have resulted in significantly higher organic carbon accumulation over inorganic fertilizers alone after harvest of maize in an alfisol was reported by Kumari *et al.*, (2013). Also, the results were on par with findings of Pandey and Awasthi (2014) and they reported highest organic content with the application of RDF (120:60:40 NPK kg ha⁻¹) + FYM 10 t ha⁻¹ in maize. The present results also expressed the similar trend. Organic carbon content of soil after harvest of pearl millet increased significantly with 100% RDF + Azotobacter + PSB or 50% RDF + 5t FYM + Azotobacter + PSB (Jakhare *et al.*, 2018).

Table 2: Efficacy of hydrogels under sensor-based irrigation on soil properties

Treatments	pH	EC (dSm ⁻¹)	OC (%)
------------	----	-------------------------	--------

Before Experiment	6.80	0.25	0.42
T₁	6.78	0.25	0.42
T₂	6.76	0.25	0.42
T₃	6.75	0.25	0.42
T₄	6.73	0.26	0.43
T₅	6.73	0.25	0.42
T₆	6.73	0.26	0.43
T₇	6.72	0.27	0.43
T₈	6.72	0.27	0.43
T₉	6.80	0.25	0.42
F test	NS	NS	NS
S E m±	0.03	0.05	0.02
CD@5%	-	-	-
CV%	3.02	4.44	4.68

Primary nutrient (N,P,K) content in soil after the experiment

After applied with different levels of hydrogels and completion of the experiments significantly higher soil nitrogen (282.03 kg/ha) content was found in T₈ which received Zeba hydrogel @ 6 kg/ac which was on par with that of T₇ (Zeba hydrogel @ 5 kg/ac) (281.92 kg/ha) and T₆ (Zeba hydrogel @ 4 kg/ac) (280.70 kg/ha), whereas, lowest nitrogen (278.87 kg/ha) was found in control (T₉) (Table 3). Significantly higher soil phosphorus (40.78 kg/ha) content was found in T₈ (Zeba hydrogel @ 6 kg/ac) which was on par with that of T₇ (Zeba hydrogel @ 5 kg/ac) (39.74 kg/ha), T₆ (Zeba hydrogel @ 4 kg/ac) (38.32 kg/ha) and T₄ (Pusa hydrogel @ 4 kg/ac) (38.24 kg/ha). Whereas, lowest soil phosphorus (37.02 kg/ha) was found in control (T₉). Significantly higher soil potassium (231.35 kg/ha) content was found in T₈ (Zeba hydrogel @ 6 kg/ac) which was on par with that of T₇ (Zeba hydrogel @ 5 kg/ac) (230.98 kg/ha), T₆ (Zeba hydrogel @ 4 kg/ac) (230.49 kg/ha) and T₄ (Pusa hydrogel @ 4 kg/ac) (230.11 kg/ha). Whereas, lowest soil phosphorus (227.04 kg/ha) was found in control plot (T₉) which was on par with that of T₁ (Pusa hydrogel @ 1 kg/ac) (227.16 kg/ha) and T₂ (Pusa hydrogel @ 2 kg/ac) (227.80 kg/ha). El-Hady and El-Dewiny, (2006) stated that soil

