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Effect of WBGT on body thermal responses for agricultural workers in Southern Rajasthan, India

S.K. SINGH, A.K. MEHTA AND S.S. MEENA

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See end of the Paper for authors' affiliation

Correspondence to :

S.K. SINGH
Department of Agricultural Engineering (Farm Machinery and Power Engineering), College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA

■ **ABSTRACT :** Rajasthan state is in west region of India. Maximum temperatures rise sharply exceeding 45° C by the end of May and early June resulting in harsh summers in the state. Heat stress is a condition that is caused by worker over-exposure to the high temperature work environments often found in outdoor agriculture operations. Wet Bulb Globe Temperature (WBGT) is a measure of heat stress. Considering the range of temperatures prevalent in the Rajasthan state during the months of May and June, agricultural operations during these months and the associated heat stress on the agricultural workers, this study was designed to ascertain the effect of WBGT on body thermal responses of agricultural workers. Southern Rajasthan was selected to conduct this study. The study was conducted on 12 farm workers. Different WBGT of 28°C, 29°C, 30°C, 31°C and 32°C were selected for this study. Thermal parameters included head, forehead and oral temperature. Forehead temperature was observed to decrease with an increase in WBGT. Heavy sweating was observed at high WBGT and this resulted in the decrease in skin and forehead temperature. Oral and head temperature was observed to increase with increase in WBGT. Since oral temperature is also considered to be the core temperature of body, it increased with increase in WBGT. Head absorbs the direct solar radiations and hence, its temperature increased with increase in WBGT.

■ **KEY WORDS :** WBGT (Wet Bulb Globe Temperature), Heat stress, Thermal responses, Head temperature, Forehead temperature, Oral temperature, Core body temperature

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In India, most of the agricultural operations are being performed by manual labour. High drudgery and low income is the main hurdle in agricultural production. Ploughing (June, July, October and April), sowing (July-August, October-November and March- April), intercultural operations (August, April – May), harvesting (September-October, March-April and May-June) are the main agricultural operations which are being performed mostly by small hand tools in hot sunny days.

Rajasthan state is in west region of India. Maximum temperatures rise sharply exceeding 45° C by the end of May and early June resulting in harsh summers in the state.

Heat stress is a condition that is caused by worker over-exposure to the high temperature work environments often found in outdoor agriculture operations. Heat stress is a build-up of heat in the body generated by muscle use and surrounding conditions. It is the result of a combination of environmental conditions, work demands, and clothing requirements that are likely to increase body temperature. When the body cannot adequately cool itself, injury, illness, or even death can occur. The more intense the work, the hotter the conditions and the higher the humidity, the faster heat will be generated and the body will struggle to get rid of excess heat. Dash and Kjellstrom (2011) concluded that heat stress is an important aspect in the lives of people working under exposed conditions for long hours. Climate change may lead to significant increase of heat events and hence, heat stress during the hot seasons in most parts of India. Heat stress may cause occupational health risks as well as reductions of work productivity that can have a negative impact on family income and the community economy. Ismail *et al.* (2009) stated that the environmental factors such as temperature and relative humidity contribute to the effect of comfort, health, performance and worker productivity. Huguette and Pierre (2009) showed that the heart rate, increased body-core temperature and sweating are the physiological responses to heat stress and they are collectively known as physiological strain. Keim *et al.* (2002) found that thermal stress from cold and heat can affect health and productivity in a wide range of environmental and workload conditions. Parsons (2006) presented heat stress Standard ISO 7243, which is based upon the wet bulb globe temperature index (WBGT) and considers its suitability for use worldwide.

Heat stress can be prevented by introducing work practices which can be accomplished by reducing the physical workload imposed on an individual worker or by scheduling appropriate breaks for thermal recovery.

Work in extreme thermal conditions may require personal thermal protection in the form of specialized clothing. Passive protection is provided by insulative and reflective garments; insulation alone can buffer the skin from thermal transients. Reflective aprons may be used to protect personnel who work facing a limited radiant source.

Considering the range of temperatures prevalent in the Rajasthan state during the months of May and June, agricultural operations during these months and the associated heat stress on the agricultural workers, this study was designed to ascertain the effect of WBGT on body thermal responses of agricultural workers. Southern Rajasthan was selected to conduct this study.

■ METHODOLOGY

Intercultural operation like weeding was selected for this study as it was performed in the month of 15th May to 15th June. The temperature is at peak with very low humidity. The average temperature is ranges between 35°C to 43°C which causes high heat stress conditions.

The study was conducted on 12 farm workers. During the study period all the operations for the study were performed by these 12 farm workers. The farm workers selected from the 50th percentile of the anthropometric criteria and physical strength. Selected subjects were having agriculture as their main source of livelihood. All the subjects selected were not having the habits of chewing tobacco and taking any type of liquor. Subjects were between 20 - 40 years of age. The weeding operation was performed both in morning and evening shifts. In morning the time of operation was kept from 9 AM to 1 PM and in evening 3 PM to 5 PM. For the assessment of effect on body thermal responses due to heat stress condition the subjects were asked to perform the weeding operation continuously for one hour.

