

EFFICACY OF HYDROGELS UNDER SENSOR BASED IRRIGATION ON BIOCHEMICAL CONTENTS OF TREE MULBERRY LEAVES

Abstract

The efficacy of hydrogels under sensor-based irrigation on biochemical contents of tree mulberry leaves was studied during 2022-23 and the experiment was laid out in Randomized Complete Block Design (RCBD) with nine treatment combinations and three replications. The hydrogels were applied during beginning of first crop and the observations were 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 (T₁- Pusa hydrogel @ 1kg/ac, T₂- Pusa hydrogel @ 2 kg/ac, T₃- Pusa hydrogel @ 3 kg/ac and T₄- Pusa hydrogel @ 4kg/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 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%) were found highest in the treatment which received Zeba hydrogel @ 6 kg/ac.

Keywords: V₁ Tree Mulberry, Sensor based Irrigation, Hydrogels, Leaf nutrient status.

INTRODUCTION

Mulberry foliage is the sole food for the silkworm (*Bombyx mori*. L). As mulberry belongs to genus *Morus* is a perennial crop can be maintained for many years, selection of land, recommended package of practices and water management are the primary factors for producing quality leaves. Among these, irrigation water plays a significant role as one of the key input in mulberry cultivation. The quality of mulberry leaves is critical to the performance and determines its economics for the farmers. Moisture content in mulberry leaves improves ingestion, digestion and also the conversion of nutrients in silkworm. 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).

At present, about 95.0 per cent of the mulberry region is under the irrigated condition and borewell water is a common source of irrigation in South India. With change in climatic scenario, the water availability is getting scarcer day by day due to quick groundwater depletion which often constrains the farmer to irrigate their mulberry gardens as per requirements. Water in the soil-plant system is a necessary medium for the distribution of nutrients through the plant, works as a solvent for biochemical reactions, represents as a medium of distribution for solutes and helps in temperature regulation as well as a source of hydrogen in photosynthesis.

Among all the agronomic inputs, for the quantity and quality of mulberry leaf irrigation water possess highest impact. In sensor-based drip irrigation system, water is applied at frequent intervals over the soil to irrigate a limited area around the plant and the soil moisture sensors can be connected to an existing irrigation system controller. The sensor measures the soil moisture content in the root zone before a scheduled irrigation event and bypasses the cycle if the soil moisture is above a 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.

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 irrigation is required per crop of 65-70 day duration to achieve the maximum leaf yield. Thus the annual requirement of irrigation water for five crops is about 75 acre inches of water equal to 1875 mm rainfall distributed equally @ 36 mm per week or 5-6 mm per day. However, 80 percent

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 superabsorbent polymers are categorised into different groups, such as naturally occurring, semi-synthetic or synthetic. Most of these polymers can retain 332-465 times water to its weight and release it slowly during drought under light 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 superabsorbent gels may last for two to five years depending on the soil environment and cultivation process. However, ultimately in due course of time, it breaks 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 super absorbent 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 its slowly to the soil, mitigating the water and nutrient requirements of the plant especially during the drought stress condition. 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., 2014).

MATERIAL AND METHODS

The experiment was conducted during 2022-23 in well-established V1 tree mulberry garden at L- Block, IFS 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 treatments were planned in accordance with regular recommended dosage of Pusa hydrogel is 1-2.5 kg per acre and Zeba hydrogel is 5 kg per acre, in view that to access hydrogels at varied dosages. The experiment was established with nine treatment combinations 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 hydrogel, were laid out in RCBD design with three replications.

UNDER PEER REVIEW

Hydrogels were applied at the root zone of the tree mulberry immediately after pruning. 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 after pruning (DAP). The data on leaf parameters at 45th 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 biochemical parameters in mulberry leaf

Quality parameters of mulberry leaf such as total chlorophyll, total carbohydrates, proteins, crude fibre, fat and ash contents of the leaf were estimated at 45 days after treatment imposition in each crop (total five crops) and the pooled data is presented in the experimental results.

