Physiological Evaluations of Various Operations in Naturally Ventilated Polyhouse

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Abstract: It has made various stakeholders like farmers, researchers, policy makers and extension agencies to think about how to maintain or increase the food production with vulnerable resources. The aftermaths of drastic increase in population has made food security questionable with increasing challenges and depleting resources. To achieve this goal one has to adopt viable technologies to increase production as well as productivity. Greenhouse technology is one of such technologies in which the environment can be modified to a certain extent so that it allows the plants to grow well in an unfavourable climate. No doubt the greenhouses are considered to be very much conducive during cool and rainy days to work inside expect the warm period of the year due to high temperature as well as relative humidity. Workers often feel uncomfortable especially when they expose to intense physical activities which may be dangerous to their health. Keeping this in view a study was conducted in the Horticultural Orchard of OUAT, Odisha. Six male agricultural workers (age group of 18-40 years) were selected for this study those had a vast experience of working inside Polyhouse or Greenhouse. This study was conducted for a period of 120 days i.e. from January 2015 to April 2015. During this period the inside temperature varied in the range of 210C to 380C and relative humidity 63 per cent to 72 per cent from 9.00 AM to 2.00 PM. Similarly the recorded inside temperature varied in the range of 240C to 360C and relative humidity 25 per cent to 34 per cent at 4.00 PM in the afternoon hours. Different operations like field preparations, digging of pit, weeding, applying irrigation, application of chemicals and harvesting are generally conducted inside the greenhouse but the data was collected for two major operations i.e. weeding and field preparation with a Spade. The ergonomical evaluation of the workers with respect to their working heart rate (WHR), oxygen consumption rate (OCR), energy expenditure rate (EER) and relative cost of work load (RCWL) were recorded. During the cool months from January to February it provided a favorable working environment comprising the inside temperature 3 to 40C higher than the ambient temperature. As the inside temperature started rising from last part of March to April the workers health status were evaluated accordingly. It was observed that the increase in temperature as well as relative humidity inside the greenhouse causing fatigue to the workers. While comparing physiological parameters of the selected subjects the WHR, OCR and EER increased from 112.4 to 140.2 beats min-1, 0.76 to 0.98 l min-1 and 15.9 to 20.5 kJ min-1 between months of March and April. Keeping these parameters in to consideration a safe work rest cycle of 30 min of continuous work followed by 15 min rest was selected to work in the natural polyhouse during the warm period. With this work rest practice the Limit of Continuous Performance, Allowable work load and Relative cost of work load were observed to be within the recommended limit of 40 beats min-1, 35 percent of VO2max.

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Hence it was also recommended to engage the workers in the early morning from 6 AM to 10 AM and 5 PM to 7 PM in the afternoon hours to visualize the climatic condition. Safe work rest practices may be chalked out for other operations like digging of pits, application of chemicals, harvesting, etc. are taken up in naturally ventilated polyhouse.

Keywords: Polyhouse, working heart rate, energy expenditure rate, work rest.

1 Introduction

Agriculture is the backbone of India's economic activity and our experience during the last 50 years has demonstrated the strong correlation between agricultural growth and economic prosperity. The present agricultural scenario is a mix of outstanding achievements and missed opportunities. If India has to emerge as an economic power in the world, our agricultural productivity should equal those countries, which are currently rated as economic power of the world. We need a new and effective technology which can improve continuously the productivity, profitability, sustainability of our major farming systems. One such technology is the green house technology. It is the most practical method of achieving the objectives of the protective agriculture where the natural environment was modified by using some engineering principles to achieve optimum plant growth and yield.

Greenhouses are framed or inflated structures covered with transparent or translucent material large enough to grow crops under partial or fully controlled environmental conditions to get the desired growth and productivity. Generally the structures which are covered with LDPE clear plastic material as well as naturally ventilated are more popular in our country are known was naturally ventilated playhouses/greenhouses or poly-greenhouses. In the North-East those are also called as rain shelters to protect the crops from the high rain fall. They are extremely useful when plants in particular period of the year cannot be grown in open condition or in areas where the climatic never guarantees a good quality crop. The vegetable also fetch good market price when those use to grow in off-season. Vegetable need very high levels of temperature with a peak of 300C and 55 per cent relative humidity but these levels cannot be considered favourbale to agricultural workers who work in this environment.

