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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(10): 405-409

www.thepharmajournal.com
Received: 21-07-2021
Accepted: 11-09-2021

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Assessment of environmental heat in naturally ventilated polyhouse

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Abstract

The research experiments were performed in naturally ventilated polyhouse at Agriculture Farm, CTAE, Udaipur. Environmental heat assessment was done for months of March, April, July and August. Polyhouse was having area of 1000 m^2 in which chilly and tomato crops were under production. To assess environmental heat in poly-house quest temperature which is 36, for measurement heat stress monitor was used. The average relative humidity in polyhouse was recorded in the range of 37 to 84 per cent for a day. The air velocity recorded in polyhouse was in the range of 0.2 to 0.4 m/sec. In March maximum WBGT was 33.2 ºC and minimum WBGT was 23.4 ºC. In the month of April maximum value of WBGT was 34.7 ºC and minimum value of the WBGT was recorded 23.7 ºC. In the July maximum WBGT was recorded for a day was 36.8 ºC at and minimum WBGT recorded was 27.6 ºC. It was recorded that maximum WBGT was 36.8 ºC at and minimum WBGT recorded was 27.9 ºC. Increase in working heart rate was observed more than resting heart rate with increase in WBGT. This indicated that there was more heat load at the time of working with increase in WBGT. Use of protective gears decreased rise in forehead temperature in case of hat with air circulation and hand guard combination significant decrease in forehead temperature was observed because of air blown by fan used in the hat gave condensation effect to sweat and the combination was found superior to others in polyhouse.

Keywords: WBGT, heat stress, polyhouse, thermal parameters, human comfort, heat index, heat stress monitor

Introduction

In developing countries like India to production of crop in the regions having high temperature, water scarcity and low humidity conditions for the maximum duration of year mainly in summer from March end to July. Since temperature starts increasing from April in India and becomes excessively hot when the day time temperature reaches 40 ºC at many locations. Many places in Madhya Pradesh, Rajasthan, Gujrat, and Maharashtra have high day time temperature during this time period. The maximum temperature was recorded up to 51 ºC at Phalodi in Jodhpur district of Rajasthan (Anonymous, 2017) [2]. These conditions make plant production quite difficult.

Therefore protected cultivation techniques are used for the crop growth and production under controlled or partially controlled environment. Generally shed net greenhouse and plastic films made of low density polyethylene (LDPE) are commonly used in protected cultivation technique. The purpose of the LDPE covering to the polyhouse is to increase internal air temperature and protecting plants from the outside agents. Human thermal comfort is defined as a condition of mind, which expresses satisfaction with the surrounding environment. In the arid regions, evaporative cooling is often applied to reduce the inside polyhouse air temperature in summer. Polyhouse environment is usually designed according to the crop growth requirements (T: 20–40 ºC; RH: 70–80 per cent) which, in many situations may not be suitable for humans that are working in the poly-house. This is mainly because of RH in the evaporative cooled poly- house is much higher than outside. High air humidity may provide discomfort sensations and heat stress in the poly-house (Ghany *et al.*) [1].

Agriculture operations in polyhouses are mostly manual and since conditions in a polyhouse are kept according to crop requirement which is having high air temperature and high relative humidity adversely affects working efficiency of farm worker in polyhouse. There is also low air velocity in a polyhouse which reduces heat transfer rate from workers body. Significant drop in worker mental performance was observed at the temperature of 32.2 ºC in conditions of hot and humid environment like polyhouse and greenhouse. In hot and dry environment conditions drop in mental performance was observed at 33 ºC (Sharma *et al.*, 1983) [15].

In order to investigate the heat stress conditions for farm workers performing agriculture operations in polyhouse research was conducted.

Materials and Methods

A polyhouse of area 1000 m^2 was selected for the research in which Chilly and Tomato crops were under growth. Four months were selected in which polyhouse was in operational conditions. Research was performed in month of March, April, July and August at Agriculture Farm, CTAE, and Udaipur. To measure the environmental heat in polyhouse heat stress index Wet Bulb Globe Temperature was selected. It is a composite temperature used to estimate the combined effect of temperature, wind speed, humidity and infrared radiation (sunlight) on human body WBGT is an indicator of feel temperature and can be used as standard for heat stress conditions. According to Occupational safety and hazard analysis (OSHA), WBGT level above 28 °C is considered as heat stress conditions. The WBGT for outdoor and indoor conditions can be calculated by using the formulae as described (Parsons, 2014) [14].

