Arbeitsgemeinschaft Tropische und Subtropische Agrarforschung (ATSAF) e.V.
Council for Tropical and Subtropical Agricultural Research

ATSAF Academy
Academy for International Agricultural Research for Development

Junior Scientists Tandems
Final Report

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Title: The role of spikes in wheat adaptation to short-term heat waves

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Arriving at the University of Hohenheim

My arrival in Germany was scheduled for the first week of October 2023. Upon reaching the Institute of Agricultural Research in the Tropics, I was warmly welcomed by the team. Introductory guidance was given by Dr Alejandro Pieters, I had the opportunity to familiarize myself with the roles of the technical staff and professors within the institute, as well as the facilities and laboratories. General meetings were scheduled throughout the week by Prof. Dr Folkard Asch for project updates from the members of his research group.

One of the most rewarding experiences during this period was participating in the seminar of the group. Presenting in these seminars allowed me to professionally introduce myself to the research group, outlining my role, objectives, and project, as well as sharing previous research findings. Also to know the different projects carried out by other students in the group. This experience was invaluable as it provided an opportunity to receive feedback from individuals with greater experience, as well as suggestions and support.

Connections and networking

I had the opportunity to establish connections with different research groups within the university. At the Institute of Plant Breeding, in my first weeks, I interacted with Prof. Dr Friedrich Longin, the wheat pre-breeder at the University of Hohenheim. We discussed the activities in his research group, and he kindly introduced me to his assistant, who had previously worked in another CGIAR center, ICARDA. We had an interesting talk about projects conducted at ICARDA and the similarities between CIMMYT and that research center.

Dr Longin extended an invitation to the plant breeding symposium, held on October 24th and 25th, 2023 (https://breedingsymposium.uni-hohenheim.de/en). At the symposium, I had the chance to meet professionals and students in the field, as well as listen to engaging presentations. This experience motivated me and made me appreciate more the work I was conducting at CIMMYT as a research assistant.

During the symposium, I met individuals involved in local plant breeding companies such as KWS and Corteva Agriscience. Engaging in discussions and introducing myself to them was a valuable opportunity. A presentation by Dr Carus John-Bejai (KWS, UK) particularly resonated with me, as he emphasized the necessity of taking bold steps and thinking outside the box regarding breeding which is commonly managed as a straightforward process. This message stuck with me, especially considering the context of the symposium on plant breeding.

Subsequently, I visited other professors within the university, including Prof. Dr Karl Schmid, who works on the biodiversity of crops and plant breeding. Prof. Dr Sandra Schmöckel, who focuses on physiological stress in crops, and Prof. Dr Hans-Peter Piepho, who specializes in applied biostatistics in crops. Visiting each of their research teams allowed me to gain insights into their projects, engage in discussions about ideas, and know the projections in their respective field of research, but more importantly than that listen to their professional recommendations. These interactions enriched my understanding of various aspects of plant science and provided valuable networking opportunities for the future.

Research project

The overall goal of the research project is to evaluate wheat spring wheat genotypes selected for their tolerance of chronic field heat stress to a short-term heat wave in a controlled environment, identify genetic variation for this type of heat stress in plant cooling traits but also to develop a phenotypic approach for spike transpiration.

To begin with the experiment, it was crucial to evaluate the capability of plant growth chambers and determine if it was feasible to simulate a heat wave in conventional chambers. To achieve this, we searched previous information in the literature and developed a temperature curve as a multi-step program (Figure 1) within the chamber to mimic normal field temperatures in the northwest region of Mexico, where these genotypes have been grown, we also installed temperature and humidity sensors inside the growth chambers to assess temperature increases and the feasibility of the treatment. The first program was for growing plants from emergence to flowering (vegetative program). Once the plants reached the flowering stage, we adjusted the temperature curve to reflect the temperature typically encountered during grain filling (grain filling program). Additionally, we introduced another temperature curve to simulate a heat wave, in this specific program the temperature was increased to 38°C for 4 hours over 5 consecutive days (heat wave program). Following the 5-day heat wave treatment, the plants went to normal growth conditions with the grain filling program.

Plants were grown in a hydroponic medium for this experiment, and the arrangements were made by boxes (blocks) of 6 x 4 plants each, the 8 genotypes were established randomly within the box, 3 times to increase the number of individual plants. Hydroponic medium was replaced completely every 2 weeks during vegetative stages, and every 1.5 weeks for grain filling stages.