Chlorophyll estimation

The content of chlorophyll in mulberry leaf was calculated by following procedure defined by Hiscox and Israelstam (1979). The total leaf chlorophyll content was determined using the formula proposed by Arnon (1949).

$$\text{Total chlorophyll (mg/g) fresh weight} = \frac{20.2(\text{O.D.645}) + 8.02(\text{O.D.663}) \times \text{Volume}}{1000 \text{ g weight of leaves}}$$

Estimation of crude protein

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

$$\text{Crude protein (\%)} = \text{N(\%)} \times 6.25$$

Estimation of total carbohydrate

Total carbohydrate of mulberry leaf was estimated by following the method of (Dubois *et al.*, 1956) using glucose as standard. The total anthrone positive substances were

expressed as mg of carbohydrate/g dry weight of leaf sample.

Estimation of crude fibre in plant sample

The crude fibre of the sample was estimated by taking 2 g sample with ether or petroleum ether and boiled (initial boiling temperature of 35-38°C and final temperature of 52°C). Then 200 ml of sulphuric acid was added and boiled for 30 min. Filtered through muslin cloth and washed with boiling water until washings were free of acid. Again, boiled the residue with 200 ml of sodium hydroxide for 30 min. Filtered through muslin cloth, again washed with 25 ml of boiling sulphuric acid, three 50 ml portions of water and 25 ml of alcohol. The residue was removed and transferred to pre-weighed ashing crucible (W1, g). The residue was dried for 2 hr at 130°C, cooled in a desiccator and weighed (W2, g), Ignited for 30 mins at 600°C and then cooled in a desiccator and reweighed (W3, g). The fibre content of sample was calculated by:

$$\text{Crude Fibre (\%)} = \frac{(W2 - W1) - (W3 - W1)}{\text{weight of the sample (g)}} \times 100$$

Estimation of ash (%)

The ash content in selected leaves of mulberry were estimated by adopting by using A.O.A.C (1980) method and expressed in percentage.

Estimation of fat (%)

The ash content in selected leaves of mulberry were estimated by adopting by using A.O.A.C (1980) method and expressed in percentage.

RESULTS AND DISCUSSION

Total chlorophyll (mg g⁻¹)

Application of different levels of hydrogels to tree mulberry exhibited significant influence 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 Zeba hydrogel @ 6 kg ac⁻¹, which was on par with that of T₇ (2.52 mg/g) and T₆ (2.46 mg/g). Whereas, minimum total chlorophyll content (1.83 mg/g) was recorded in leaves harvested from mulberry tree raised without any hydrogel application (T₉), which was on par with T₁

(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 plant growth. Additionally, hydrogels can improve soil structure, promoting root development and overall plant health, leading to increased chlorophyll production in leaves. The present results are in close agreement with the findings of Singhal *et al.* (1999) reported that nitrogen is an essential constituent of chlorophyll, nitrogen harvests solar energy and aids in the synthesis of chlorophyll. Photosynthetic efficiency is indicated by the increased amount of chlorophyll content in leaves; thus, it can be used as one of the criteria for photosynthetic rate quantification in mulberry (Sujathamma and Dandin, 2000). Nalborczyk *et al.* (1994) reported that the nitrogen fertilizer application affects chlorophyll content in plants.

Janardhan *et al.* (2008) reported that more amount of nitrogen (614 kg/ha) combined with recommended dose of farm yard manure and fertilizers compared to other treatments (0 to 250 kg ha⁻¹) lead to more chlorophyll content and higher mulberry leaf yield. The enhanced carbohydrate status also may be attributed to higher photosynthetic efficiency due to presence of higher chlorophyll levels (Ramachandra *et al.*, 2008). The application of hydrogel avoid the stress of humidity fluctuations and protects the durability of chlorophyll. In stress conditions the protection of durability of chlorophyll by super absorbent polymer materials were shown in 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 media of Siberian elm (*Ulmus pumila*) and silver maple (*Acer saccharium*) had significant influence on chlorophyll concentration by improving photosynthetic activities over control.