$$WBGTi = 0.7Tw + 0.3Td \quad \text{…….. (1)}$$
$$WBGTo = 0.7Tw + 0.2Tg + 0.1Td \quad \text{…….. (2)}$$

WBGTi = Wet bulb globe temperature indoor
WBGTo = Wet bulb globe temperature outdoor
Tw = Natural wet bulb temperature
Td = Dry bulb temperature (actual air temperature)
Tg = Globe thermometer temperature (measured with globe thermometer)

Quest Temp 36 model heat stress monitor was used which offers measurement of wet bulb temperature, dry bulb temperature, globe temperature, WBGT for outdoor and indoor conditions, relative humidity and heat index.
Since polyhouse is subjective to considerable amount of solar radiation, therefore wet bulb globe temperature of outdoor conditions was taken under measurement and relative humidity was also measured. For research WBGT was noted in March 2021, April 2021, July 2021 and August 2021for every hour from 10: 00 AM in morning to 5: 00 PM in evening.

Fig 1: Quest temp 36 heat stress monitor

Fig 2: Display screen of heat stress monitor

Results and discussion

The index for the heat stress assessment was WBGT (wet bulb globe temperature). The observations were recorded with help of heat stress monitor Quest temp 36. Since in polyhouse considerable amount of sun radiation was present so WBGT outdoor observations were recorded. The variations in WBGT for the day as well as whole month are discussed below.
The average relative humidity in polyhouse was recorded in the range of 37 to 84 percent for a day. The air velocity recorded in polyhouse was in the range of 0.2 to 0.4 m/sec. For the month of March observations were recorded from 1st March to 26th March and from 10 AM to 5 PM observations were recorded every hour to consider the daily change in heat stress index in polyhouse.
For month March 2021 it can be seen below in figure 1 and figure 2 that as the polyhouse faces sun radiation heat index start increasing and about 01:00 PM maximum WBGT was noted for whole month was 33.2 ºC and minimum WBGT was noted at 10: 00 AM was 23.4 ºC. The daily variation in the WBGT in polyhouse was also analyzed and got the results that on a clear and sunny day heat stress index WBGT was found higher than usual. The maximum value of WBGT was recorded on 23th March was 33.2 ºC and the minimum WBGT was recorded on 12th March was 23.6 ºC. In the month of April 2021 observation in polyhouse were recorded till government pushed lockdown again which was till the 16th April and in day time from 10:00 AM to 5:00 PM at interval of one hour.
In the month of April daily as well as day time observations of WBGT were recorded for the first half of April and recorded that in the day time maximum value of WBGT in all days was 34.7 ºC at 2:00 PM and minimum value of the WBGT was recorded 23.7 at 10:00 AM. It was also analyzed that on a clear and sunny day WBGT was found more than usual. The average WBGT for a sunny and clear day was found more than regular. In daily observations it was recorded that maximum WBGT recorded was 34.7 ºC on 16th April and minimum WBGT recorded was 23.7 ºC on 1st April and it was observed that as from April sun radiation was more, number of clear and sunny days was increasing and WBGT daily average was increasing with it.
Government lifted the lockdown on 7th June and polyhouse was also not in operational mode for the month of May and June. The polyhouse came in operation from 8 July and from

that heat stress analysis was restarted. In the July the observations were recorded from 8th July to 30th July and 10:00 AM to 5:00 PM at the interval of one hour. The variation in the value of WBGT the maximum, minimum and average values of WBGT are shown below in figure 7 and figure 8.

The possibility of rain in Rajasthan increased from 2nd half of July. It was recorded that in 1st half of July days were mostly clear and sunny due to which average WBGT for a day was recorded higher. In the July maximum WBGT was recorded for a day was 36.8 ºC and on a clear day and minimum WBGT recorded for month was 27.6 ºC on a cloudy day. Value of WBGT for the month was higher in the 1st half of the month but in 2nd half or July most of the days were observed cloudy and on some days it was raining which reduced the globe temperature due to

which WBGT in polyhouse was also recorded less but on the same day working in polyhouse on cloudy day was found difficult than outside environment because humidity was observed in the range of 52 to 84 %. The day time and daily variation in WBGT conditions for the month of July are shown below in fig. 7 and fig. 8.

