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SUMMARY OF DOCTORAL THESIS

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Title: Improved agronomic practices increase productivity of teff in a water erosion-prone environment
（水食が起こりやすい環境における改良栽培法によるテフの生産性向上）

Teff is an important food-security crop and serves as a source of income for millions of smallholder farmers in Ethiopia. Teff flour is used to make a staple flat bread called 'injera', as well as pancakes, porridge, and alcoholic beverages. Teff straw is a major source of livestock feed in both Ethiopia and elsewhere. Teff takes the major share of total crop production in Ethiopia, more than three million hectares of land is cultivated annually with teff. The demand for teff grain is expanding worldwide owing to its nutritional benefits, mainly as it is gluten free and is rich in lysine, iron, and calcium. Despite it's a high value crop, the productivity of teff remained very low (< 1.5 t ha^{-1}) highly constrained by occurrence of lodging, drought, decline in soil fertility and low input application. Moreover, teff-based cultivated lands in Ethiopia are highly degraded and vulnerable to water erosion exacerbated by traditional agronomic practices such as repeated tillage, soil compaction, mono-cropping and complete removal of crop residues. The traditional teff cultivation system is thus the major driver of high rates of soil erosion that led to the low teff productivity. Therefore, implementation of improved agronomic practices in the framework of sustainable land management is inevitable to reverse the adverse effects being caused by the traditional agronomic practices would sustainably improve teff productivity in erosion-prone environments in Ethiopia. Therefore, studies in this doctoral research that contains five chapters investigated the comparative effects of different tillage and sowing practices on teff productivity in a water erosion-prone environment in northwestern Ethiopia.

The first chapter gives a highlight of crop production in Ethiopia by focusing more on the challenges and opportunities in the teff cultivation system. Chapter one further narrates how the low teff productivity is linked with the existing traditional crop management practices. Possible alterative crop management options that could potentially improve teff productivity by minimizing natural resource degradation were also discussed in chapter one supported with concentrate evidence from previous experiences and studies. Finally, the rationale, objectives and the hypothesis of the doctoral research are indicated in this chapter.

Chapter three presents the results of the field experiment carried out at one of the representative regional learning watersheds (Aba-Gerima watershed) selected from erosion-prone teff growing environments in northwestern Ethiopia. This chapter justified how different teff tillage and sowing practices influenced soil loss, physio-chemical soil properties, and soil moisture. Reduced tillage practices minimized soil loss by 19% relative to that of conventional tillage, whereas row sowing resulted in a 13% reduction in soil loss over broadcasting. The non-compacted plots showed a 15% reduction in soil loss as compared to compacted ones. As a result, a significant increase in soil total carbon and

nitrogen with reduced tillage practices were recorded compared to conventional tillage. Reduced tillage and row sowing practices improved soil moisture content compared to the conventional tillage and broadcast sowing practices. This chapter also highlighted the greater teff growth and yield performance observed under improved agronomic practices (reduced tillage and row sowing) compared with the conventional ones (conventional tillage and broadcasting) was due to the better topsoil conditions and soil moisture favorable for crop growth. Overall, this chapter concludes that the use of reduced tillage, row sowing without soil compaction practices can effectively minimize soil loss leading to an enhanced topsoil conditions for improved teff growth and yield.

The fourth chapter discusses the details of how different tillage, sowing, and soil compaction practices, and their combinations, impacted teff agronomic and yield performance. Chapter four clearly showed that reduced tillage improved growth, yield performance and decreased production costs compared with conventional tillage; however, the weed population was substantially larger with reduced tillage than with conventional tillage practices. In the other hand, row sowing improved teff growth and yields, reduced lodging but increased weed population. Again, row sowing reduced seed cost but with higher costs for sowing and weeding compared with broadcast sowing. Despite labor costs being significantly greater with soil compaction than without, little to no differences were observed in teff agronomic and yield performance. Therefore, the combined use of reduced tillage, row sowing without soil compaction was identified as the most economical treatment combination for teff production in an erosion-prone environment.

Chapter five synthesized the conclusions from chapter two, three and four. This chapter marked the fact that the traditional teff cultivation system is the major cause for the low teff productivity in erosion-prone areas. The minimum soil disturbance and increased biomass cover in reduced tillage practices resulted in a significant reduction in soil loss that could be lost with the runoff that in turn helps to conserve soil organic matter and soil moisture. This improvement in topsoil conditions contributed to the higher teff productivity observed in reduced tillage than in conventional tillage practices. The better resource utilization (water, nutrients and light) in row sowing leads to a better teff productivity compared with broadcast sowing. This research work also proved that teff productivity was not influenced by soil compaction practices. Therefore, improved agronomic practices (reducing the number of tillage, row sowing without soil compaction) can be promoted for improving teff productivity if properly integrated with an appropriate weed control and labor-reduction strategies in water erosion sensitive areas in Ethiopia.

"* In addition, chapter two has been omitted."