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ATSAF - CGIAR++ Junior Scientists Program Final Report

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Final Report Anna Sauer

In this report I want to inform you about my stay at the International Crop Research Institute for the Semi-Arid Tropics ICRISAT in Patancheru, Hyderabad, India. From 17th of September 2018 to 16th of February 2019 I joined the Crop Physiology Group under supervision of Dr. Jana Kholóva as an Intern to do research for my master thesis. It was part of a joined project between the German universities Bayreuth and Göttingen and the Crop Physiology Department of ICRISAT.

Aim of the project is to do research on drought adaptation mechanisms and nutrient uptake in multiple varieties of Sorghum. To observe this I conducted an experiment with five genotypes – the commercial variety M35-1 and four landraces from Africa and India. These were grown under controlled conditions in the lysimetric facility of ICRISAT. The area is covered by the "rainout shelter", a movable roof which protects the experimental site from exposure to any rain and is opened during dry weather. The lysimetric facility itself consists of eight pits with 2 and 1.2 m depth, where thousands of PVC-tubes filled with soil and closed at the bottom by a plate can find space. They have various diameters, soil types and phosphorus contents. Therefore, depending on the examined crop, controlled conditions can be created where even the crop density roughly represents the usual field conditions. For the soil experiment 200 cylinders with 2 m length were used, each 50 of them with the respective soils: Alfisol, Vertisol, Sandy Loam and Loamy Sand (the last two are mixtures of Alfisol with lower and higher amounts of sand). Additionally 60 lysimeters with 1.2 m length and a smaller diameter were used to grow 15 more plants for each soil type and examine their root development and three different growth stages.

The project was started in July 2018 when two German students from Göttingen University came to cultivate Cowpea plants on half of the soil experiment. Those were regularly injected with isotopic Nitrogen (15N), as these plants can fix Nitrogen in the soil. Aim of this part of the experiment was to determine the Nitrogen uptake from different sources. Contrary to the organic source from the cowpea we later fertilized the other half of the experiment with mineralized 15N. After harvesting the Sorghum it will be possible to examine the Nitrogen uptake by the plants by testing for the 15N in the different treatments. Upon my arrival mid of September 2018 the Cowpeas were ready to be harvested, dried, milled and packed to be sent to Germany, also for 15N analysis.

To start the Sorghum experiment several preparations needed to be conducted. First, in about two thirds of the overall 200 big lysimeters soil samples were taken with an auger. Each sample was divided into subsamples, always according to certain depths. All samples were frozen at -80° C to ensure that no reactions can take place, as they were stored for later analysis for mineralized and isotopic Nitrogen. In 40 of the lysimeters (10 per soil type) one meter long tubes were installed to conduct soil moisture measurements during the later ongoing experiment. After taking soil samples and installing the tubes all remaining holes had to be filled with the respective soil type.

1 Soil sample of Alfisol

Then the preparations for sowing could take place. The top soil was mulched, fertilized with DAP and watered. After testing the different genotypes for their germination rate in the lab and proofing they were of good quality for each lysimeter one package of seeds was packed. According to a randomized layout those were distributed and the sowing could take place mid of October 2018. To ensure ending up with at least one healthy plant per cylinder, four seeds were sown in each lysimeter.

2 Sorghum plants two weeks after sowing

After sowing and during the first days after germination the seedling were watered daily with small amounts of water to ensure healthy growth despite the hot climatic conditions. The germination dates were recorded and if necessary in some exceptions I did resowing and transplanting until at least one healthy plant was growing in each cylinder. After decreasing the number of plants with the initial thinning to two plants per cylinder shortly before starting the main experiment final thinning took place. Furthermore, nutrition deficiencies were detected and fertilizer provided as needed. Additionally, plant health was maintained by continuous monitoring of the seedlings and application of pesticides and fungicides.

Once the majority of the plants had reached five leaf stage (meaning five fully developed leaves) the experiment could be started. First all the lysimeters were saturated step by step in the evening, to avoid any enhanced evaporation from the soil by the sun. Second, on the next day early morning a bit more water was added, then a thin layer of plastic sheet and on top of that a 2-3 cm thick layer of small plastic pearls. This was necessary to prevent any further water loss due to evaporation. Then the cylinders were left again over night to drain any excess water which might be still there, as draining some of the lysimeters could take a while and they might have still been oversaturated. Third, on the next day the experiment was started by weighing each of the cylinders. This could be done with a hanging balance

attached to a rolling device which could take up the lysimeters with two hooks at the sides, connected to the balance. This hard work handling the up to 160 kg heavy cylinders could only be done with the help of four men and was repeated weekly. Any weight loss from week to week could now be related to transpiration of the plants.