conditioning can improve the retentivity of NPK and keep them in available forms for growing plants. Liu *et al.* (2007) expressed that superabsorbents slow release nitrogen fertilizer (SSRNF) exhibits good slow release properties and also possess excellent soil moisture preservation capacity, which could effectively improve the utilization of fertilizer and water resources in *Pinus pinaster*. Karimi *et al.* (2008) observed that by using Igita, a Japan-made super absorbent, nutrient (NPK) uptake was increased by plants and also the possession of these elements in clay, loamy and sandy soil was in the amounts of 0.05, 0.1 and 0.3 percent, respectively. In corn, Seyed *et al.* (2010) reported that potassium was increased by 21 percent and 17.6 percent by the application of 35 percent manure with 65 percent of superabsorbent polymer and 65 per cent manure with 35 per cent super absorbent polymer, respectively compared to control, which supports the present investigation. In *Pennisetum glaucum*, Leila *et al.* (2012) reported application of zeolite increased the nitrogen content significantly (0.05 %) as compare to control (0.042 %) by preventing from its leaching. Dabhi *et al.* (2013) reported that superabsorbent polymers influenced optimum use of fertilizers in cash crops in arid and semi-arid regions. The soil organic C, available N, P and K were significantly influenced due to different treatments. The favourable soil conditions might have helped in the mineralization of soil N leading to its higher build-up in different treatments. An increase in available P might be due to release of organic acids viz. maleic and citric acid on decomposition of organic manures which helps in solubilization of unavailable P. An increase in available K due to the addition of organic manures may be ascribed to the reduction of K fixation and release of K due to interaction of organic matter with clays, besides the direct K addition to the soil (Hazarika and Boris, 2019). Incorporation of FYM along with fertilizers enhanced the available N content in post-harvest soil as compared to control. Increase in available N may be attributed to mineralization of FYM (Chandel *et al.*, 2014), which was also confirmed in the present study. The polymer functions in absorption and desorption cycles of water and nutrients. Application of zeba gel @ 37.5 kg ha⁻¹ in tomato was resulted in enhancing nutrient NPK use efficiency (70.2, 11.8 and 76.1% respectively). Due to hydrogel application the nutrient and water holding capacity of soils and growing media is kept in optimal conditions (Jeevan *et al.*, 2023). The trend of the present results follows in similar way.

Table 3: Efficacy of hydrogels under sensor-based irrigation on major nutrient status in post-harvest soil

Treatments	Nitrogen(kg/ha)	Phosphorus(kg/ha)	Potassium(kg/ha)
------------	-----------------	-------------------	------------------

Before Experiment	276.36	36.26	225.35
T₁	278.07	37.09	227.16
T₂	278.62	37.33	227.80
T₃	279.14	37.91	228.54
T₄	280.38	38.24	230.11
T₅	279.54	38.12	228.96
T₆	280.70	38.32	230.49
T₇	281.92	39.74	230.98
T₈	282.03	40.78	231.35
T₉	278.87	37.02	227.04
Ftest	NS	*	NS
S.E.m±	2.72	0.07	1.19
CD@5%	-	0.20	-
CV%	2.17	5.79	1.16

Secondary nutrient (Ca, Mg and S) content in soil after the experiment

The maximum calcium (2.87 c. mol/kg) content was recorded in T₈ (Zeba hydrogel @ 6 kg/ac) among all the treatments and the value is on par with T₇ (Zeba hydrogel @ 5 kg/ac) (2.82 c. mol/kg), T₆ (Zeba hydrogel @ 4 kg/ac) (2.70 c. mol/kg) and T₄ (Pusa hydrogel @ 4 kg/ac) (2.67 c. mol/kg). Whereas, lowest soil calcium (2.38 c. mol/kg) was found in control (T₉) which was on par with that of T₁ (Pusa hydrogel @ 1 kg/ac) (2.45 %) and T₂ (Pusa hydrogel @ 2 kg/ac) (2.50 c. mol/kg). Significantly higher magnesium (2.32 c. mol/kg) content was observed in the T₈ which received Zeba hydrogel @ 6 kg/ac after 60 days after pruning of tree mulberry followed by T₇, T₆, T₄ and T₅ (2.30, 2.26, 2.23 and 2.18 c. mol/kg, respectively). However, lowest soil magnesium (1.75 c. mol/kg) was found in control plot

(T₉) which was on par with that of T₁ (Pusa hydrogel @ 1 kg/ac) (1.77 %) and T₂ (Pusa hydrogel @ 2 kg/ac) (1.97 %). The Sulphur (7.68 mg/kg) content was significantly abundant in T₈ which received Zeba hydrogel @ 6 kg/ac after 60 days after pruning of tree mulberry garden. Whereas, less Sulphur (6.06 mg/kg) content was found in control (T₉) (Table 4).

The increase in exchangeable Ca and Mg content of soil might be due to release of these nutrients from added organic sources which was confirmed even by Sanjivkumar (2014).

Comment [H6]: Please check it?