Protein (%)

The current results revealed significant variations with respect to protein content of tree mulberry leaf. Higher protein content (20.32 %) was found in the leaves obtained from the treatment T₈ (Zeba hydrogel @ 6 kg ac⁻¹) which was on par with that of T₇ (Zeba hydrogel @ 5 kg ac⁻¹) (20.07 %), T₆ (Zeba hydrogel @ 4 kg ac⁻¹) (19.75 %) and T₄ (Pusa hydrogel @ 4 kg ac⁻¹) (19.51%). The lowest protein content was registered in leaves harvested from the tree mulberry without hydrogel application T₉ (17.75 %). Hydrogels can help plants withstand stress. When plants are less stressed, they can allocate more resources to metabolic processes like protein synthesis.

The findings at CSR&TI, Mysore indicated that application of higher dose of nitrogen in combination with phosphorous and potassium increased the crude protein content in mulberry leaf from 15 to 23 per cent (Anon., 1976). It was also reported that irrigation with holding conditions with hydrogel at different growth stages increased protein percentage in soybean (Ashkiani *et al.*, 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 with application 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 lesser attributes (3.06 µg) and these are in conformity with present findings.

Carbohydrate(%)

The carbohydrate content in leaves was non-significant with various levels of hydrogel application. The relatively higher carbohydrate content of 20.29 percent was recorded in tree mulberry leaves harvested raised with the application of Zeba hydrogel @ 6 kg ac⁻¹ followed by T₇ (Zeba hydrogel @ 5 kg ac⁻¹) (19.84 %). The lowest carbohydrate content (18.13%) was observed in the leaves obtained from the plants raised without hydrogel application T₉. Hydrogels might probably promote sustained photosynthetic activity by enhancing water retention leading to increased carbohydrate synthesis in mulberry leaves.

Rajanna *et al.* (2000) reported that mulberry raised with recommended NPK had significantly higher total soluble carbohydrates (17.61%) and crude protein content (17.89 %). Similarly, Suresha (2004) opined that the treatment of nitrogen and potassium (300:200 kg/h/yr) recorded higher biochemical constituents in mulberry leaf which indicated a significant difference in total soluble protein, total reducing sugars and total chlorophyll.

Crude fibre(%)

Significant variation was noticed among different treatments with regard to crude fibre content of leaf harvested from tree mulberry on 45th day after hydrogel application and was significantly 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 (Zeba hydrogel @ 4 kg ac⁻¹) (11.30%). However, the lowest crude fibre content (9.85%) was

registered in the leaves obtained from the treatment T₉ (control).

Fat(%)

The results revealed significant variations with respect to fat content of tree mulberry leaf. Higher fat content (1.12 %) was found in the leaves obtained from the treatment T₈ (Zeba hydrogel @ 6 kg ac⁻¹) which was on par with that of T₇ (Zeba hydrogel @ 5 kg ac⁻¹) (0.89 %), T₆ (Zeba hydrogel @ 4 kg ac⁻¹) (0.85 %) and T₄ (Pusa hydrogel @ 4 kg ac⁻¹) (0.83 %). The lowest fat content (0.74 %) was registered in leaves harvested from the plants raised without hydrogel application T₉.

Fertilizers provide essential nutrients for plant growth, including proteins, fats, ash, fibre, and carbohydrates. When hydrogels are combined with fertilizers, they can help control the release of these nutrients. This controlled release ensures that nutrients are available to the plants over an extended period, reducing the risk of nutrient leaching and waste. This steady nutrient 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 root zone, preventing them from being washed away by rain or irrigation. This helps the plant to take up more of the applied nutrients, which can lead to improved biochemical contents in the leaves (Balet *al.* 2010).

Ash(%)

The ash content in leaves varied significantly due to various levels of hydrogel application. Significantly higher ash content of 9.54 per cent was recorded in leaves harvested from tree mulberry raised with the application of Zeba hydrogel @ 6 kg ac⁻¹, which was on par with T₇ (Zeba hydrogel @ 5 kg/ac) (9.26 %). The lowest ash content (7.28 %) was observed in the leaves obtained from the trees raised without hydrogel application T₉.