To prevent workers from taking periodic breaks during warmest months, it is also necessary to control the temperature utilizing shading or mechanical ventilation systems during the day. Here workers are exposed to two different kinds of stress: firstly the long time exposure to severe environmental conditions, according to the standards, secondly the thermal change, when they leave their work site. Prevention against chemicals disease has been the main focus of research earlier but now climatic risks from exposure to heat environment which is increasing has been recognized. Hence the study has been undertaken to evaluate the risk from long period of exposure to unfavbourable environmental conditions of workers inside a natural ventilated greenhouse or polyhouse.

2 Material and Methods

2.1. Experimental Site: The experiment was conducted for a period of four months from 1st week to 14th week of the year in a naturally ventilated polyhouse with a floor area of 100m2, covered with a UV stabilized LDPE plastic film (0.2mmthick). The poly-greenhouse is oriented in a E-W direction in the Campus of college of Agriculture, OUAT, Bhubaneswar; 20° 14′ 0″ N, latitude , and 85° 50′ 0″ E, longitude with an elevation of 25.9 meter above the mean sea-level and nearly 64 k.m. west of Bay of Bengal.

2.2. Collection of climatic data: The climatic data pertaining to the temperature of ambient air, greenhouse temperature and relative humidity of inside and outside of greenhouse were taken. Finally the same were used to evaluate the thermal performance and for the validation of proposed graphs for better understanding.
2.2.1 Temperature: The temperature of the outside ambient air and the enclosed room air of green house or polyhouse were measured with the help of thermometer. It was measured on hourly interval for 12 hour cycle for typical days from January 2015 to April 2015.Weekly average temperature was recorded.

2.2.2 Relative humidity: With increase in the enclosed air temp inside greenhouse the presence of large amount of water at various location results in the rise of relative humidity. The evapotranspiration from the plants, soil water in the ground under normal conditions cause excess water to be present, which rises the relative humidity inside the greenhouse. The high relative humidity inside the house was beneficial in cushioning the impact of very high or low outside temperature to some extent. It has been well established that the optimum level of relative humidity for proper plant growth is around 55per cent which is available inside the greenhouse. The hourly variation of relative humidity for typical days from January 2015 to April 2015 were recorded.

2.3 Measurment of physical parameters

2.3.1 Measurement of heart rate: The polar heart rate monitor was used to measure the resting heart rate and the working heart rate in beats min-1of the workers during the study. The advnatge of using this instrument is that those dates upto 99 hours can be stored in the heart rate monitor and data can be transferred to computer.

Oxygen consumption rate (OCR) of the workers was calculated by using following formula:
OCR (liter min-1) = (0.114 x working heart rate) -0.68

2.3.2 Work rest cycle: For every strenuous work in any field require adequate rest to have an optimum work output. Better performance result can be expected from the workers when proper attention is given for the work rest schedule for different operation.

3 Results

3.1 Temperature: Poly-Greenhouse temperature was very much suitable for the workers

working inside an natural ventilated greenhouse during the cool months of the year i.e. from November – January as it gives a fabourable working environment. During that period the inside greenhouse temperature was found to be more than 2-30C higher temperature as compared to the ambient temperature. But in advancement of weeks i.e. from 8th week of the year which is the last part of February, the greenhouse inside environment started rising. The inside greenhouse temperature in the early hours of the day i.e. from 6 -10 AM varied from 18-300 which was observed to be 3-50C higher than the outside temperature. Similarly during the afternoon hours the poly-greenhouse inside temperature varied from 300-250C i.e. from 4-6 PM. However during the mid hours the inside temperature recorded to be round 400C. Therefore during 8th week the working environment inside greenhouse during early and late hours of the day was found to be acceptable for the workers (Fig.1) Further during advancement of weeks i.e. on 12th week the temperature inside the greenhouse was recorded to be 20-380C i.e. 6 to 10 AM as compared to outside temperature was observed to be 35-300C i.e. from 4-6 PM against 32-270C being the outside temperature. The inside temperature was recorded to be 40C higher than the outside temperature. But the inside temperature recorded to be 400C against 360C being outside at mid hour of the day i.e. 12 noon. Similarly moving ahead to 14th week i.e. month of April the greenhouse inside temperature observed to be 100C higher than the outside temperature both in morning and afternoon hours. The inside temperature at 10 AM recorded to 380C which rise upto even 500C during mid day (1-2 PM). Greenhouse inside temperature was also observed to be 400C at 6 PM while it was 280C outside.

