The Bioscan 16(3): 199-202, 2021
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

THERMAL PERFORMANCE FOR HYDROPONIC MAIZE FODDER PRODUCTION

SANJAY KUMAR SINGH[1], AMIT KUMAR PATIL[1]*, SHESHRAO KAUTKAR[2] AND P. N. DWIVEDI[1]
[1]Farm Machinery and Post-Harvest Technology Division,
ICAR-Indian Grassland and Fodder Research Institute, Jhansi - 284 003, INDIA
[2]ICAR- Central Institute for Research on Cotton Technology, Mumbai - 400 019, INDIA
e-mail: amitpatilbetul@gmail.com

KEYWORDS
Hydroponic
Evaporative
Fodder
Maize

Received on :
29.12.2020

Accepted on :
15.08.2021

***Corresponding author**

ABSTRACT

It is difficult to fulfill the daily green fodder requirement of farm animals throughout the year in the era of global warming. The study focused on the development of an evaporative cool hydroponic chamber (ECHC) to grow green fodder in summer season. It consists of a double layered wall, filler material inside the wall, fogging system, drip system for water application and a shading curtain. The thermal performance of chamber was evaluated in terms of humidifying performance and its utility for production of hydroponic maize. Combined effect of evaporative cooling and misting system maintained the daily average temperature and relative humidity (RH) in the range of 28.6-30.2ºC and 65.2-75.1% respectively under ECHC as compared to temperature and RH of ambient in the range of 28.5-41.4º C and 37–77% respectively.

INTRODUCTION

India has emerged as the biggest producer of milk in the world producing 187.7 MT of milk in the year 2018-19 (Annual report, 2019-20, Ministry of Fisheries, Animal Husbandry and Dairying, GOI) and the reason is its vast livestock population. Production of fodder is a challenging task for the farmers in adverse conditions or even in suitable growing seasons because of uncertainty in rainfall, less land holdings, enormous climatic changes and pressure of producing food crops. Hydroponics is a systematic and scientific method of growing green fodder without soil, with or without nutrient solution under environmentally controlled structures, devices, houses or machines (Naik and Singh, 2013 and Naik *et al.,* 2015). The fodder grown hydroponically is known as hydroponics fodder or sprouted grains or sprouted fodder (Dung *et al.*, 2010). Al-Karaki and Al-Hashimi (2012) evaluated for barley, cowpea, sorghum and wheat for green fodder production under temperature-controlled hydroponic conditions (24 ± 1ºC) and natural window illumination at growth room of Soilless Culture Laboratory, Arabian Gulf University, Manama, Bahrain. Highest yields for hydroponic fodder after 8 days for cowpea, barley and alfalfa were 217, 200, and 194 tons/ha, respectively. In India, hydroponic fodder maize is preferred because of its easy availability of seed, good biomass production and fast growing habit. Girma and Gebremariam (2018) concluded that the dry matter content of 11-14%, yields of 5-6 folds on fresh basis for hydroponics maize and 8-13% increase in milk production. Naik *et al.* (2012) observed the highest values of crude protein (13.57%) for hydroponics fodder maize on 7th day of growth which was higher than the conventional green fodder maize (10.67%). The crude fiber content of the maize seed was 2.50% and increased to 14.07% on 7th day of growth in hydroponics system but was lower than the fodder maize grown under conventional practices (25.92%).

There are many organizations working on development of low cost hydroponic devices made from locally available material like bamboo, wood, greenhouse net *etc*. These local structures are not suitable for the regions of hot and dry climate where the relative humidity stays to lower side during 7-8 months in a year. Also, these structures are not strong enough to use for longer periods, there are chances of growth of fungi because of unhygienic environment and there is no scientific data available in terms of literature on thermal variation under these structures. Therefore, it is need of the hour to develop the economic, stable and permanent solution which could be utilized for the production of green fodder throughout the year.