Table 1: Biochemical constituents in tree mulberry leaves as influenced by hydrogels under sensor based irrigation

Treatments	Total chlorophyll (mg g ⁻¹)	Protein (%)	Carbohydrate (%)	Crude fibre (%)	Fat content (%)	Ash content (%)
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

T₃	2.25	19.00	18.99	10.49	0.80	8.16
T₄	2.38	19.51	19.15	10.87	0.83	8.50
T₅	2.29	19.23	19.08	10.63	0.81	8.32
T₆	2.46	19.75	19.53	11.30	0.85	8.89
T₇	2.52	20.07	19.84	11.70	0.89	9.26
T₈	2.59	20.32	20.29	12.13	1.12	9.54
T₉	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 major component of amino acids, the building blocks of proteins. Nitrogen deficiency reduces the protein 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 many compounds in plants such as nucleic acids, phospholipids, coenzymes, NAD, NADP and ATP. It has close relationship with the metabolism of fats and carbohydrates, synthesis of proteins, respiration, photosynthesis and other metabolic activities (Shankar, 1997).

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. Hence, there is a need to cultivate crops with good agricultural practices. Application of hydrogel increases maximum water holding capacity, prevents 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

- ANONYMOUS, 1976, Studies on the response of NPK on the productivity and quality of mulberry leaf. *f. Ann. Rep., CSR&TI, Mysore*, p. 26.
- A.O.A.C., 1980, *Official Methods of Analysis*. (Ed. Daniel Banes), Association of Official Analytical Chemists., Washington D.C. P. 771.

- ARNON, O. I., 1949, Copper enzymes in isolates chloroplasts poly phenoxidase in BetaVulgaris.*Pl. Physiol.*, **24**:1-15.
- ARUNADEVI, K. AND SELVARAJ, P.K., 2007, Effect of drip fertigation on mulberry leaf growth attributes, leaf yield and leaf quality characters. *Crop Res.*, **33**(1-3):237-243.
- ASHKIANI, A., GHOOSHCHII, F. AND TOHIDIMO GHADAM, H.R., 2013, Effect of super absorbent polymer on growth, yield components and seed yield of wheat grown under irrigation withholding at different growth stages. *Res. Crops*, **14**(1): 48-53.
- BAI, W., ZHANG, H., LIU, B., WU, Y. AND SONG, J., 2010, Effects of super- absorbent polymers on the physical and chemical properties of soil following different wetting and drying cycles. *Soil Use Manage.*, **26**(3): 253-260.
- DANDIN, S.B., AND GIRIDHAR, K., 2014, *Handbook of Sericulture Technologies*. Central Silk Board, Bangalore. P. 287.
- DEHKORDI, D.K., 2016, The effects of super absorbent polymers on soils and plants. *Pertanika. J. Trop. Agric. Sci.*, **39**(3):267-298.
- DUBOIS, M., GILLES, K. A., HAMILTON, J. K., REBERS, P. A. AND SMITH, F., 1956, Colorimetric method for determination of sugars and related substances. *Anal. Chem.*, **28**:350-356.
- GUPTA, S.K. AND DESHPANDE, R.D., 2004, Water for India in 2050: first-order assessment of available options. *Curr. Sci.*, **86**: 1216–1224.
- HAFIZ, N.F., MUHAMMAD, A.P., CHOUDHARY, M.A., MUHAMMAD, Y., MADIHA, B. AND MOHSIN, B., 2014, Effect of Soil Application of humic acid and hydrogel on morphophysiological and biochemical attributes of potato (*Solanum tuberosum* L.). *Pak. J. life Soc. Sci.*, **12**(2): 92- 96.
- HANSON, B. AND ORLOFF, S., 2002, Monitoring soil moisture for maximum profit irrigation of alfalfa. Proceedings, Western Alfalfa and Forage Conference.
- JANARDHAN, G., GOWDA, T. S., BHASKAR, S., RAMACHANDRA, C. AND MAHANTHESH, B., 2008, Impact of integrated nitrogen management practices on

yield of mulberry (*Morus indica* L.) in southern transition zone of Karnataka. *Environ. & Ecol.*, **26**: 804-806.

