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Field Surveys of Soil Conditions in Steppe of Northeastern Mongolia

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Abstract: Licorice (*Glycyrrhiza*) is among the world's most ancient herb. It is a temperate-zone herb but grows wild also in arid lands including northern China, Mongolia and central Asia. Recently, it is said that overharvest of licorice have been leading to the land deterioration and/or desertification. As a final goal of this study, we are attempting to develop a cultivation technique of high-quality licorice which can bring a solution for a stable supply of licorice as well as for countermeasure against the desertification. As a first step for establishing the licorice cultivation technique, field surveys were carried out in natural growth areas of southern and northeastern Mongolia. The surveys were conducted focusing on subsurface conditions where licorice grows to find the soil condition which is suitable for growing high-quality licorice. This paper presents results of the measurements; grain size distribution, water content, chemical composition and electric conductivity, etc. Licorice roots collected in the fields contain high concentration of the active ingredient called glycyrrhizin, indicating that the soil conditions made clear from the investigations will provide a clue to a solution for establishing the cultivation technique of high-quality licorice.

Key Words: Field survey, Licorice, Mongolia, Soil condition, Steppe.

1. Introduction

Licorice (*Glycyrrhiza*) is among the world's most ancient herb. Licorice is a leguminous plant and its roots contain an active ingredient called glycyrrhizin that have been used in food, medical remedies and cosmetics, etc (**Fig. 1**). It grows wild in arid land, including northern China, Mongolia and other central Asian countries, as well as in some temperate-zones in Europe. Licorice has an extensive branching root system and its taproot extends deep in the ground. The roots are harvested by generally digging deep holes in the ground, indicating that the harvest can damage the land if backfilling is not carried out. It is a problem that most of the licorice production has been intended for wild resources, and thus, the overharvest leads to not only a decline in the wild licorice but also a cause of land degradation and/or desertification of the natural growth area. **Figure 2** shows the change of licorice resource in Bayankhongor province (*see* Fig. 4) in Mongolia. It is evident that the resource has drastically decreased from 1980s to 2000s. Recently, China, one of the main country of origin, has restricted the export of licorice. This restriction have brought a serious situation in wide range of diverse industries in Japan.

The final goal of this study is to develop a cultivation technique of high-quality licorice which can bring a solution for a stable supply of licorice as well as for countermeasure against the desertification. As a first step for establishing the licorice cultivation technique, field surveys were carried out in

Fig. 1. Licorice (*Glycyrrhiza uralensis*).

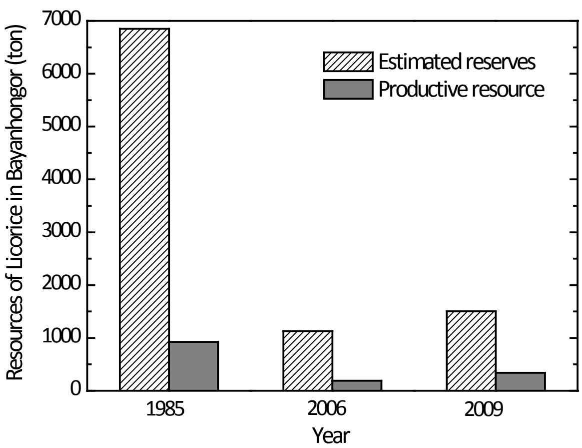

Fig. 2. Change of licorice resource in Bayankhongor province in Mongolia.

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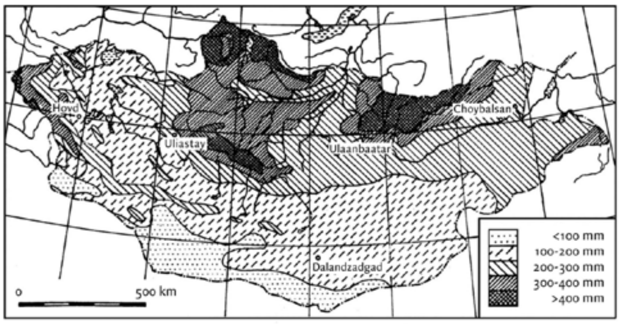
natural growth areas of southern and northeastern Mongolia for the purpose of making clear the soil conditions where wild licorice grows.