Considering all the above enlisted drawbacks of existing hydroponic fodder production units, it was hypothesized that the application of evaporative cooling principle could be effective in overcoming this problem up to some extent lowering down the temperature inside the chamber using evaporative cooling technique. In hot and dry climate "evaporative cooling" refers to the cooling obtained solely by the evaporation of water in air. Air surrounding the structure gives up its heat energy to evaporate water and gets cool (Bokade *et al.,* 2017). This eco-friendly technology can reduce temperature by 10-15° C. However, in mild climatic conditions, the evaporative cooling is not very much effective. Maximum temperature drop under fan pad cooled greenhouse in Bangalore, Karnataka (India) during peak summer and overall cooling efficiency of 7.3°C and 53.6% were observed by Singh *et al.,* 2005. Several studies on the zero energy cool chamber using evaporative cooling technique shows its importance with reference to its low cost, eco-friendly and energy saving (Islam *et al.,* 2012, Ganesan *et al.,* 2004, Singh *et al.,* 2006 and Rajeswari *et al.,* 2011). However, to the best of our knowledge, environmentally controlled small and medium size evaporative cool hydroponic system for fodder production, that can operate in hot and dry regions does not exist. Therefore, it was realized to develop a suitable evaporative cool hydroponic fodder production chamber specially designed for small and marginal farmers who can easily adopt this technology for fodder production. When dry air passes over water, the air absorbs water and evaporative cooling occurs. The evaporative cooling system cools the inner space by evaporating water from the wet walls containing wet fillers. Considering all these points, the main objective of this work was to develop an evaporative cool hydroponic chamber (ECHC) for growing green fodder especially in summer season study and to study the thermal performance of developed chamber for the production of hydroponic fodder maize.

MATERIALS AND METHODS

Structural development of evaporative cool hydroponic fodder production chamber

An evaporative cool hydroponic chamber (ECHC) of 1.5m x 1.5m x 1.2m dimension was developed as shown in Fig. 1. The chamber consists of a double wall (inner and outer wall), a filler (evaporating medium), inside the double wall, fogging system to increase the humidity, drip system for watering the filler and a shading curtain (Nagaraj *et al.,* 2015). The outer and inner walls of the ECHC were made of solid clay bricks. The gap between the outside and inside wall was 5 cm packed with filler consisting of a mixture of sand (80%) and gravel (20%). Sand was used to increase the water retention capacity and gravel stone was used to enhance the evapo-transpiration rate. The tap water from tank was supplied to the filler material through low pressure drippers placed on the walls and to the fogger having solid cone nozzle (capacity: 1.0 l/h with 0.8m spray dia) inside the chamber. The bottom of the cool chamber was covered with gunny bags. A shading curtain that reduces solar radiation by 80% was also used to cover the entire structure including water tank.

Testing of evaporative cool hydroponic chamber for maize fodder production

Testing of ECHC was done continuously from 15th to 21st June 2020 during summer. The maize (variety: maize hybrid seed 'ASC-555', Ajanta Seed Corporation) seeds were cleaned and soaked in water for 24h and then packed tightly in gunny bag for 12h to sprout the seeds. The sprouted seeds were spread in three hydroponic trays each of size 35.6 cm x 26.10 cm, at the seed rate of 300g/m^2 and the trays were placed in the ECHC on 15th June 2020. Spraying of water was done only in day time in an interval of 2h. Inside the ECHC, the plants were allowed to grow for seven days and harvested at the end of seventh day (BHOI *at el.,* 2012).

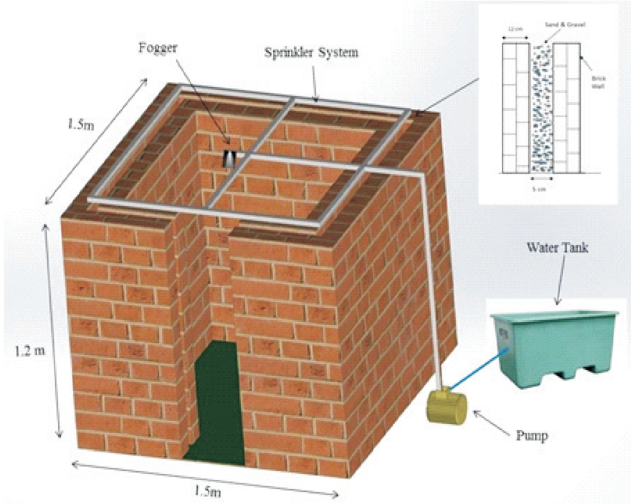

Figure 1: Experimental set up of evaporative cool hydroponic chamber

RESULTS AND DISCUSSION

Variation of temperature and relative humidity under ECHC

The variations of temperature (T) and relative humidity (RH) at different timings of day and night during hydroponic maize production are given in Table 1. These are based on hourly observations of day and night temperature and relative humidity for 7 days during experimentation. The average T and RH in the morning (8 am), afternoon (1 pm), evening (5 pm) and mid night (2 am) were (29 ° C, 76%), (33° C, 58.7%), (29.8° C, 67%) and (29.4° C, 71.6%) respectively. Maximum T and minimum RH of 34.3° C and 52% at 1 PM and minimum T and maximum RH of 26° C and 87% at 2 AM (mid night) were observed. To bring down the temperature, evaporative cooling system through application of water on walls and to increase the humidity level, fogging system were operated in