Heat Stress Monitor offers high quality heat stress monitoring without the hassle of wet-bulb maintenance. This model measures/calculates the dry bulb, wet bulb and globe temperatures along with WBGT indoors, WBGT outdoors, relative humidity and heat index. Real time clock provides accurate reporting with time stamping. This was used to measure the WBGT at the study area. Different WBGT of 28°C, 29°C, 30°C, 31°C and 32°C were selected for this study.

An infrared non contact thermometer is a thermometer which infers temperature from a portion of the thermal radiation sometimes called blackbody radiation emitted by the object being measured. They have the ability to measure temperature from a distance. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can often be determined. This was used to measure head and forehead temperatures of twelve subjects.

A Doctor's thermometer is a device that measures temperature or temperature gradient using a variety of different principles. It has two important elements: the temperature sensor (e.g. the bulb on a mercury-in-glass thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer). This was used to measure the oral temperature of twelve subjects.

Following thermal parameters were measured during the study:

– Head temperature in °C using an infrared non contact thermometer

– Forehead temperature in °C using an infrared non-contact thermometer

– Oral temperature in °C using a doctor's thermometer

RESULTS AND DISCUSSION

Heat stress and physiological responses of twelve male farm workers were assessed for weeding operation in summer Moong (green gram) in Southern Rajasthan, India. Wet Bulb Globe Temperature (WBGT) was recorded with the Quest temp 36 heat stress monitor. Clear sky duration of five days was selected in the month of May to meet the required heat stress. Work was started at 09:00 AM to 01:00 PM and then 03:00 PM to 05:00 PM and the physiological parameters were measured after one hour of continuous operation. All the 12 subjects were asked to work simultaneously for three days. Following data presented are the average of three days observation. The days were selected after visiting the current satellite images hosted on the website *www.imd.gov.in* of Indian Meteorological Department, Government of India, Pune. Also the forecast statement issued by Indian Meteorological Department was considered to see the clear sky.

The data of the study were collected in the month of May 2009. The parameters which were recorded were as follows:

– Head temperature in ºC

– Forehead temperature in ºC

– Oral temperature in ºC

These experiments were conducted for five WBGT of 28 ºC, 29 ºC, 30 ºC, 31 ºC and 32 ºC. Mean values of thermal parameters of twelve workers were calculated from the observations and the mean value table of thermal parameters with WBGT is shown in Table 1.

It can be seen that oral temperature varied from 36.7° C at WBGT of 28° C to 38.1° C at WBGT of 32° C. Head temperature varied from 40.3° C at WBGT of 28° C to 44.8° C at WBGT of 32° C. Forehead temperature varied from 36.1° C at WBGT of 28° C to 33.2° C at WBGT of 32° C.

Forehead temperature was observed to decrease with an increase in WBGT. Heavy sweating was observed at high WBGT and this resulted in the decrease in skin and forehead temperature. Oral and head temperature was observed to increase with increase in WBGT. Since oral temperature is also considered to be the core temperature of body, it increased with increase in WBGT due to heat stress. Head absorbs the direct solar radiations and hence, its temperature increased with increase in WBGT due to heat stress.

There was a linear trend in graph and R^2 values were higher than 0.98 in all cases of variance of thermal parameters with WBGT (Fig. 1). Forehead temperature exhibited a negative linear trend while oral and head temperatures showed positive linear trend with increase

Table 1 : Mean values of thermal parameters with WBGT

Treatments	Oral temp	Head temp	Forehead temp
28 ºC WBGT	36.7	40.3	36.1
29 ºC WBGT	37.0	41.5	35.3
30 ºC WBGT	37.4	42.5	34.5
31 ºC WBGT	37.9	43.7	33.7
32 ºC WBGT	38.1	44.8	33.2
GM	37.4	42.61	34.60
C.D. (P=0.01)	0.29	0.76	0.81
CV	0.72	1.65	2.17

Table 2 : ANOVA for thermal parameters with WBGT

Sr. No.	Characters	Treatments	Error
1.	Oral temp	4.38**	0.07
2.	Head temp	36.99**	0.4
3.	Forehead temp	17.46**	0.5

