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Abstract of Thesis/Dissertation

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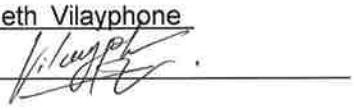
Signature of Applicant: 

Title : Effects of silicon nutrition on wheat growth and quality in upland soils of Hokkaido

Abstract

Silicon (Si) is known as an important element for cereal crops including wheat (*Triticum aestivum*) by enhancing resistance against stresses thereby increasing productivity. The Tokachi district of Hokkaido occupies 20 % of the national wheat production area with various soil types present, but the availability of soil Si in relation to the physicochemical and mineralogical properties of the soils and the relation to Si in plants in upland soils have not been assessed in detail. Our finding goals were; (i) to clarify the soil morphological features and characteristics of the soil profiles and to classify the soils developed on the river terrace. (ii) to evaluate the soil Si ability in both vertically in the subsoil and soil surface and to the assess the influence of other soil properties on soil Si availability, (iii) to assess the status of wheat Si uptake, concentration and understand their relation to the soil available and other nutrients. (iv) to evaluate soil Si solution extraction methods that could be used to determine Si for upland soil.

The 40 paired of soil and wheat samples were collected from farmers' fields of Shimizu town, Tokachi, Hokkaido in 2020 and 2021 along river terraces and four soil profiles were drug at different river terraces, Lowland, Low terrace, Middle terrace and High terraces. Surface soil samples at 20 cm depth and soil samples from all horizons of the four profiles were analysis for total C, phosphate absorption coefficient (PAC), cation exchangeable capacity, and soil mineralogical properties through selective dissolution methods and available soil Si using 0.1 M acetate buffer, 0.02 and 0.04 M phosphate buffer methods were also analyzed. Wheat samples were air dried and determined for plant agronomic properties, grain yields and biomass. Later wheat samples were separated into 3 parts stem, husk and grain then grounded for Si and nutrient contents.

From this study we found that soils, soil profiles developed on river terraces in the Shimizu town, Tokachi district revealed completely different morphological features and remarkably different physicochemical and mineralogical properties. The soil formation processes and a significant difference in the vertical distribution of humic substances and amorphous minerals were strongly affected by the soil moisture regime in the lower horizons and the differences in the parent materials such as alluvial and volcanic deposits. According to the Japanese Soil Classification, these soil profiles, one of them could be classified Fluvic soils and other three were classified as Andosols, however one of the Andosols was classified as Inceptisols according to Soil Taxonomy due to a subtle difference in the criteria of the andic properties.

The vertical distribution of soil available Si contents were remarkably different in each horizon and were higher in the horizons where allophane formation was advance. The

available Si of soil surface varied from field to field and notably higher in the fields located in the areas where allophane formation was more progressive as in Middle terrace and High terrace. From our results, suggesting that the amorphous minerals contributed as a source of available Si in the upland soils of Shimizu, Tokachi, Hokkaido. Increase of pH enhanced soil Si availability.

In average, wheat took up Si from the soils 13.4 g m^{-2} which was significant amount comparable to major essential element like N and K and remarkably higher than P. Wheat stored Si mainly in stem and husk and minor amount in grains. The highest concentration of Si was almost 28 g kg^{-1} of dry matter in husk, this might be related to protection the grain from biotic and abiotic stresses during harvest. It was important to note that soil available Si affected Si concentration in wheat rather than plant Si uptake. The negative correction between Si and C concentration from our finding supporting the theory that there is tradeoff between these 2 elements in wheat.

Among three extracted solution methods, acetate buffer method showed the most promising method for measuring soil available for upland soils, as soil available Si obtained by acetate buffer reflected better amount Si obtained in wheat plants. Even through the interesting in Si research has been increased and Si has showed the positive impact in plant productions, however the understanding on the mechanism on different source of Si supply and the limitation for uplands crops and the hypothesis of the depletion of Si in cropping system is still related, hence there is need to further research for better and nutrient balance management.