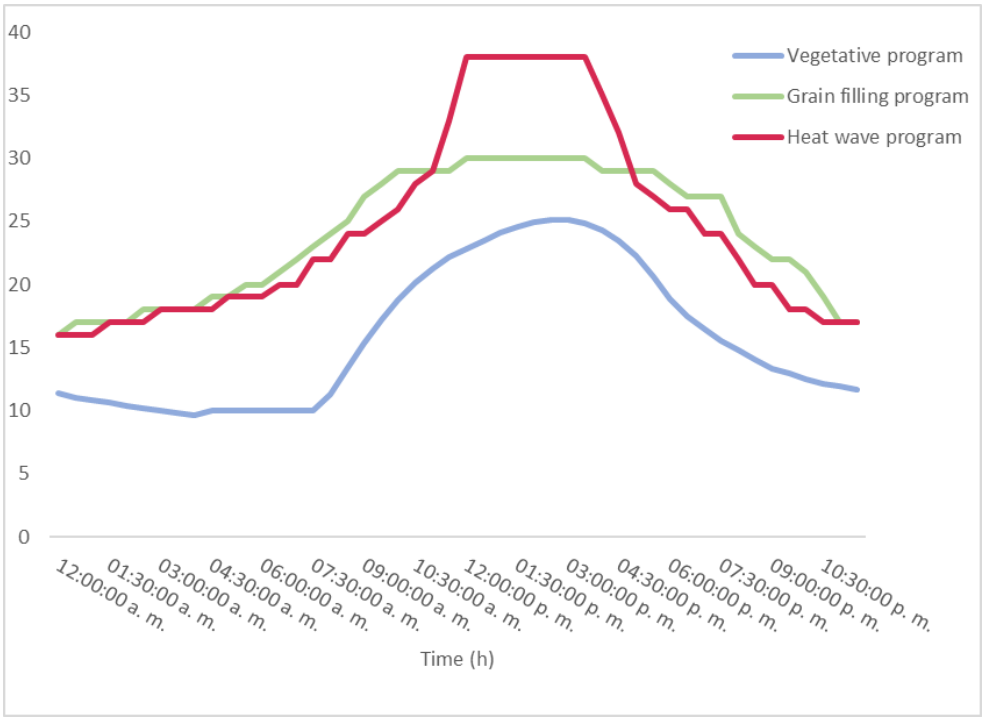

Figure 1. Multi-step programs used in the growth chambers to simulate the temperature conditions.

An important part of the experiment was to develop a small sealed chamber that can be connected to infrared gas analyzer (IRGA) equipment to estimate gas exchange in 3-dimensional parts of plants as the spikes. In this case, our prototype is a cylinder made of transparent acrylic plastic, the 2 side apertures are sealed with O-rings to avoid Co2 leaks, and inside the cylinder, a small fan is connected to an external battery to create a more homogeneous distribution of Co2 introduced in the cylinder chamber by the IRGA (Figure 2). We performed some tests with the GFS-3000 from WALZ using a thermocouple placed in the middle of the spike to have organ temperature readings that will allow us to do correct estimations. Some measurement points were collected and sent to WALZ technical support for feedback and technical aspects.

Fluctuations of Co2 have logically behaved in the system while increasing or blocking the light and also by increasing the temperature inside of the growth chamber. All of these observations suggest a positive result by implementing this homemade cylinder chamber to estimate the assimilation rate on wheat spikes.