In August the observations were recorded till the 18th August from 10:00 AM to 5:00 PM at the interval of one hour. Since August was also partially cloudy month so it was recorded that on a clear day average WBGT was higher than a cloudy day. The day time as well as daily variation recorded shown below in fig. 9 and fig. 10. It was recorded that maximum WBGT value recorded was 36.8 ºC and minimum WBGT recorded was 27.9 ºC.

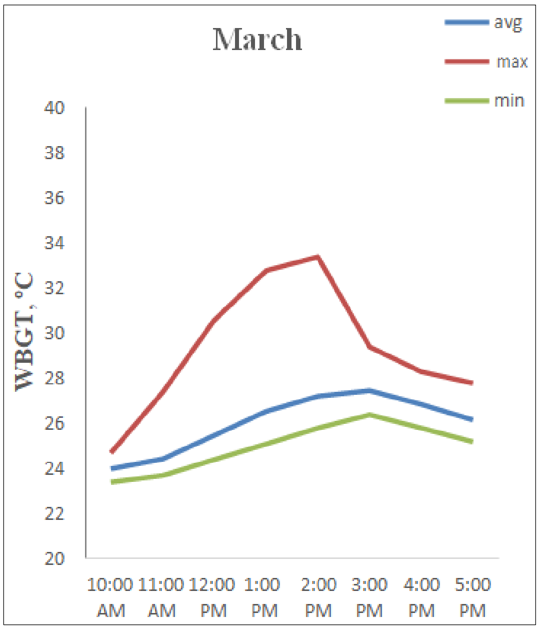

Fig 3: Day time variation of WBGT in March

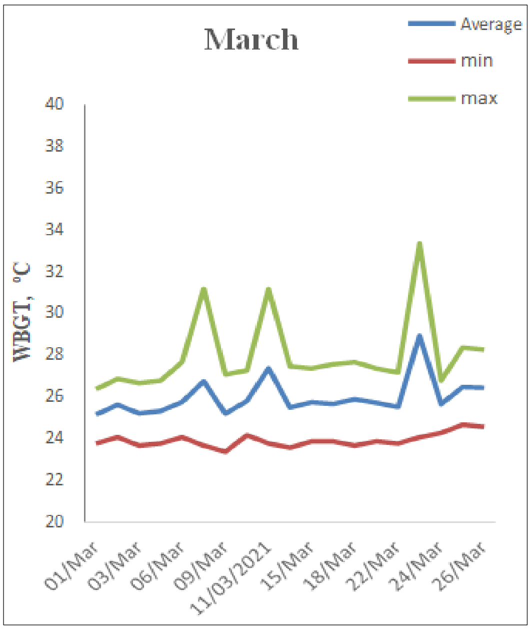

Fig 4: Daily variation of WBGT in March

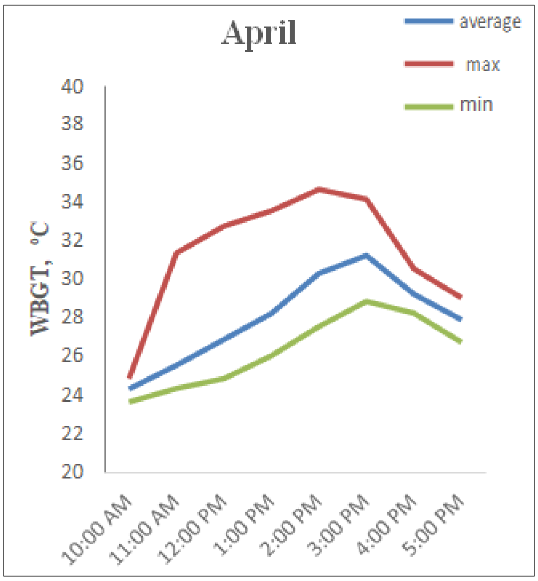

Fig 5: Day time variation in WBGT in April

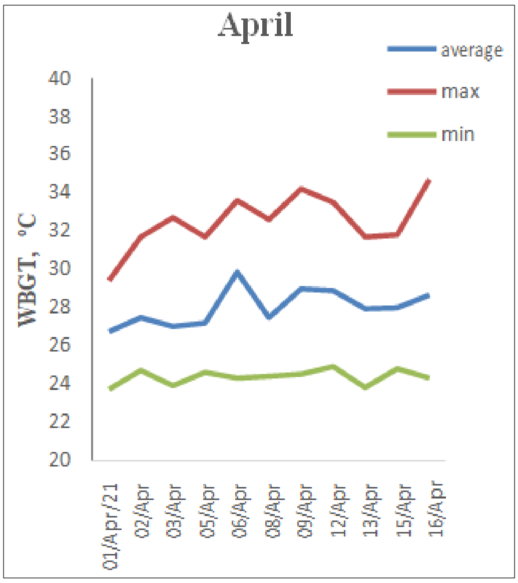

Fig 6: Daily variation in WBGT for April

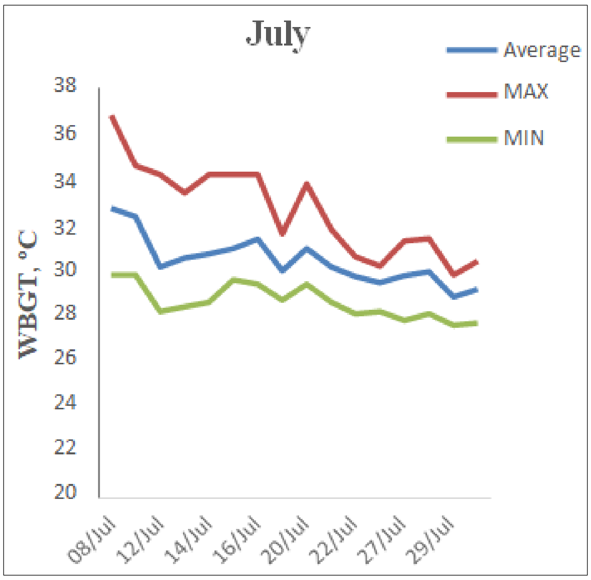

Fig 7: Variation in WBGT value for day time in July

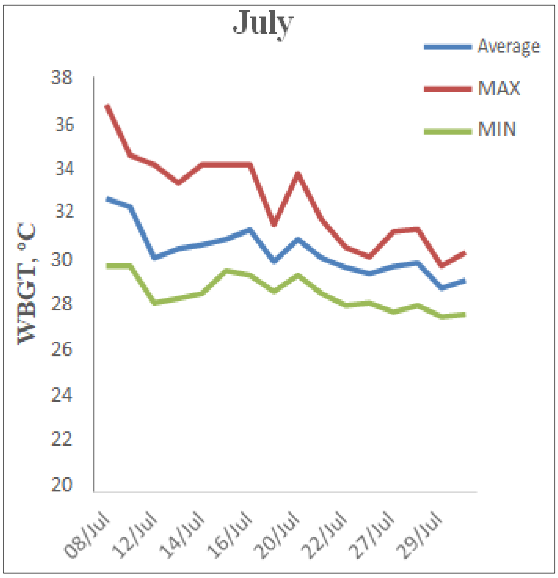

Fig 8: Daily variation in value of WBGT for July

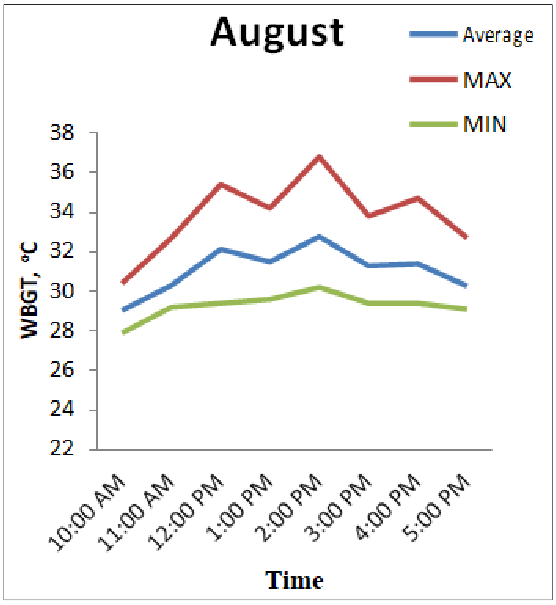

Fig 9: Day time variation of WBGT in August

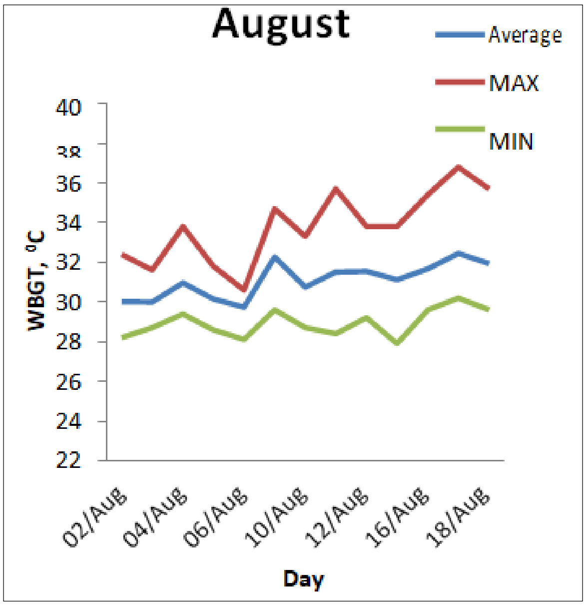

Fig 10: Daily variation of WBGT in August

Conclusion

The average relative humidity in polyhouse was recorded in the range of 37 to 84 percent for a day. The air velocity recorded in polyhouse was in the range of 0.2 to 0.4 m/sec. In March maximum WBGT was 33.2 ºC and minimum WBGT was 23.4 ºC. In the month of April maximum value of WBGT was 34.7 ºC and minimum value of the WBGT was recorded 23.7 