3 First weighing after saturation and application of plastic coverage

At this point all the other measurements started as well. Simultaneously to weighing also the soil moisture was measured weekly with the TDR (Time Domain Reflectance) method, using the small tubes which were installed before sowing. This was conducted in 7 different depths up to 95 cm deep to monitor the distribution of water in the soil over time. Every second week the plant development was noted by measuring the plant height and the numbers of developed, still developing and already senesced leaves. Especially towards the end these data could show the impact of the drought stress on the plant health. Additionally we measured the leaf area of all developed leaves from leaf five upwards, including the leaves of possible tillers (side branches additionally to the main plant). The flowering date of each individual plant was also noted.

4 Experiment during flowering time

Besides taking down data other management needed to be done. After reaching about 1.5-2 m height the plants needed to be secured to rods to prevent them from falling. If necessary more pesticides were applied to exclude the influence of any pathogens. Furthermore, after flowering the panicles were packed into thin, transparent nets to prevent any birds or small animals from eating the harvest.

Finally end of January the harvest could take place. For this we ensured that the majority of panicles each genotype in each treatment was ripened. The plants were cut and the stem diameter above ground was measured. Then the plants were separate into stem, leaves, panicle and if necessary tiller stem, leave and panicle. All bags were placed in dry ovens at 60° C and fully dried. Then the dry weight of the

different biomass compartments was weighed. The panicles were then threshed and the seeds weighed again, then counted. Afterwards all individual plants parts were milled, subsamples taken and those packaged and sent to Germany to conduct further analysis.

After harvesting all plants the cylinders were weighed again to measure the dry weight without plants. Then all the plastic coverage could be removed and a second round of soil samples was taken in the same cylinders as before the experiment in order to monitor the development. These samples were again frozen and analyzed in the same procedure as in the beginning.

5 Panicles of two different Sorghum varieties

Besides the main experiment 60 additional plants were grown in smaller cylinders, 15 plants for each soil type. These were harvested during three extra harvests, which were defined by different plant stages. In each extra harvest one plant per genotype and soil type were harvested. The first time point was shortly after saturation and the start of the experiment in order to generate some initial data. The second harvest was conducted during flowering, where the root system is expected to reach its peak biomass. Finally, the third harvest was conducted at the same time as the final harvest after ripening. The harvest of the plant itself was carried out in the same procedure as for the main experiment. Then additional soil samples were taken and all the soil was washed out of the cylinder to isolate the roots. These were collected and later scanned to examine factors like the total root length and the distribution of different root types.

6 Washing out the soil to isolate the roots

Apart from the soil experiment there was another experiment examining high and low Phosphorus input under well-watered compared to water stressed conditions. For this experiment the same measurements were done. To ensure that the workload was manageable with two experiments at the same time two Indian students were helping as part of their mandatory internship during their bachelor studies.

Summing it up, there were different stages throughout the experiments and various kinds of tasks to master during these months. In general the work could be divided in three parts. The first step was usually management and scheduling of work, including organization of labors, necessary materials and the timing of the field work. The second and most time consuming step consisted of multiple measurements and tasks to care for the plants. Third, there was as well office work, mostly made up by data management, sample processing and analysis.

Besides my own project I also got the opportunity to see a lot of other projects which are run at ICRISAT. It was always very interesting to join the colleagues and get to know more about their research. Outstanding of all of them was a trip to the area around Adilabad, which is located in the north of the state. My department collaborated with a nongovernmental organization working. We brought different varieties of Sorghum to be grown on local field, managed by their respective owners and also did interviews with the farmers. The scientists hope to get insights on what the farmers like in the various genotypes and asked them about their opinion again after the harvest. It was an important reminder about the greater purpose of the research and an interesting interaction with the farmers.

Apart from work the ICRISAT campus is a very good place to live and work. It consists of an enormous area of arable land, besides a few lakes and forests which are important habitats for a lot of birds and other animals. All the important buildings are located within a small area, making it very convenient for everyone living on campus to move from work to the canteen, the rooms or free time activities. In general there is a very nice, international community of students living there, which makes it easy to find social contacts and have cultural exchange with people from all over the world. Also the mostly Indian colleagues in the department were really nice and welcoming to everyone joining.

Overall, working in ICRISAT and conducting these experiments was challenging, especially in terms of managing the different ongoing tasks in a good time frame and fulfilling all necessary requirements while not wasting too much time for unnecessary steps. Nevertheless it was a great experience to be surrounded by specialized scientists who were there to help with any problem and helped me to make a lot of progress in my scientific approaches and knowledge of methods. Furthermore I learned a lot about organization and management of experiments and interaction with scientists, technicians, students and workers.

My next steps now are working with the data and then starting to write the master thesis. I am very grateful for having the opportunity to not only grow on a scientific level during this thesis, but also on a personal one. I would like to thank ATSAF and GIZ very much for making this possible with their support.