2. Field Surveys in Mongolia

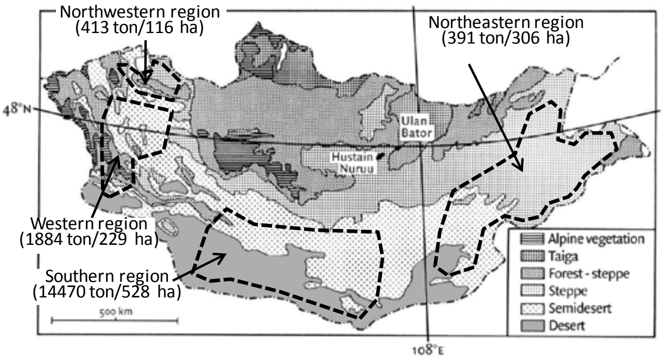
Mongolia is one of the countries that high quality licorice grows in wild. In 1985, a Russian-Mongolian joint team had achieved a large-scale field survey that aimed to make a licorice vegetation map in Mongolia. They reported that wild licorice distributed in mainly four regions (*see* **Fig. 3**(b)); northeastern region (grassland and steppe), northwestern region (semidesert and flood plain), western region (semidesert and plain), and southern region including Bayangkhongor province (semidesert and plain-oases, accounted for 84% of the whole distribution).

As shown in Figure 3 (Hilbig, 1995; Van Staalduinen and Werger, 2005), going from north to south aridity increases together with decrease of the mean annual precipitation. The zoning of the vegetation corresponds rather well with the gradient of decreasing precipitation from north to south. It is can be seen that licorice can grow in harsh environment, such as a land where the annual precipitation is less than 100 mm.

In this study, field surveys were conducted in southern and northeastern regions shown in **Figure 4**. Objectives of the surveys are to update a licorice vegetation map and to make clear the soil conditions where licorice grows wild. The surveys were conducted in May 2010 (in the southern area) and September 2010 (in the northeastern area) by a joint research team of Kyushu University and the Mongolian Academy of Science (Institute of Botany).



(a) Mean annual precipitation in Mongolia (Hilbig 1995)



(b) Vegetation zones of Mongolia (after Wallis de Vries 1996)

Fig. 3. Precipitation and vegetation map in Mongolia.

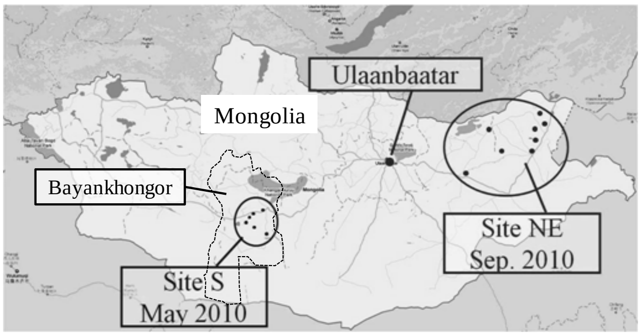


Fig. 4. Survey area map.

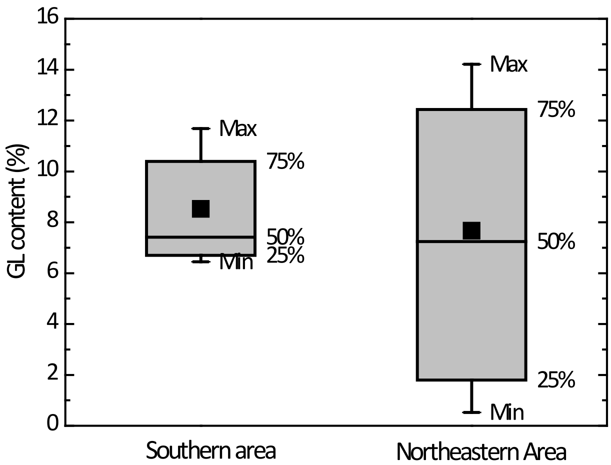


Fig. 5. Glycyrrhizin (GL) contents in collected licorice roots.

3. Survey Results and Discussions

3.1. Glycyrrhizin (GL) contents in collected licorice roots

The Japanese Pharmacopoeia XIV (JP XIV) requires that Glycyrrhizae Radix for medical use should contain not less than 2.5% of glycylrrhizin (GL) (Yamamoto and Tani, 2002). **Figure 5** shows the GL contents of wild licorices collected in the surveys. Although variation arises especially in samples of the northeastern area, it is seen that they have GL content of around 8% on average. It is said that licorice can be grew easily, but the GL content doesn't exceed the reference value easily. This results indicate that the environments including soil conditions of the natural growth areas in Mongolia hold the key to cultivating high quality licorice.