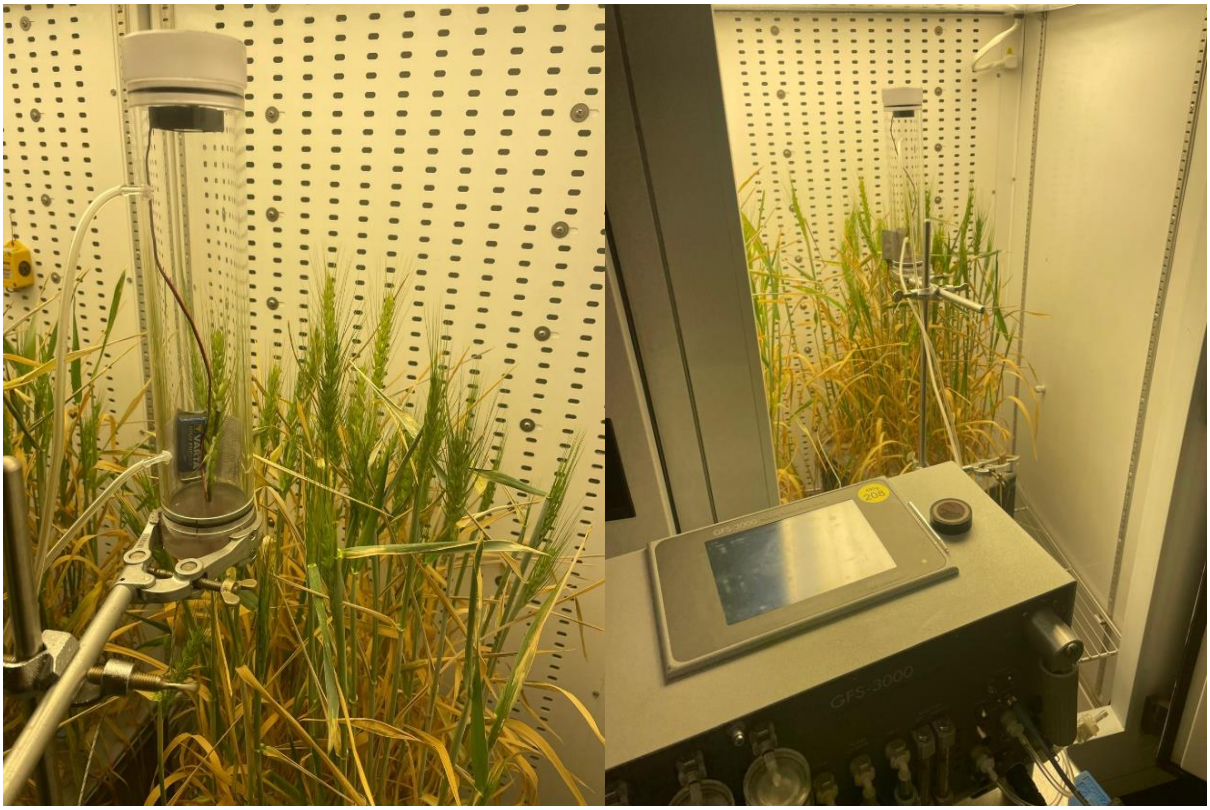

Figure 2. Cylinder prototype connected to the GFS-3000 for gas exchange measurements.

Exploration of stomata was made by implementing the same methodology of stomata impressions used commonly in leaves to the spike structure (glumes of the spike) to analyze the structure in a microscope connected to a camera (Figure 3) to analyze stomatal density and compare data collected from leaves.

Future research will be carried out to evaluate the transpiration system in wheat spikes combining these methodologies, and gas exchange will help us to understand the performance of spikes under heat stress and potential traits to incorporate in breeding schemes.

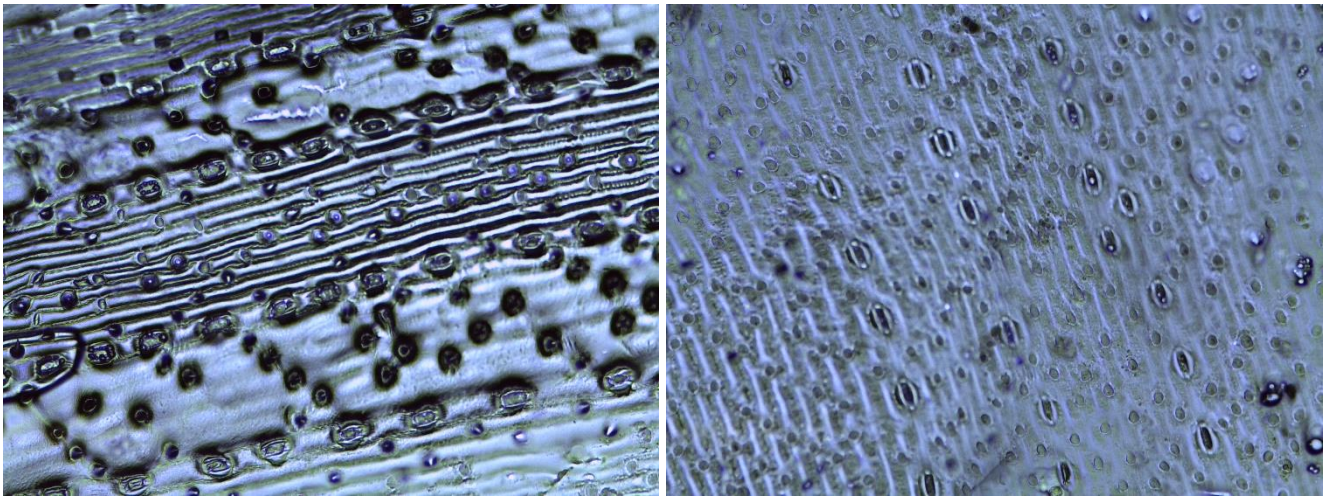

Figure 3. Stomata impressions analyzed in the microscope. From leaves (left) and spikes (right).

Acknowledgment

I would like to acknowledge the ATSAF JST team for providing me with the financial support and the opportunity to participate in this program. It was an invaluable experience working in an international research team. I ended up inspired to grow personally and professionally. I think interacting with different cultures always gives you an interesting way of comprehension but also a different way of thinking. I am especially thankful for the chance I had to connect with individuals from different research areas in the seminars or symposiums offered by the university.

The experience in the JST program helped for better decision-making in my next steps in research and helped me to make more important decisions in my future, personally and professionally.