

## **Tef Improvement Project: Promoting Research and Development of an African Understudied Crop**

Tef [*Eragrostis tef* (Zucc.) Trotter] is a cereal crop of significant importance in the Horn of Africa, particularly in Ethiopia where it is annually cultivated by over six million smallholder farmers on about three million hectares of land<sup>1</sup>. The crop is a staple food for about 50 million people in Ethiopia alone. Compared to other cereals, tef is tolerant to extreme environmental conditions especially to water-logging which gives it a unique position to perform well on poorly drained soils. Unlike other cereals, the seeds of tef can also be safely stored without losing viability since the grains are resistant to attack by storage pests<sup>2</sup>. Tef is nutritious and, due to the absence of gluten and a relatively high mineral content, it is considered to be a lifestyle crop<sup>3</sup>. In general, tef provides quality food and grows under marginal conditions, poorly suited to other cereals.

Despite its versatility in growing under diverse agro-ecological conditions, the productivity of tef is extremely low mainly due to its susceptibility to lodging and the region's widespread drought problem (Fig. 1A & B). Tef possesses tall and weak stems that easily succumb to lodging caused by wind or rain. In addition, lodging hinders the use of fertilizer to improve the yield as its application results in severe lodging. A consequence of lodging is that both the yield and the quality of the grain and the straw are severely reduced.

### **Tef Improvement Project: goals and strategy**

The Tef Improvement Project was established in mid-2006 with the financial support of Syngenta Foundation for Sustainable Agriculture and the University of Bern, and is hosted at the Institute of Plant Sciences, University of Bern. The main goal of the project is to boost the productivity of tef by tackling major production constraints through developing cultivars with desirable agronomic traits.

To ultimately deliver the intended output to farmers in Ethiopia, we designed a strategy of technology generation and technology transfer. At technology generation, the project applies modern genetic, molecular and genomic tools to improve important traits in tef. High-throughput techniques such as TILLING and EcoTILLING<sup>4</sup> as well as techniques related to molecular markers such as RAD, GBS and SSR<sup>5</sup> are also implemented in order to develop markers related to traits of importance. Our sequencing of the whole tef genome and transcriptome supports the molecular-based methods of crop improvement. The result of this technology generation, non-GMO new candidate tef cultivars, are then transferred to the partners in Ethiopia for introgression to locally adapted cultivars and for multi-location field-testing before release to the farming community.

### **Stakeholders of the project**

The project has established partnerships with institutions in Switzerland and Ethiopia in order to promote the research and development processes. The financial support from Syngenta Foundation, SystemsX.ch and the University of Bern, and the hosting of the Institute of Plant Sciences are the cornerstones for the

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<sup>1</sup> CSA (2014) Agricultural Sample Survey for 2013/14. Central Statistical Agency Bulletin, Addis Ababa, Ethiopia.

<sup>2</sup> Ketema (1997) Promoting the conservation and use of underutilized and neglected crops. 12. International Plant Genetic Resources institute, Rome.

<sup>3</sup> Spaenij-Dekking *et al.* (2005) New England Journal of Medicine 353:1748-1749.

<sup>4</sup> TILLING (Targeting Induced Local Lesion IN Genomes) is a non-transgenic method. Tadele *et al.* Molecular Techniques in Crop Improvement (2009).

<sup>5</sup> GBS (genotyping by sequencing), RAD (restriction site-associated genomic DNA), SSR (Simple Sequence Repeats)

project. The collaboration with the Ethiopian Institute of Agricultural Research (EIAR) has enabled us to evaluate the performance of candidate lines *via* field-testing in Ethiopia. The collaboration with EIAR also focuses on capacity building especially through provision of short- and long-term trainings, and exchange of research materials. We also collaborate with Regional Agricultural Research Institutes in Ethiopia to develop tef cultivars tolerant to acid soil, and with Addis Ababa University (Ethiopia) to teach and supervise students. The tef genome and transcriptome sequencing and analysis has been done by the partnership with public and private organizations including Swiss Bioinformatics Institute in Lausanne, Functional Genomic Center in Zurich, MWG in Germany, Macrogen in South Korea, Fasteris at Geneva. Our project also uses modern greenhouse facilities of Syngenta AG at Stein for phenotypic screening of candidate lines. In general, the collaboration established by the project involves a proto-type of private-public partnership (PPP).

### Achievements and expected impacts

The application of diverse techniques allowed us to obtain several lodging tolerant and/drought tolerant lines. Most of these candidates were introgressed to locally adapted cultivars and were tested at 15 locations in Ethiopia where they showed outstanding performance. Among these, the semi-dwarf and lodging tolerant cultivars called *kegne* (Fig. 1C) and *Zeru* performed well at diverse agroecology and received high acceptance by farmers. Two candidates for drought tolerance (Fig. 1D) were also crossed to tef cultivars and soon will be tested at diverse drought-prone areas in Ethiopia. In addition, our group led an international group of researchers to sequence and publish the first genome of this vital crop of developing country.

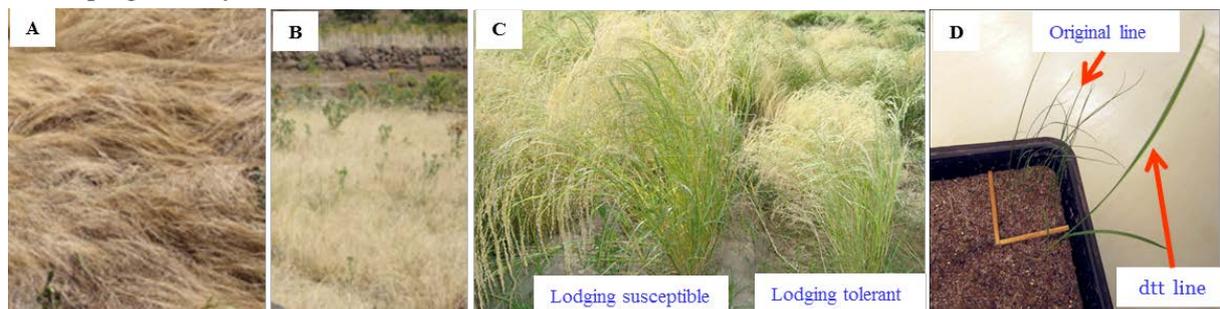


Figure 1. Major tef production constraints and achievements. Lodging (A) and drought (B) are the two major bottlenecks affecting the productivity of tef. The performance of lodging-tolerant tef in the field in Ethiopia (C) and the drought-tolerant line in the Greenhouse in Bern (D). Both lodging- and drought-tolerant lines have been developed by our team.

We expect that with only half a ton per ha increase in tef productivity, the total tef production will raise from the current 4.5 million tons to 6.0 million tons without an increase in the cultivable area. This increase is equivalent to the amount of cereal imported by Ethiopia in 2011<sup>6</sup>. Hence, the introduction of new tef cultivars will contribute towards food self-sufficiency of the country.

### Conclusion

Our lodging tolerant semi-dwarf cultivars as well as drought tolerant cultivars are at the final stage of field testing at several sites in Ethiopia. Once they will be approved for the release, they will be disseminated to small-scale farmers and will eventually raise the productivity of this crop vital to the Horn of Africa. Our active participation in research, training and development and partnership with private and public institutions will facilitate these processes and eventually will improve the livelihood of subsistence farmers in the region.

<sup>6</sup> <http://faostat.fao.org/site/342/default.aspx> , accessed July 7, 2015.