3.2 Relative humidity: The relative humidity which was also recorded during cool months found to be around average 45 per cent inside the natural ventilated greenhouse was conducive for the workers. On the starting of summer i.e. on 8th week (end of February) the inside relative humidity observed to be 60 per cent against 52 per cent outside at 10 AM in the morning. The same was recorded 68per cent and 58per cent respectively at 6 PM. Hence it was 10per cent higher in the both the cases. Similarly in 12th week the relative humidity recorded to be 62 per cent inside the greenhouse where it was 55per cent at outside at 10 AM (Fig.2). The values found to be 66per cent to 58 per cent in the evening at 6 PM . The higher Relative Humidity observed to be higher in the morning session was due to irrigation to the crops. Similarly the relative humidity observed to be more than 50per cent at 10 AM and 6 PM in the 14th week inside the greenhouse.

3.3 Physiological evaluation: Natural ventilated greenhouses give a microclimate upto certain extent that make plants to grown well even in unfavourable condition. Hence during cool months as the temperature rises around 300C than the ambient temperature it was very much suitable to grow vegetables or flowers in the study area which is 60 Km away from the coast. The same greenhouse was also suitable during rainy season which protects the crop very well. Hence growing crops under natural ventilated greenhouse round the year or indirectly to achieve a quick payback period the selection of crop should be accordingly made. One of such alternate is growing some off season vegetable for raising bothvegetables as well as floriculture seedlings/ cuttings round the year or propagation of fruit grafts of mango, cashew, etc. Therefore after 12th week i.e. March-April i.e. summer season as the inside temperature rises around 400C and relative humidity more than 50 per cent it is

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difficult on the physical part of labours to go for different operations under greenhouses. Which was observed for typical operations like digging the soil with a trench hoe/spade or weeding. The maximum heart rate during operation of the workers inside greenhouse even recorded upto 140 and 129 beats/min for the operations like filed preparation and weeding respectively. The corresponding oxygen consumption rate (VO2) calculated for the above two operation observed to be 0.93 and 0.79 liters per minute (Fig.3).

3.4 Sweat analysis: Sweat analysis of a worker can be considered by the weight loss of a person before and after a whole day work. Here in the experiment it was observed the weight loss in the month of January is lowest i.e. 0.7 Kg. During the 3rd week of March and 1st week of April it was observed to be 1.5 and 1.7 Kg, respectively (Fig.4). It showed a good working environment inside the poly-greenhouse is maintained in the months of January and February when the temperature is cool. But during hot days of months March and April continuous work inside the greenhouse showed a higher loss in weight of the worker which should be avoided.

4 Conclusion

During the field investigation the different climatic parameters such as temperature and relative humidity during the summer period (March-April) inside the natural ventilated greenhouse are above a reasonable level of comfort of agricultural workers working inside the greenhouse. Both inside air temperature as well as relative humidity clearly show that the human body is stressed in non-appropriate mode even though the laborers are acclimatized. Working under around 400C temperature and more than 55 per cent relative humidity will lead to a loss of water and mineral salts through remarkable perspiration and breathing which will ultimately may lead to the immediate and remote serious consequences as heat stroke.

Besides this some precautions may be taken up for minimizing the risk.

a) To take the advantage of climatic conditions workers should work earlier in the morning i.e. from 6 to 10 PM and 5 to 7 PM in the afternoon hours.

b) The heavy operations like digging of soil with spade/trench hoe may be taken only for 15 to 20 minutes in the morning session followed sufficient rest.

c) Cotton clothing should preferred by the workers which is comfortable.

d) The workers should be supplied with sufficient water enriched with glucose and salt to overcome the exertion during the summer.

e) Both the sides of the naturally ventilated greenhouses should be opened intermittently so that excess temperature and humidity can be replaced due to natural ventilation.

f) The easiest technological solution to avoid these dangerous lies in drastic reduction of solar energy entering to the natural ventilated greenhouse during summer period of the year by providing a shade net over the greenhouse . This shade net should be of a pull over type which will be used during summer period and the rest of period it will be drag out so that required solar energy can be used for greenhouse production.

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Fig.1 Average temperature and relative humidity inside greenhouse during 8th week