ºC. In the July maximum WBGT was recorded for a day was 36.8oC at and minimum WBGT recorded was 27.6 o C. In the month August heat stress index was recorded that maximum WBGT was 36.8oC at and minimum WBGT recorded was 27.9. According to OSHA standards of heat stress working environment having WBGT above 28oC is considered under heat stress. And according to recorded WBGT in polyhouse most of the time working conditions had temperature above 28oC.

References

1. Abdel Ghany AM, AL-Helal IM, Shady MR. Effect of the evaporative cooling on the human thermal comfort and heat stress in a greenhouse under arid conditions. Advances in Meteorology 2013,7-13.
2. Anonymous. Manson Report 2017 (1st June 2017 to 31st September 2017), Published by Indian Meteorological Department, New Delhi 2017.
3. Chad Karen E, Brown JMM. Climatic stress in the workplace - Its effect on thermoregulatory responses and muscle fatigue in female workers. Applied Ergonomics 1995;26:29-34.
4. Christensen EH. Physiological valuation of work in Nykroppa iron works. In W.F. Floyd and T Wellford (eds). Ergonomics Society Symposium on Fatigue, Lewis, London 1953;12:93-108.
5. Gonzalez RR, Halford C, Keach EM. Environmental and physiological simulation of heat stroke: A case study analysis and validation. Journal of Thermal Biology 2010;35:441-449.
6. Gusman A, Maricci A, Salvatori L. Control of the climate parameters inside greenhouses to defende workers health 2008.