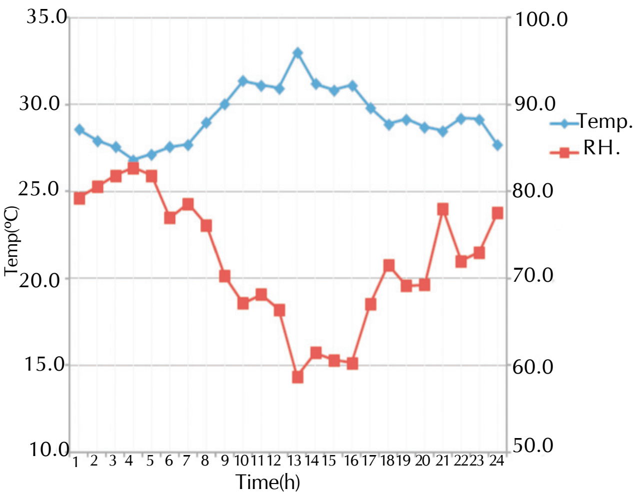

Figure 2: Variation of hourly average temperature and RH during 7 days growth under ECHC

Table 1. Variation of T and RH at different timing during 7 days of hydroponic maize production

S.No.	Description	Temperature (° C)				Humidity (%)			
		Max.	Min.	Avg.	Variation	Max.	Min.	Avg.	Variation
1.	Variation in the morning (8 am)	30	28.1	29	1.9	81	67	76.1	14
2.	Variation in the afternoon 1pm	34.3	32	33	2.3	63	52	58.7	11
3.	Variation in the evening 5pm	31.1	28.4	29.8	2.7	86	54	67	32
4.	Variation from morning to evening (8am to 5pm)	31.1	28.1	29.4	3	86	54	71.6	32
5.	Variation in the midnight (2am)	29.2	26	27.9	3.2	87	73	80.6	14
6.	Variation in the hourly avg.	33	26.8	29.3	6.2	82.7	58.7	72	24

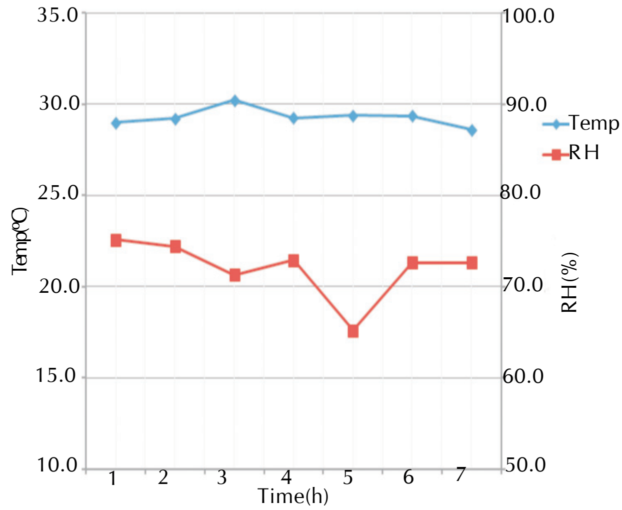

Figure 3: Variation of daily average T and RH during 7 days growth under ECHC

day time during 8 AM to 5 PM. The variation of T from morning to evening (8AM to 5 Pm) was 3° C. Minimum variation of T of 1.9° C was observed in the morning (8AM) and maximum variation of 3.2° C was observed in the mid night (2 AM). This is due to absence of sunshine in the night and non operation of evaporative cooling. It was also observed that during this period, the variations of RH were 32%. The excessive build-up of T could be avoided due to evaporative cooling. The average RH value of 71.6% from morning (8AM) to evening (5PM) was achieved due to fogging system and ventilation through shade net. The hourly average T and RH ranged from 26.8° C to 33.0° C and 58.7% to 82.7% respectively (Fig. 2) along with average T and RH of 29.3° C and 72% respectively. The variation of daily maximum, minimum, average T and RH under ECHC are shown in Fig. 3. The optimum temperature required for hydroponic crops is around 22°C and the maximum temperature that the crop can tolerate is usually around 30-32 °C (Sinsinwar and Krishna, 2012). Dirpan *et al.*, 2017 also observed zero energy cool chamber suitable for decreasing temperature and increasing relative humidity.

REFERENCES

Al-Karaki, G. N. and Al-Hashimi, M. 2012. Green fodder production and water use efficiency of some forage crops under hydroponic conditions. *International Scholarly Research Network* .P.1-5.

