

## 学位論文審査の結果の要旨

### Summary of Doctoral Dissertation Examination

氏 名/Name	Muluken Bayable Tadege
審査委員 Examining Committee	<p style="text-align: center;">Chief Examiner 主 査 Nigussie Haregeweyn AYEHU (印)</p> <p style="text-align: center;">Assistant Examiner 副 査 Atsushi Tsunekawa (印)</p> <p style="text-align: center;">Assistant Examiner 副 査 Tsugiyuki Masunaga (印)</p> <p style="text-align: center;">Assistant Examiner 副 査 Yasuomi Ibaraki (印)</p> <p style="text-align: center;">Assistant Examiner 副 査 Takayoshi Ishii (印)</p>
題 目 Title	A genome-wide association study on lodging resistant related traits in the Ethiopian germplasm collections of teff ( <i>Eragrostis tef</i> )
<p>審査結果の要旨 (2,000字以内) / Summary of Doctoral Dissertation Examination (Within 1200 words)</p> <p>Teff (<i>Eragrostis tef</i>) is a small grain belonging to the family Poaceae and subfamily Chloridoideae where its center of origin is reported to be in Ethiopia. It is Ethiopia's staple food and hence the crop covers about one-third of the total crop area coverage by cereals. Despite its huge national significance, average productivity of teff stands low at 1.76 t/ha while its potential yield might reach as high as 6 t/ha. Lodging- a permanent displacement of the stem from the upright position- is a major yield limiting factor accounting for 25-50% yield loss. This characteristic hinders farmers from applying optimum fertilizer rate.</p> <p>Past research efforts in teff lodging resistance cultivar development so far focused on utilization of dwarfing genes particularly using mutation techniques such as TILLING (Targeting Induced Local Lesions in Genomes) but yielded limited success. On the other hand, application of molecular techniques to assess the genetic diversity and identify candidate genes controlling lodging resistant related traits is still lacking. Therefore, it is crucial to advance the search for potential sources of lodging resistance, identify related traits, and dissect their genetic basis through Genome-wide association study (GWAS), to see if any variant is associated with a lodging trait.</p> <p>On the basis of this background information Mr. Muluken Bayable Tadege aimed at dissecting key genomic regions that are essential for controlling lodging resistant related traits of teff through genome-wide association mapping using germplasm collections of Ethiopia. The study specifically addressed the following three objectives: (i) analyze the yield potential of teff genotypes under lodging controlled and non-controlled for screen house and field growing conditions, respectively; (ii) examine the variability of stem mechanical properties and agro-morphological traits and their associations with lodging and (iii) explore the genetic diversity, population structure and trait-marker associations using next generation sequencing (NGS) method.</p> <p>Firstly, he studied the grain yield potential, heritability, and genetic advance for 317 teff genotypes under intensive and field growing conditions. Under the intensive management condition (optimum fertilizer and water) when lodging was artificially controlled with mechanical support, wider range of harvest index was observed than the field growing condition. On the other hand, high coefficient of variation, heritability and expected genetic advance for grain yield were observed in both experiments.</p>	

The harvest index showed strong positive relationship with grain yield under the intensive management but weak positive correlation with grain yield and a negative correlation with biomass under the field experiment, in which lodging was relatively higher. These suggest the presence of wide genetic potential in the teff gene pool and its opportunity to enhance the productivity.

Secondly, he characterized teff germplasm collections for lodging resistance in terms of the biomechanical properties of the culm and lodging related agro-morphological traits using 320 teff genotypes of which six are commercial cultivars. This study revealed the presence of wider variability in both biomechanical and agro-morphological traits among the accessions. It is also noted that lodging index, failure moment, pushing resistance and lodging related traits such as culm diameter had a strong positive correlation with plant height. This suggests the shorter the plant height the lower the material strength of the teff culm. In contrast, tiller number showed a significant negative correlation with lodging index. Hence, peduncle–panicle length, which generally accounted for 59% of the plant height, should be a target when breeding for semi-dwarfism.

Thirdly, he explored the genetic diversity, population structure and dissected the genetic basis controlling lodging resistant related traits of 179 teff genotypes through genome-wide association study (GWAS) using double digest Restriction site Associate DNA sequencing (ddRADseq) derived single nucleotide polymorphisms (SNPs). The application of alternative statistical tools such as neighbor-joining phylogenetic tree and the principal component analysis (PCA) scatter plot of TASSEL program consistently showed the presence of three sub-populations. The dendrogram based on biomechanical and agro-morphological traits contributing to lodging resistance also showed reasonable level of similarities among the members of each sub-population. The analysis of molecular variance showed that only 1% of the variations was due to genetic variability among the sub-populations, whereas 99% of the variation was within populations. He identified significant SNP-trait associations for stem strength, lodging index, stem diameter and tiller number. This will help to prioritize breeding targets, and to commence advanced molecular research such as genomic selection and marker development for efficient selection.

In summary, his study observed high grain yield performance, wider range of harvest index coupled with the moderate to high coefficient of genetic variation, heritability and genetic advance witnessing the genetic potential of teff for further improvement. Specifically, higher stem strength, wider stem diameter, and reduced tiller number were found important lodging-related mechanical and agro-morphological traits, all of which were found in the tall plant stature. The GWAS identified significantly associated SNPs for stem strength, stem diameter, and tiller number. Thus, strong hybridization program focusing on desirable trait recombination and selection based on the lodging resistant related traits could benefit the future teff breeding programs.

On the basis of the above background data, members of the Examining Committee unanimously voted for that the PhD thesis of Mr. Muluken Bayable Tadege presents original research results that have large scientific and developmental importance and hence recommended for the award of his doctoral degree.