KARGAR, M., SURESH, R., LEGRAND, M., JUTRAS, P., CLARK, O. G. AND

PRASHER, S. O., 2017, Reduction in Water Stress for Tree Saplings Using Hydrogels in Soil. *J. Geosci. Environ. Protect.*, **5**(1): 27-39.

KHADEM, A., GALAVI, M., RAMRODI, M., MOUSAVI, R. R. ANDREZVANI, M. P.,

2010, Effect of animal manure and superabsorbent polymer on corn leaf relative water content. *Aust. J. Crop Sci.*, **4**(8): 642-647.

LAL, M., 2001, Climate change-Implications for India's water resources. *J. India Water Res. Soc.*, **21**: 101-119.

LI, X., HE, J., LIU, Y. AND ZHENG, M., 2014, Effects of super absorbent polymers on soil microbial properties and Chinese cabbage (*Brassica chinensis*) growth. *Journal of Soils and Sediments*, **13** (4): 711-719.

MARIBASHETTY, V. G., RAGHURAMAN, R., VENKATESH, A. AND PUTTASWAMY,

S., 1999, Competitive nutritive value of bush and tree mulberry leaves in bivoltine seed rearing. *Sericologia*, **39**: 67-72.

NALBORCZYK, E., WRÓBLEWSKA, E., MARCINKOWSKA, E. AND ROSZEWSKI,

1994, Amaranthus—prospect cultivation and utilization. *J. Agric. Res.* **76**(5): 179-186.

NAZARLI, H., ZARDASHTI, M. R., DARVISHZADEH, R. AND NAJAFI, S., 2010. The

effect of water stress and polymer on water use efficiency, yield and several morphological traits of sunflower under greenhouse condition. *Notulae Scientia Biologicae*, **2**(4): 53-58.

PANSE, V. G. AND SUKHATME, P. V., 1967, Statistical methods for agricultural workers.

Indian Council of Agricultural Research, New Delhi. P. 381.

RAJANNA, M. V., DANDIN, S. B., MAGADUM, S. B. AND DATTA, R. K., 2000,

Nutritional evaluation of mulberry (*Morus spp*) genotypes through silkworm growth studies. *Uttar Pradesh Journal of Zoology* **20**(1), 47-53. red (*Morus rubra*) and black (*Morus nigra*) mulberry fruits. *Food Chemistry*. **103**: 1380-1384.

- RAMACHANDRA, Y.L., PADMALATHARAI, S., SUDEEP, H.V., SUJANGANAPATHY, P.S., KAVITHA, B.T. AND KRISHNAMURTHI, N.B., 2008, Evaluation of leaf quality at different growth stages and maturity levels of selected mulberry varieties. *Environ. Ecol.*, **26**(1): 272-276.
- SHANKAR, M.A., 1997, *Hand Book of Mulberry Cultivation*. Department of Sericulture, UAS, Bangalore and Multiplex, Karnataka Agro Chemicals, Bangalore. P.121.
- 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.
- SINGHAL, B.K., MALAV, R., SARKAR, A. AND DATTA, R.K., 1999, Nutritional disorders of mulberry (*Morus spp.*): III. Leaf nutrient guide for secondary nutrients. *Sericologia*, **39**(40): 599-609.
- SUJATHAMMA, P. AND DANDIN, S. B., 2000, Quality evaluation of mulberry (*Morus spp.*) genotypes through bioassay under Rayalaseema conditions of Andhra Pradesh. *Indian J. Seric.*, **40**(1): 27-34.
- TRENKEL, M.E., 1997, *Controlled release and stabilized fertilizers in Agriculture*. International Fertilizer Industry Association, Paris, France. P.76.

UNDER PEER REVIEW