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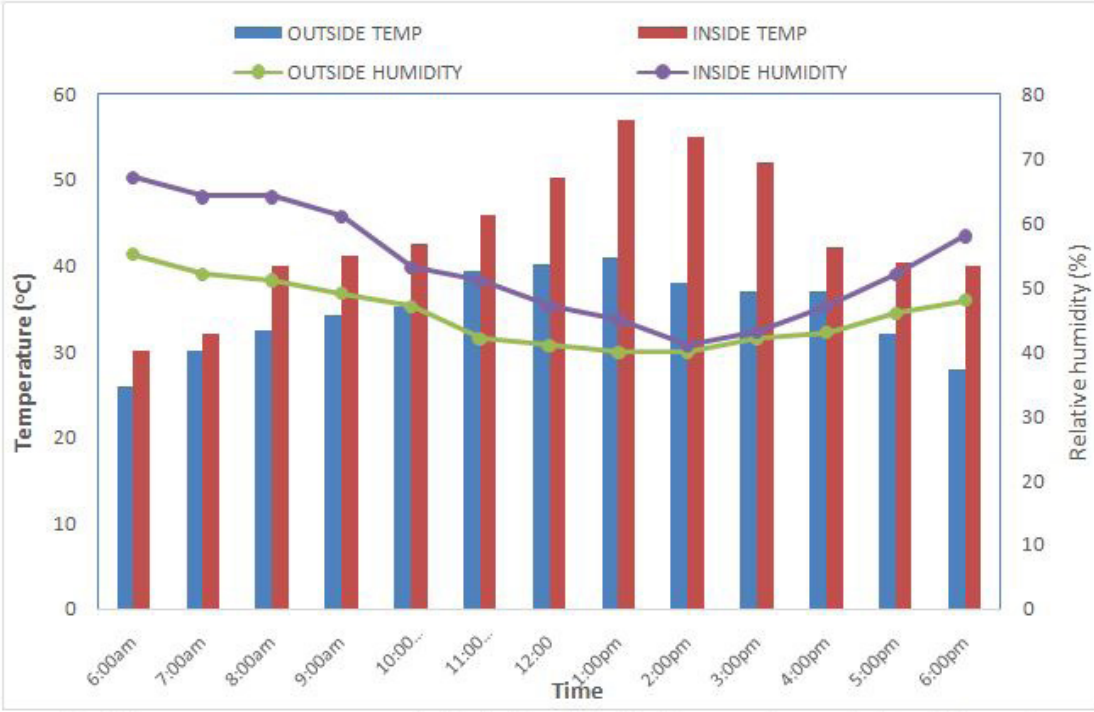

Fig. 2 Average temperature and relative humidity inside greenhouse during 14th week

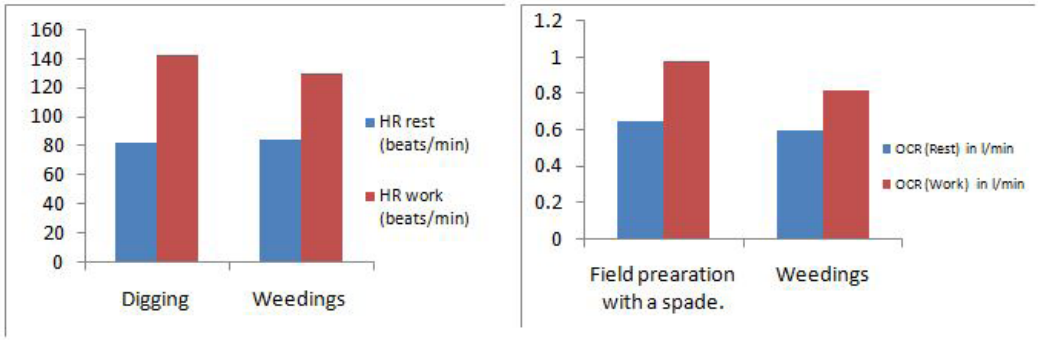

Fig. 3 Physiological parameters during two major operations inside poly-greenhouse

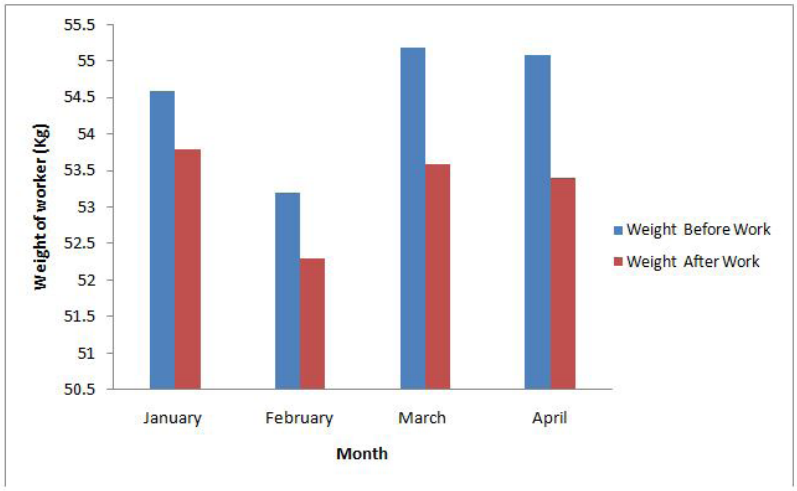

Fig. 4. Weight of worker before and after work in a particular day of different month.