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学位論文審査の結果の要旨
Summary of Doctoral Dissertation Examination

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題　　目 Title	Effectiveness of bio-physical and soil amendment land management practices in reducing soil loss

審査結果の要旨（２,０００字以内）／Summary of Doctoral Dissertation Examination (Within 1200 words)

Soil erosion-caused land degradation as a result of unsustainable land use and land management practices are causing significant on- and off-site impacts in large parts of the world. This is particularly severe in developing countries like Ethiopia, where the livelihood of most of the population depends predominantly on small-scale agriculture that receives limited proper land improvement interventions. On the other hand, Ethiopia has made some efforts in implementation of different bio-physical LM practices such as soil/ stone bunds integrated with or without biological measures such as multipurpose grasses. However, effectiveness of these practices was less studied especially across land uses and agro-ecologies. On the other hand, little development and research attentions were given to alternative management practices dealing with conditioning the soil itself, such as use of Polyacrylamide (PAM) that might reduce soil erosion as well as improve land productivity through improving soil physicochemical properties. Earlier studies conducted outside Ethiopia indicate that application of PAM integrated with other soil amendments, such as gypsum, lime and biochar, could further improve effectiveness of PAM.

The main purpose of his study was therefore to contribute for the development of effective LM practices through clarifying the separate and combined effectiveness of bio-physical and soil amendment LM practices by integrating laboratory, field and modelling studies. To address this, he conducted the following specific studies: (1) clarified the effectiveness of bio-physical practices [soil bund, fanya juu, soil bund combined with grass in cropland; trench combined with exclosure in non-cropland as well as different cover types] and (2) tested under Ethiopian field conditions, the effectiveness of PAM when applied alone or integrated with other soil amendments (gypsum, lime and biochar) through first determining the effective PAM rate under laboratory conditions. The main results corresponding to the specific studies are summarized as follow:

Firstly, he evaluated effectiveness of different physical and bio-physical LM practices (soil bund, fanya juu, soil bund combined with grass and trench combined with exclosure) and four crop types (barley, *teff*, chili pepper and finger millet) in reducing soil erosion. To achieve this he adopted the RUSLE model and determined the support practice (P) and cover and management (C) factors for the different LM practices and land cover types in three agro-ecologies: Guder (highland), Aba Gerima (midland), and Dibatie (lowland)

in the Upper Blue Nile basin of Ethiopia. He collected and used two seasons daily soil loss data collected from 42 runoff plots established in the three agro-ecologies. His key findings on P-factor are: (1) soil bund combined with grass (76% soil loss reduction) in cropland and trench combined with exclosure (82% soil loss reduction) in non-cropland were the most effective LM practices, implying that integrating physical measures with biological measures could increase their effectiveness and (2) LM practices were more effective in the lowland (Dibatie) than the highland and midland environments, which is attributed to the relatively lower seasonal rainfall amount and higher daily rainfall-runoff threshold in the lowland than the other two sites. Likewise, the key results on C-factor are: (1) cropland was found to be twice more sensitive to soil erosion than non-croplands due to higher human disturbance in the earlier case and (2) there exists significant variation in effectiveness within the cropland even, in which a cropland covered with chili pepper was found five times more sensitive to soil loss than barley sown plots.

Secondly, he tested the effectiveness of different PAM rates of 0 kg ha^{-1} (Control), 20 kg ha^{-1} (PAM-20), 40 kg ha^{-1} (PAM-40), and 60 kg ha^{-1} (PAM-60) for six consecutive simulated rainfall storms of 70 mm h^{-1} intensity for 1-hr duration using the Japanese Oxisols, one of the dominant soils found in humid tropics such as Ethiopia. He reported that smaller PAM rates (e.g. PAM-20) have had immediate and positive effect in increasing infiltration rate and reducing runoff due to the relatively lower viscosity of the soil solution at the beginning, compared to the higher PAM rates (e.g. PAM-40 and PAM-60) that take more time to dissolve before they become effective starting from the third storm through the end of the consecutive storms. Effectiveness of PAM rates diminishes with time due to the washing a way of PAM as the rain progresses, however, the time it takes directly depends on the application rate. He identified that PAM-40 was selected as the most suitable rate for the given test soil and total rainfall amount (420 mm) that corresponds with the Ethiopian summer rainfall amount.

Thirdly, he evaluated under field conditions in Aba Gerima watershed of northwest Ethiopia, the effectiveness of PAM-40, selected based on the laboratory experiment, alone or integrated with other locally available amendments such as gypsum, lime, or biochar in reducing soil loss. He collected daily sediment loss data from plots planted with *teff* (*Eragrostis tef*) crop during the 2018 and 2019 rainy seasons and investigated associated changes in soil properties and crop growth parameters. He reported that plots treated with amendments reduced soil loss by 13 – 53%, compared to the control. Specifically PAM+lime treatment reduced soil loss nearly 50%, as compared to the control, as integrating PAM with lime was found to have a synergetic effect on improving soil aggregate, pH, moisture and organic matter properties that enhanced in the end the *teff* crop biomass yield.

In summary, the candidate has successfully integrated laboratory, field and modelling approaches for his study. He identified from the tested LM practices that soil bund combined with grass and PAM+lime were the most effective biophysical and soil amendment measures, respectively, in croplands; likewise trench with exclosure in non-croplands. His model simulation at runoff plot-scale of 3m wide and 30m long m revealed that separate implementation of soil bund combined with grass and PAM+lime can reduce plot soil loss by 48% and 68%, respectively. The plot-scale soil loss can further be reduced up to 83% through integrated application of those two best performing biophysical and soil amendment measures. Additional benefits of this integration involve improvement of soil physiochemical properties that could also improve crop biomass yield. Equally important in controlling soil erosion would be the crop selection as crops' sensitivity to soil erosion found significantly different. This study provides important scientific basis for tackling soil erosion while improving land productivity in the study region as well as other areas experiencing high soil erosion problem. On the basis of the above background data, members of the Examining Committee unanimously voted for that the PhD thesis of Mr. Birhanu Kebede Gebru presents original research results of large importance and recommended for the award of his doctoral degree.