Table 4: Efficacy of hydrogels under sensor-based irrigation on secondary nutrient status in post-harvest soil

Treatments	Calcium (c.mol/kg)	Magnesium (c.mol/kg)	Sulphur (mg/kg)
Before Experiment	2.30	1.71	6.03
T ₁	2.45	1.77	6.11
T ₂	2.50	1.97	6.16
T ₃	2.56	2.06	6.20
T ₄	2.67	2.23	6.84
T ₅	2.62	2.18	6.59
T ₆	2.70	2.26	7.09
T ₇	2.82	2.30	7.15
T ₈	2.87	2.32	7.68
T ₉	2.38	1.75	6.06
F test	*	*	*
S.E.m±	0.03	0.06	0.18
CD@5%	0.11	0.09	0.54
CV%	3.30	7.15	6.32

Micronutrient(Zn,Fe,CuandMn)contentinsoilaftertheexperiment

Among all the treatments, the micronutrient content was significantly higher in soil collected from T₈ which received Zeba hydrogel @ 6kg/ac with Zn, Fe, Cu and Mn of 2.50mg/kg, 20.97mg/kg, 3.80mg/kg and 23.78mg/kg, respectively, followed by T₇ (2.21mg/kg, 20.88mg/kg, 3.74mg/kg and 22.62mg/kg), T₆ (1.96mg/kg, 20.55mg/kg, 3.61mg/kg and 21.85mg/kg), T₄ (1.77mg/kg, 20.25mg/kg, 3.56mg/kg and 21.26mg/kg) and T₅ (1.68mg/kg, 19.04mg/kg, 3.45mg/kg and 21.09mg/kg). Whereas, lowest Zn, Fe, Cu and Mn content was observed (1.46 mg/kg, 18.39 mg/kg, 3.28 mg/kg and 20.16 mg/kg) in control (T₉) which was on par with that of T₁ (1.52 mg/kg, 18.22 mg/kg, 3.35 mg/kg and 20.12 mg/kg) and T₂ (1.58mg/kg, 18.66mg/kg, 3.39mg/kg and 20.64mg/kg) on 60 days after pruning (Table 5). Ahmed *et al.* (2015) reported that addition of more concentration of hydrogels raises CEC, and thereby increases the retention of soil nutrients which corroborates even the present study. The dissolved fertilizer diffuses from the hydrogel network and releases slowly into the soil by the dynamic exchange of free water between swollen hydrogel and soil. The rate of fertilizer release increases with the increase in swelling. Eventually when the hydrogel swelling reaches equilibrium the fertilizer release rate also becomes constant (Olad *et al.*, 2018), which could be the reason for more quantum of micronutrients compared to control. Also the highest copper, boron, iron and manganese content was observed in the treatment having FYM @ 10 t ha⁻¹ + 100% RDF followed by treatment receiving FYM @ 10 t ha⁻¹ + 50% RDF (Prashaanth *et al.*, 2019).

Table 5: Efficacy of hydrogels under sensor-based irrigation on micro nutrient status in post-harvest soil

Treatments	Zn(mg/kg)	Fe(mg/kg)	Cu (mg/kg)	Mn(mg/kg)
Before Experiment	1.42	18.25	3.25	20.12
T ₁	1.52	18.42	3.35	20.23
T ₂	1.58	18.66	3.39	20.64
T ₃	1.63	18.90	3.43	20.80
T ₄	1.77	20.25	3.56	21.26

T ₅	1.68	19.04	3.45	21.09
T ₆	1.96	20.55	3.61	21.85
T ₇	2.21	20.88	3.74	22.62
T ₈	2.50	20.97	3.80	23.78
T ₉	1.46	18.39	3.28	20.16
Ftest	*	*	NS	*
S. Em±	0.07	0.45	0.33	0.60
CD@5%	0.20	1.30	-	0.85
CV%	8.87	5.14	12.03	6.35

CONCLUSION

It can be concluded that climate change affected the distribution of rainfall affecting the plant growth due to unavailability of moisture and nutrients during critical stages, especially in dryland areas. That demands to cultivate crops with good agricultural practices. Application of hydrogel enhances maximum water holding capacity, prevent runoff and evaporation loss of water from the soil. Besides, loss of nutrient through leaching and volatilization can be prevented which in turn plants are benefited for their growth and development.

REFERENCES

Ahmed, E.M., 2015, Hydrogel: Preparation, characterization, and applications: A review.

