HEAT TREATMENT DURING MICROSPOROGENESIS AFFECTS THERMO-TOLERANCE AND ONTOGENESIS OF TOMATO POLLEN

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Introduction

Pollen functionality is essential for the successful reproduction of all plant species and therefore plays a key role in the crop species cultivated to produce seeds and /or fruits. Within the Mediterranean region, the alternation of the seasons has characterized the traditional cultivation calendar and determined whether a crop must be cultivated in protected environment or in open field. Within the current scenario of climate changes, in addition to the gradual global warming, also extreme weather events such as heat waves, are becoming more intense and frequent rising the risk of catastrophic losses of crop productions. According to the World Meteorological Organization, a heat wave is a period of five or more consecutive days during which the daily maximum temperature surpasses the average maximum temperature by 5 °C or more. In this framework, more studies on the effects of heat waves on plant reproductive processes are claimed. Previous experiments showed that heat treatments on mature pollen negatively affect pollen viability and germinability of several crop species (e.g., Hedhly et al. 2009; Mesihovic et al. 2016). Differently, we aimed to study pollen thermo-tolerance comparing the effect of a heat treatment exerted during microsporogenesis with that applied during microgametogenesis. We hypothesised that all the heat-induced defects during microsporogenesis may strongly affect the progression of male gametogenesis and therefore, the correct formation of mature pollen. In this work we used *Solanum lycopersicum* 'Micro-Tom', a dwarf variety of tomato selected for experiments in space and quite convenient for cultivation in small and highly controlled growth chambers. Specifically, we tested if high temperature occurring during microsporogenesis can affect pollen formation and subsequent functionality of the male gametophyte.

Materials and Methods

The experiment was performed in two VELP® growth chambers and we ensured that the plants were exposed both at optimal (22 ± 1°C) and at high temperatures (30 ± 1°C) only during microsporogenesis. To compare the effect of the two microsporogenesis temperatures on the subsequent pollen functionality, we evaluated pollen viability and germinability after further 72 hours of in vitro pollen incubation at 22°C and 30°C.

Results and Discussion

Data showed that pollen whose microsporogenesis occurred at optimal temperature, resulted more thermotolerant to the following exposure to both higher and optimal incubation temperatures. Conversely, 30°C temperature at microsporogenesis drastically reduced percentage of microspores developing into viable pollen grains. Effects of high temperatures were even more severe on pollen germinability and in fact, heat-treated microspores developed into not germinable pollen. Germinability of pollen developed at optimal temperature increased along flowering and reached the maximum percentage at anthesis. These results were deepened by additional cytological analysis in which we assessed that the highest germination percentage corresponded to the bi-cellular stage that in the control treatment occurred at anthesis. Indeed, tomato pollen is dispersed as bi-cellular gametophytes and the second mitotic division only occurs after germination on the stigma. In the high temperature treatment, all the developmental stages resulted shifted forward compared to the control. In particular, the transition into the bicellular stage representing the condition of mature pollen had already occurred before anthesis. We thus hypothesize that high temperature during microsporogenesis also cause a premature transition of microspores into bi-cellular pollen to ensure mature pollen formation ready for dispersal but reducing pollen lifespan throughout flowering. Therefore, both direct effects of high temperatures during microsporogenesis and pollen lifespan reduction throughout flowering can be responsible for a drastic loss in pollen viability and germinability.

Conclusions

Overall, results revealed that temperatures slightly higher than the optimum during the earliest stage of pollen development, can be crucial for pollen viability and consequently reproductive success. Results also highlighted that short period of high temperature can accelerate pollen senescence processes by shortening gametophyte lifespan so that pollen is already unviable before pollination.

References

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