3.2. Physical properties of the soils

Figure 6 shows the typical grain size distributions collected in natural growth areas in a southern and northeastern survey points. For reference, a grain size distribution of a weathered

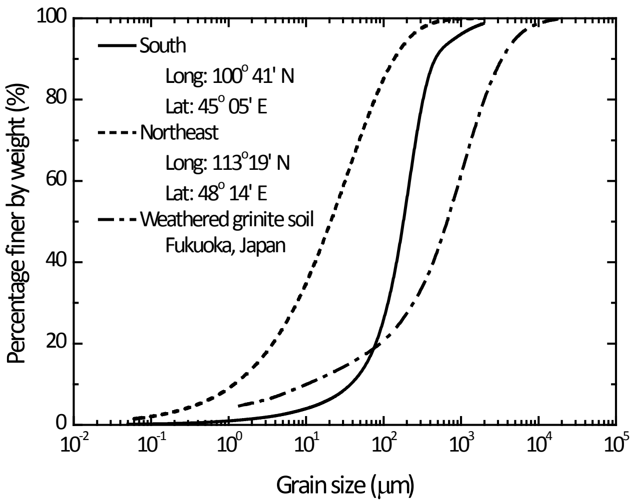


Fig. 6. Grain size distributions.

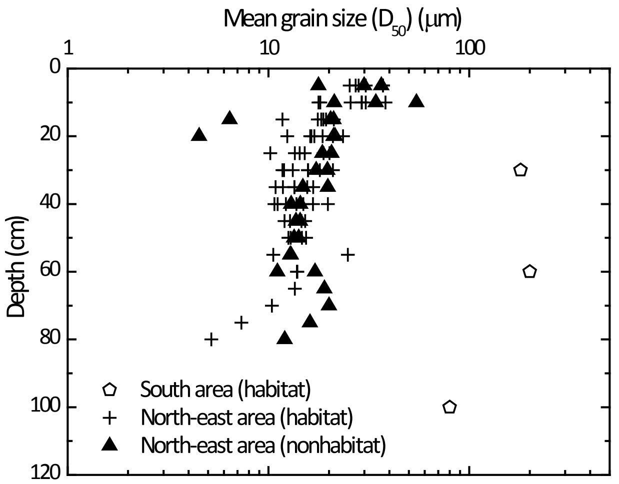


Fig. 7. Mean grain size versus depth.

grinite soil sampled in Fukuoka Japan is also plotted in the graph. The southern investigation site is on semidesert zone and the northeastern site is on steppe zone. The soil in the northeastern steppe zone can be categorized as Loam and/or Silt loam and is finer than that in the southern semidesert zone. The soil in the semidesert zone is categorized as sand and has a poorly graded gradation.

Figure 7 shows variations of mean grain size (D_{50}) with respect to the depth. There seems to be a general trend that the grain size becomes slightly smaller with depth. Although data obtained from the northeastern site is plotted by separating it into habitat and nonhabitat in this graph, a difference in the grain size cannot be seen clearly. It appears that finer grains are suited for the growth of licorice but the grain size, in terms of a physical property, will not be a major factor.

Figure 8 shows variations of volumetric water content with respect to the depth. It is seen that discrepancies appear in shallow zones (up to around 20 cm deep) but the variations converge to a narrow range with increasing depth. It is of

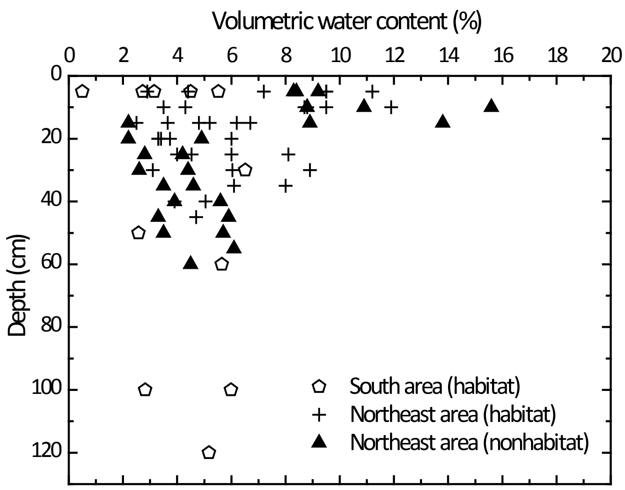


Fig. 8. Volume water content versus depth.