7. Holland EJ, Laing RM, Lemmon TL, Niven BEH. Design to facilitate thermo neutrality during forest

harvesting. Ergonomics 2002;45:699-716.
8. Huguette Lumingu, Pierre D. Physiological responses to heat strain: A study on personal monitoring for young workers. Journal of Thermal Biology 2009;34:299-305.
9. Majid M, Mansour RA. Heat Stress Evaluation Using Environmental and Biological Monitoring. Pakistan Journal of Biological Sciences 2006;9:457-459.
10. Marucci A, Pagniello B, Monarca D, Cecehini M, Colantoni A, Biondi P. Heat stress suffered by workers employed in vegetable grafting in greenhouses. J. food Agric. Environ 2012;10:1117-1121.
11. Nag PK, Sebastian NC, Mavlankar MG. Occupational workload of Indian agricultural workers. Ergonomics 1980;23:91-102.
12. Occupational safety and hazard analysis (OSHA) technical manual, Chapter- 4 Heat stress.
13. Okushima L, Sase S, Lee IB, Bailey BJ. Thermal environment and stress of workers in naturally ventilated greenhouses under mild climate. In V International Symposium on protected cultivation in Mild Winter Climates: Current Trends for Suistainable Technologies 1992;559:793-798.
14. Parsons K. Human thermal environment: the effects of hot, moderate and cold environments on human health, comfort and performance, CRS press 2014;3:121-122.
15. Sharma VM, Pichan G, Panwar MR. Differential effects of hot-humid and hot-dry environments on mental functions. International Archives of Occupational and Environmental Health 1983;52:315-327.