J. Adv. Res., **6**(2):105-121.

Anonymous, 2018, Annual Report. CSB, Bengaluru, pp.100.

BLACK, C.A., 1965, Methods of soil analysis part-

I: Physical and Mineralogical properties. *Agronomy Monograph Number 9*, American Society of Agronomy, Inc, Madison, Wisconsin, USA, pp.234-284.

CHANDEL, B.S., SINGH, S., SINGH, H. AND SINGH, V., 2014, Direct and residual

effect of nutrient management in wheat maize cropping sequence.

J. Indian Soc. Soil Sci., **62**(2):126-130.

DABHI, R., BHATT, N. AND PANDIT., 2013, Superabsorbent polymers an innovative

Comment [H7]: Follow the journal guidelines for references.

Comment [H8]: Chandel, B.S., Singh, S., Singh, H., and Singh, V., 2014

Please write all the references on this pattern.

- water saving technique for optimizing crop yield. *Int. J. Innovative Res. Sci. Eng. Technol.*, **2**(10): 5333-5341.
- DANDIN, S. B., AND GIRIDHAR, K., 2014, *Handbook of Sericulture Technologies*. Central Silk Board, Bangalore. P. 287.
- DEHKORDI, D. K., 2016, The effects of superabsorbent polymers on soils and plants. *Pertanika. J. Trop. Agric. Sci.*, **39**(3): 267-298.
- EL-HADY, O. A. AND WANAS, S. A., 2006, Water and fertilizer use efficiency by cucumber grown under stress on sandy soil treated with acrylamide hydrogels. *J. Appl. Sci. Res.*, **2**(12): 1293-1297.
- GOHA, K. M. AND MALKOUT, M. L., 1992, Preliminary nitrogen, phosphorus, potassium, calcium and magnesium DRIS norms indices for apple orchards in Canterbury. *New Zealand Rev. Indust. Agric.*, 49-115.
- GUPTA, S. K. AND DESHPANDE, R. D., 2004, Water for India in 2050: first-order assessment of available options. *Curr. Sci.*, **86**: 1216-1224.
- HANSON, B. AND ORLOFF, S., 2002, Monitoring soil moisture for maximum profit irrigation of alfalfa. *Proceedings, Western Alfalfa and Forage Conference*.
- HAZARIKA, T. K. AND BORIS., 2019, Soil nutrient status, yield and quality of lemon (*Citrus limon* Burm.) cv. 'Assam lemon' as influenced by bio-fertilizers, organic and inorganic fertilizers. *J. Pl. Nutr.*, **42** (8): 853-863.
- JACKSON, M. N., 1973, *Soil Chemical Analysis*. Prentice Hall of India, New Delhi, pp. 259-260.
- JAKHAR, R. R., SHEKHAWAT, P. S., YADAV, R. S., KUMAWAT, B. A. AND SINGH, A. P., 2018, Integrated nutrient management in pearl millet in north-western Rajasthan. *Ind. J. Agron.*, **63**(2): 180-184.
- JEEVAN, R. J., ANANTHAKUMAR, M. A., KADALLI, G. G., THIMME Gowda, M. N. AND ASHA, N. N., 2023, Influence of hydrogel on growth, yield and soil properties at varied moisture regimes under drip fertigation of tomato (*Solanum lycopersicum* L.). *J. Pharm. Innov.*, **12**(2): 1483-1486.
- KARIMI, A., NOUSHADI, M. AND AHMADZADEH, M., 2008, Effect of water super absorbent (Igita) amendment material on water soil, plant growth and irrigation