Annual Report. 2019-20. Basic Animal Husbandry Statristics. *Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. New Delhi.*

Bhoi, Lakshmikanti, Dullav, Bhosagar and Mishra P. C. 2012. Germination Potential And Seedling Performance Of Yellow Mustard In Arsenic Contaminated Hydroponic Culture. *The Bioscan.* **7(2):** 299-302

Bokade, S. D., Varghe, A. P. and Ghumde, A. A. 2017. Fabrication and experimental study of new zero energy cooling chamber with a solar-driven adsorption refrigerator. *International J. Engineering Development and Research.* **5(4):** 24-31.

Dirpan, A., Muhammad, T., Muhammad, A. K., Tahir, M. M. and Rahimuddin. 2017. Evaluation of temperature and relative humidity on two types of zero energy cool chamber (ZECC) in South Sulawesi, Indonesia. *IOP Conf. Series: Earth and Environmental Science.* **101** 012028.

Dung, D. D., Godwin, I. R. and Nolan, J. V. 2010. Nutrient content and *in sacco* degradation of hydroponic barley sprouts grown using nutrient solution or tapwater. *J. Animal and Veterinary Advances* **9(18):** 2432-2436.

Ganesan, M, Balasubramanian, K. and Bhavani, R. V. 2004. Effect of water on the shelf life of brinjal in zero energy cool chamber. *J. Indian Institute of Science* **84:** 1-7.

Girma, F. and Gebremariam, B. 2018. Review on hydroponic feed value to livestock production. *J. Scientific and Innovative Research* **7(4):** 106-109.

Islam, M. P. And Morimoto, T. 2012. Zero energy cool chamber for extending the shelf life of tomato and eggplant. *Japan Agricultural Research Quarterly.* **46:** 257-67.

Naik, P. K., Swain, B. K. and Singh, N. P. 2015. Production and utilisation of hydroponics fodder. *Indian J. Animal Nutrition.* **32(1):** 1-9.

Naik, P.K. and Singh, N.P. 2013. Hydroponics fodder production: an alternative technology for sustainable livestock production against impeding climate change. In: compendium of Model Training Course '*Management Strategies for Sustainable Livestock Production against Impending Climate Change*', held during November 18-25, 2013. Southern Regional Station, National Dairy Research Institute, Adugodi, Bengaluru, India, PP. 70-75.

Nagaraj, D. M., Nemichandrappa, M., Ayyanagowdar, M. S., Srinivasareddy, G. V. and Patil, M. G. 2015. Growth And Yield Of Bell Pepper (Capsicum Annuum Var. Grossum) In Soilless Media Under Shade House. *The Bioscan.* **10(3):** 1391-1394

Prakash Chandra Gupta, Mukherjee Arkabanee and Rai, A. K. 2012. Accumulation Of Nutrients Within Rice Crop System Under Arsenic Toxic Condition: A Hydroponic Study. *The Bioscan.* **7(4):** 611-617

Reddy, G. V. N., Reddy, M. R. and Reddy, K. K. 1988. Nutrient utilization by milch cattle fed on a rations containing artificially grown fodder. *Indian J. Animal Nutrition.* **5(1):** 19-22.

Rajeswari, D. Nautiyal, M. C. and Sharma, S. K.. 2011. Effect of pedicel retention and zero energy cool chamber on storage behaviour of Malta fruits. *International J. Agricultural Sciences.* **3(2):** 78-81.

Singh, K. P., Singh, S. K., Chandra, P. and Mandhar, S. C. 2005. Temperature and humidity regimes in naturally ventilated and fan-pad cooled greenhouses under mild climatic conditions. *J. Ornamental Horticulture*. **8(3):** 173-179.

Singh, Sanjay Kumar and Gangwar, Varshika. 2020a. Drying behavior of osmo-convective drying of carrot slices and quality characteristics of dehydrated products. *International J. Current Microbiology and Applied Sciences*. **9(10):** 1424-1431.

Singh, Sanjay Kumar and Gangwar, Varshika. 2020b. Effect of temperature and concentration of osmotic solution on moisture loss and solid gain during osmotic dehydration of carrot. *International J. Chemical Studies*. **8(5):** 2017-2022.

Singh, R. K. P and Satapathy, K. K. 2006. Performance evaluation of zero energy cool chamber in hilly region. *Agricultural Engineering Today*. **30 (5&6):**47-56.

Sinsinwar, S. and Krishna, T. C. 2012. Development of a cost effective, energy sustainable hydroponic fodder production device. *Project Report. Agriculture Engineering Interns, IIT, Kharagpur*.