** indicates significance of value at P=0.01

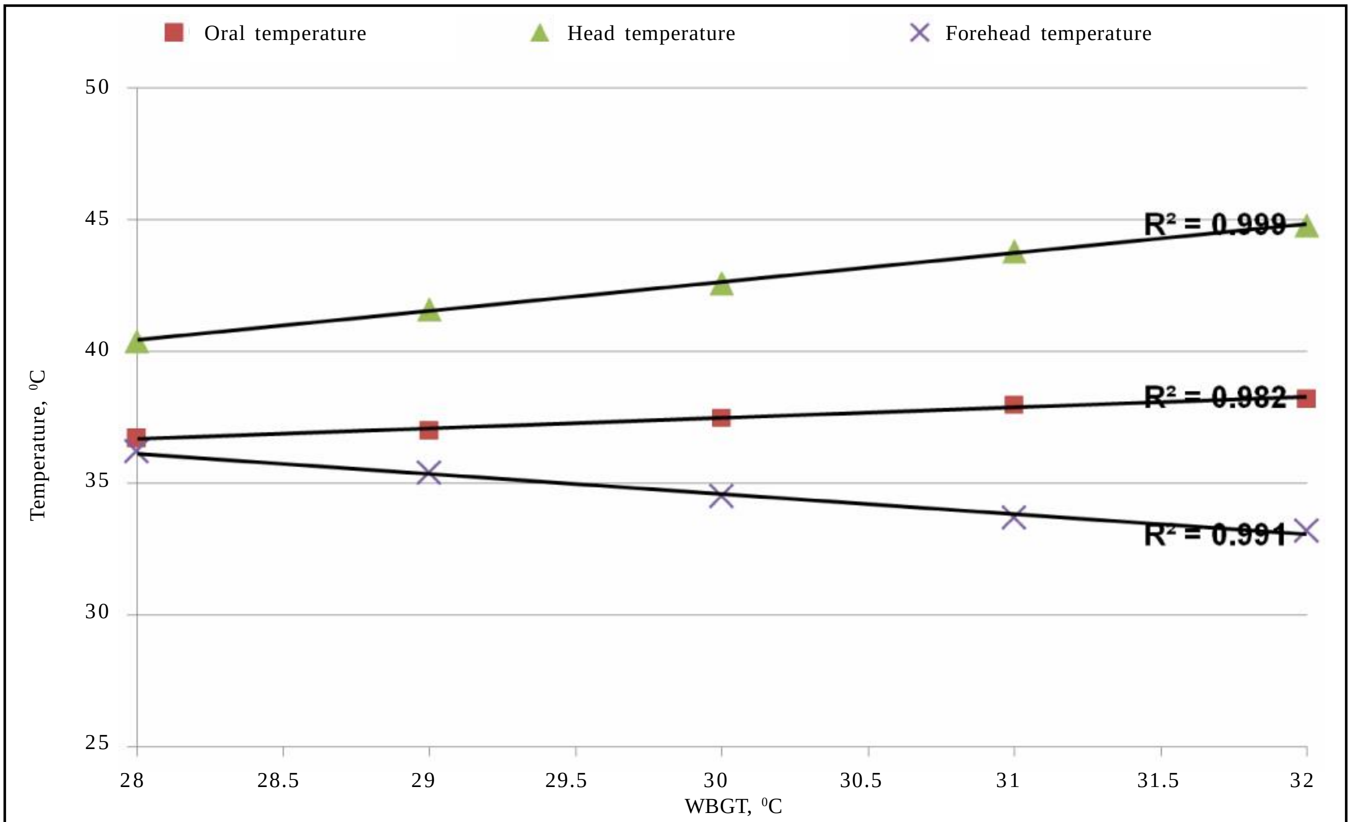

Fig. 1 : Variation of body thermal responses with WBGT

in WBGT.

Statistical analysis of the data was carried out to find out the significance of effect of WBGT on thermal parameters. ANOVA table of thermal parameters and their variance with WBGT is given in Table 2.

It can be seen from the ANOVA Table 2 that skin temperature of subjects significantly decreased with increase in WBGT at 1 per cent level, Oral Temperature of subjects significantly increase with increase in WBGT at 1 per cent level, head temperature of subjects significantly increased with increase in WBGT at 1 per cent level and forehead temperature of subjects significantly change with increase in WBGT at 1 per cent level. The difference of CD at 1 per cent was observed in all the mean values of skin, oral, head and forehead temperature.

Conclusion :

The study conducted on twelve farm workers for assessing the effect of WBGT on body thermal responses reveals that WBGT induces heat stress on the bodies of agricultural workers. The head temperature and oral temperature of workers increased with increase of WBGT from 28 ºC to 32 ºC, while forehead temperature of workers decreased with increase of WBGT due to heavy sweating during agricultural operation of weeding in summer season crop.

Considering this increase in oral temperature which is also considered the core temperature of body, a proper work rest cycle should be developed so that the worker may stop working after an increase of oral temperature of certain range and then shall take rest till the oral temperature drops back to normal. Proper head gear should be introduced so as to reduce the increase in head temperature of agricultural workers during field operations in which they are exposed to direct sunlight.

Authors' affiliations:
A.K. MEHTA AND S.S. MEENA, Department of Agricultural Engineering (Farm Machinery and Power Engineering), College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA

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