- intervals. *J.Sci. Tech.Agric.Naturalsour.*, **46**:403-414.
- KHANDAY,A.S.ANDALI,N.,2012,Effectofdifferentfertilizerandirrigationmanagement systems on soil physicochemical properties and pod yield of garden pea(*Pisumsativum*L.).*Annals of Horti.*, **5**(1): 34-40.
- KUMARI, G.,THAKUR,S.K.,KUMAR,N.ANDMISHRA,B.,2013,Longtermeffectof fertilizers,manureandlimeonyieldsustainabilityandsoilorganiccarbonstatusundermaize (*Zea mays*) –wheat (*Triticum aestivum*) cropping system in Alfisols. *Indi. J.Agro.*,**58**(2): 152-158.
- LAL,M.,2001,Climatechange-ImplicationsforIndia'swaterresources.*J.IndiaWaterRes. Soc.*,**21**: 101 -119.
- LEILA,K.,HASAN,F.,POORAN,O.,2012,Theeffectsofdroughtstressandsuperabsorbentpolym eronmorpho-physiologicaltraitsofpearlmillet(*Pennisetumglaucum*).*Int. Res.J. Appl. BasicSci.*, **3**(1):148-154.
- LI, X., HE, J., LIU, Y. AND ZHENG, M., 2013, Effects of super absorbent polymers on soilmicrobialpropertiesandChinesecabbage(*Brassicachinensis*)growth.*J.SoilsSedimen ts*,**13** (4): 711–719.
- LI,W.,AWAIS,M.,RU,W.,SHI,W.,AJMAL,M.,UDDIN,S.ANDLIU,C.,2020,Review of Sensor Network-Based Irrigation Systems Using IoT and RemoteSensing.*Adv. Meteorol.*,**9**:1-14.
- LINDSAY, W. L. AND NORVELL, W. A., 1978, Development of DTPA soil test for Zn,Fe,Mnand Cu. *Soil Sci.Soc. Ame. J.*,**42**: 421-428.
- LIU,F.,MA,H.,XING,S.,DU,Z.,MA,B.ANDJING,D.,2013,Effectsofsuper-absorbentpolymerondrymatteraccumulationandnutrientuptakeof*Pinuspinaster* containerseedlings. *J.For.Res.*,**18**(3):220-227.
- OLAD,A., GHAREKHANI, H., MIRMOHSENI, A. AND BYBORDI, A., 2018, Superabsorbentnanocompositebasedonmaizebranwithintegrationofwater-retainingandslow-releaseNPKfertilizer.*AdvPolym Technol.*,**37**:1682–1694.
- PANSE,V.G.ANDSUKHATME,P.V.,1967,Statisticalmethodsforagriculturalworkers. *IndianCouncil ofAgricultural Research*, NewDelhi. P.381.

- PANDEY, K.K. AND AWASTHI, A. 2014, Integrated nutrient management in the maize (*Zea mays* L.) yield and soil properties. *Int. J. Agric. Sci.*, **10**(1): 244-246.
- PRASHANTH, D.V., KRISHNAMURTHY, R., NAVEEN, D.V., MUDALAGIRIYAPPA AND BORAIHA, B., 2019, Long term effect of integrated nutrient management in soil micro nutrient status in finger millet mono-cropping system. *Indian J. Pure App. Biosci.*, **7**(4): 152-159.
- SANJIV KUMAR, V., 2014, Effect of integrated nutrient management on soil fertility and yield of maize crop (*Zea mays*) in Entic Haplustart in Tamil Nadu, India. *J. App. Natural Sci.*, **6**(1): 294-297.
- SEENAPPA, C. AND DEVAKUMAR, N., 2015, Effect of different methods and levels of irrigation and mulching on growth and yield of mulberry in eastern dry zone of Karnataka. *Mysore. J. Agri. Sci.*, **49** (2): 206-210.
- SEYED, H.K., MOHAMMAD, J.R., MUSTAFA, C., SEYED, A.K. AND ALI, K., 2010, The effects of different rates of super absorbent polymers and manure on corn nutrient uptake. *19th World Congress of Soil Science*, Soil Solutions for a Changing World 1-6 August, Brisbane, Australia.
- SUBBIAH, B. Y. AND ASIJA, G. L., 1956, A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.*, **25**: 259-260.
- TRENKEL, M.E., 1997, Controlled release and stabilized fertilizers in Agriculture. *International Fertilizer Industry Association, Paris, France*. P.76.
- TRUNG, T.N., DARYL, C., JOYCE AND SON, Q.D., 2009, Effects of artificial amendments in potting media on *Orthosiphon aristatus* growth and development. *Sci. Hort.*, **123**: 129-136.
- WALKLEY, A.J. AND BLACK, I.A., 1934, An examination of the method for determining soil organic matter and a proposed modification of the chromic acid titration method. *J. Soil Sci.*, **37**: 29-38.

UNDER PEER REVIEW