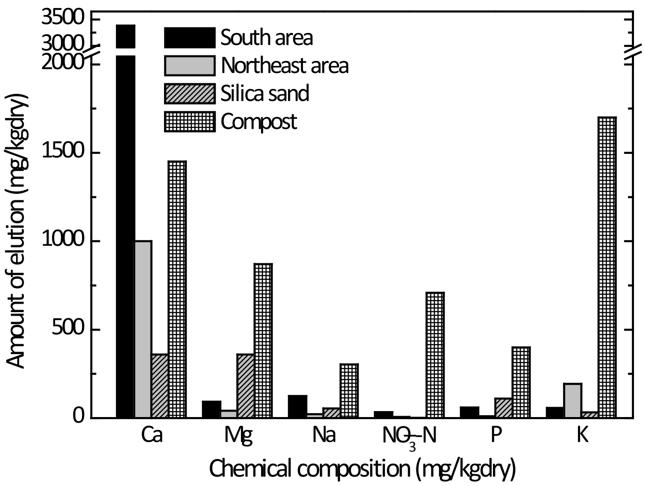


Fig. 9. Chemical compositions of the soils.

interest to note that the water contents below the grounds lie in the narrow range, between approximately 2 and 6%, regardless of the grain size. Also, noteworthy is that the soils contain similar low water contents regardless of the climate; the southern and the northeastern site are located in semidesert and steppe zone, respectively. Compared to general cultivated lands, this range of water content is low, therefore, soil moisture control will play a important role to cultivate high quality licorice. Note that matric suction is dependent on soil characteristics even if the soil have the same water content. Further investigation is needed to make clear the detailed root-soil interactions systems.

3.3 Chemical properties of the soils

Figure 9 shows chemical compositions leached from the soil samples. For reference, test results for a manufactured silica sand and a compost were also shown in the graph. It is obvious that the soil in the southern site (sandy soil) contains extremely high calcium (Ca). In general, sandy soils have low levels of calcium and tend to be acid, because sandy soils

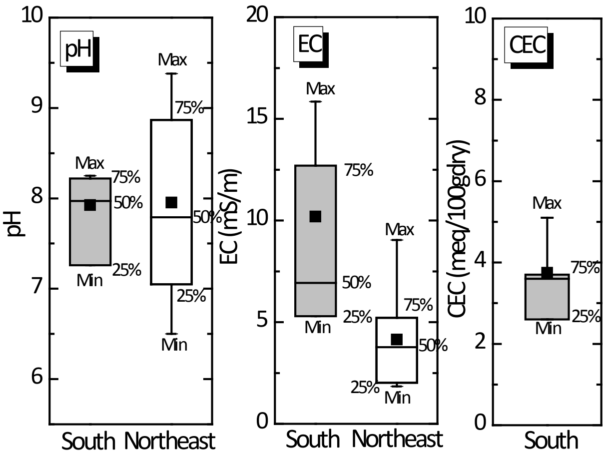


Fig. 10. pH, EC and CEC of the soils.

quickly lose their calcium content by water drains (this is evident in Figure 9 that the silica sand contains low Ca compared to others). It seems that rare precipitation results in the Ca accumulation in the sandy ground. Figure 9 also shows that the soils of the semisedert and steppe zones have little other nutrients contained, suggesting that licorice can grow up even in such unbalanced low-nutrition soils.

Figure 10 shows the results of pH, Electro Conductivity (EC) and Cation Exchange Capacity (CEC) of the collected samples. Both of the soils shows alkalinity and the average is around pH = 8. This seems to be attributed to the high Ca content. There is a trend that the soil EC of the southern site (sandy soil) exceed that of the northeastern site (silty soil) although finer soils generally tend to have higher EC values. The CEC value of the southern site seems to be quite low compared to general cultivated soils. By adding certain amount of calcium to a manufactured silica sand, it may be possible to create a soil which is suited for the Licorice cultivation. It goes without saying that further examinations from various viewpoints requires to establish a promising cultivation technique, however, the findings from the surveys will provide a clue to the solution.

4. Conclusions

This paper presents results of field surveys in a semidesert and a steppe zone of Mongolia. The surveys were carried out to find the physical and chemical conditions of soils that is suitable to the growth of high quality licorice. The findings of the surveys are summarized as follows:

1) It is confirmed that a high quality licorice grows wild in the southeastern semidesert and the northeastern steppe zones in Mongolia and the active ingredient (glycyrrhizin) content is about 8% on average.
2) The licorice grows in Sand, Loam and Silt loam with the volumetric water content of 2 - 6%.
3) The semidesert and steppe zones investigated contain high calcium and so the soil trends to be alkaline (the soil pH is around 8 on average).
4) The soils have little other nutrients contained, suggesting that licorice can grow up even in such unbalanced low-nutrition soils.

Acknowledgement

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