TECHNICAL REPORT

D3.6: Report on solutions to mitigate heat stress for workers of the agricultural sector

Nathan B. Morris[1], Tord Kjellstrom[1], Leonidas G. Ioannou[2], Chuansi Gao[3], Marco Morabito[4], Alessandro Messeri[4], Miriam Levi[5], Alberto Baldasseroni[5], George Havenith[6], Josh Foster[6], James Smallcombe[6], Lars Nybo[7], and Andreas D. Flouris[2]

[1]Centre for Technology Research and Innovation (CETRI Ltd), Lemesos, Cyprus.
[2] FAME Laboratory, Department of Exercise Science, University of Thessaly, Trikala, Greece;
[3]Ergonomics and Aerosol Technology, Lund University, Lund, Sweden;
[4]Centre of Bioclimatology, University of Florence, 50121 Florence, Italy;
[5]CeRIMP - Local Health Unit Tuscany Centre, Florence, Italy;
[6]Environmental Ergonomics Research Centre, Loughborough Design School, Loughborough University, Loughborough, UK;
[7] Department of Nutrition, Exercise and Sports, University of Copenhagen, Denmark;

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SUMMARY (overview of identified issues and screened solutions)

European workers in the agricultural sector are seasonally exposed to heat stress that affects productivity (with ~ 0.7% lost efficiency per degree increase in air temperature above 21°C) **and potentially threatens individual health if appropriate precaution procedures are not adopted. This report is dedicated to providing guidelines with screened (effective, feasible and sustainable) solutions and strategies to mitigate or minimize negative effects of excessive heat exposure.**
Occupational heat strain (OHS) in the agricultural sector involve high body internal heat production associated with physically demanding tasks, seasonal exposure to outdoor conditions with high ambient temperature, humidity and solar radiation levels or indoor settings with limited ability to lower the environmental heat load (i.e. traditional cooling solutions are not applicable). Furthermore, specific settings (e.g. greenhouse work) or task with safety requirements such as wearing protective clothing may hamper heat loss and worsen heat stress.
It is advisable that agricultural firms, from large industrial operations to small family farms, consider/develop an appropriate heat response plan as it will benefit both employer and employee perspectives. Single or combined heat resilience methods appropriate/applicable for the specific work setting should be identified and translated into feasible actions and habits that workers can adopt during hot periods – with timely information at the beginning of the summer and regular follow-up reminders.
Importantly, workers must be allowed time to adapt to the heat. Workers will acclimatize to heat during the first days, however depending on the initial fitness and previous exposure it will take at least one week before workers get used (physiological adapted) to the increased heat.
Staying hydrated is critical for maintaining productivity and health; but workers routinely fail to rehydrate from day-to-day. Thus, more than 50% of agricultural workers arrive at work with inadequate/low hydration status, which is problematic, because heat-exposure combined with dehydration markedly impairs cognitive and physical performance and increase physiological strain. **This means they start the day at an elevated risk of heat intolerance and reduced performance.** To best correct this problem, workers should drink at least 500-750 ml (two cups of water) before work, during a mid-day break and after work, in addition to drinking water regularly throughout the day whenever thirsty. To ensure adequate hydration status, workers can self-monitor by ensuring they are drinking sufficiently to need to urinate approximately once every two-three hours and that their urine remains clear or slightly yellow. During periods where workers are sweating profusely, healthy workers should add a larger amount of salt (electrolytes) to their diet, however, this advice should only be followed by doctor's recommendations in those with heart, blood pressure, or other medical conditions.
Additional breaks can be planned and included without compromising the net/effective working time (e.g. 1-2 min, every 30 min)**.** Adding, preplanned work breaks during periods of hot weather has been demonstrated to improve worker health, wellbeing and comfort without reducing net worker productivity. This is because when workers overheat, they begin to work slower and take more frequent unplanned breaks, whereas taking preplanned breaks allows the workers to cool down and limit becoming overheated. These preplanned breaks should be undertaken in **shaded areas with plenty of ventilation**. Although air conditioning is the most effective method for reducing environmental heat stress, it is often prohibitively expensive, cannot be employed in the field, and detrimental to the environment. However, it can be employed more efficiently by cooling specific "cooling oases" such as small rooms or utilizing the air conditioning of workers' cars. The efficiency of air conditioning can be further improved by using it with ventilation and by limiting the amount and/or thickness of clothing worn while in the cooling spaces, in which case the air temperature need only to be lowered to ~26-28°C to be highly effective.
Cooling interventions can be applied during breaks to further lower physiological strain and improve worker performance. Several interventions have been identified which have been demonstrated to be effective at lowering physiological strain and improving performance during periodic breaks. These include immersing the arms up to the elbow in tubs of cool water, ingesting cool water or slush ice, applying ice wrapped in wet towels to the neck, wetting the skin while sitting in front of a fan or wearing a phase change material cooling vest (i.e. vests filled with cooling gel packs or ice). It should be noted, each of these interventions vary in effectiveness, cost and feasibility (discussed below) and employers should consider which interventions make the most sense for their given work environment.

Some interventions can be used during work as well. For workers that have to undertake very thermally demanding tasks (such as spraying pesticides in chemical protection suits) pre and intermittent cooling with more effective but less feasible and more costly methods, such as consuming large volumes of slush ice, wearing phase change material cooling vests, or precooling limbs through water immersion may be warranted. Additionally, if a task requires the person to be somewhat immobile in very hot environments for extended periods of time, liquid and air-cooled garments are available and are very effective, however, they are also very costly. For the majority of farmers who do not wear special chemical protective clothing, but need great mobility during work, clothing incorporated with ventilation fans is beneficial and is a preferred solution.

Appropriate clothing can lower the thermal stress. Some tasks require special protective clothing and clothing is also beneficial for protecting the agricultural worker from excessive sun exposure, but clothing can also limit heat loss as it provides a boundary layer that limits evaporation and convective and radiative heat loss from the skin**.** To facilitate heat loss, clothing worn during the work shift should be selected based upon promoting air flow across the skin and improving sweat evaporation (reducing clothing evaporative resistance). This can be accomplished by reducing the total amount of skin covered by clothing via wearing a t-shirt vs long sleeve (if indoors), wearing looser fitting clothing which allows for greater air flow underneath the clothing, and wearing clothing with a wider knitting pattern which allows for more air flow to pass through the clothing. Otherwise, novel ventilated garments can be worn which provide an elevated amount of cooling relative to standard clothing, facilitated by air flow underneath the clothing. Additionally, in outdoor environments on sunny days, hats should be worn to protect the head from solar radiation but designed and made of materials that allow for adequate air flow. In situations where long, rigid clothing must be worn (e.g. coveralls), ventilation patches can be incorporated into more protected areas such as under the arms and between the legs to help promote air flow through the garment. Finally, recent research suggests a cooling benefitted from using new generations of synthetic “sweat wicking” fabrics in lieu of natural fabrics, however, compression garments should be avoided.