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Relationships between Soil Water / Calcium Environment and Growth of Licorice (*Glycyrrhiza uralensis*)

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Abstract: Desertification is one of the most remarkable global environmental problems. This paper investigates opportunities to combat desertification utilizing the medicinal plant licorice (*Glycyrrhiza uralensis*). Licorice natively lives in arid region such as Mongolia and China, although the numbers of individuals are decreasing due to excessive harvesting, overgrazing and decreasing groundwater levels caused by unstable rainfall, ultimately leading to increase desertification. Due to these facts, licorice was picked up as a "precious genetic resource" at COP 10 (Conference of the Parties, Convention on Biological Diversity) because there is a supply shortage of licorice as herbal medicine. Therefore, there may be anti-desertification opportunities through the development of a planting method for licorice in arid ground, especially those areas of extreme desertification where other crops are not grown. Furthermore, if the method is given to local people, it will provide value-added greening. This means that the method will contribute to anti-desertification while also decreasing the supply shortage of licorice and stimulating the local economy. As the fundamental research to accomplish these purposes, the relationships between soil water environment, soil saline environment and growth of licorice should be determined. This paper examines the function of "greening soil material" (*i.e.* commercial compost) on the growth of licorice in a cultivation experiment. And the evaluation method about relationships between soil water environments, soil saline environment, especially calcium concentration, and the growth of licorice were examined by using greening soil material and imitating arid ground.

Key Words: Desertification, Licorice (*Glycyrrhiza uralensis*), Soil saline environment, Soil water environment

1. Introduction

Desertification is accelerated by climate change, excessive plant harvesting and over grazing and is one of the most urgent global environmental problems (UNEP, 1992). This paper examines methods of combating this problem by utilizing medicinal plant licorice (*Glycyrrhiza uralensis*, **Fig. 1**). Licorice natively lives in arid regions such as Mongolia and China, although the plant's population is decreasing due to excessive harvesting, overgrazing and decreasing groundwater levels caused by unstable rainfall (Shoyama, 2002). These factors are leading to increasing desertification. Due to these facts, licorice was identified as a "precious genetic resource" at COP10 (Conference of the Parties, Convention on Biological Diversity) because there is a supply shortage as herbal medicine. Therefore, there may be anti-desertification opportunities through the development of a planting method for licorice in arid ground, especially in those areas of extreme desertification where other crops are not grown. Furthermore, if the method is given to local people, it will provide value-added greening. This means that the method will contribute to anti-desertification while decreasing the supply shortage of licorice. In order to accomplish these purposes, it is important to understand the relationships between soil water environment, soil saline environment and growth of licorice.

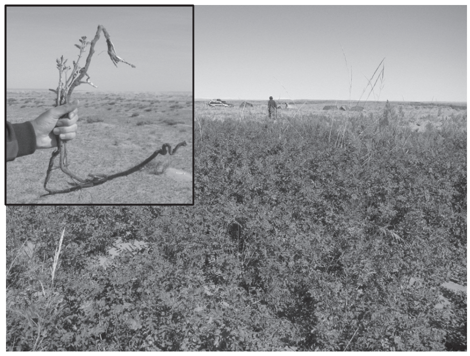

Fig. 1. Habitat of wild licorice and root of licorice.

In this paper, we identify the function of "greening soil material" (compost), shown in **Figure 2**, which can supply significant water and nutrition to young licorice due to its high water and nutrient holding capacity. The cultivation experiment in Mongolia and Japan using greening soil material, which used evaluation methods to quantify the relationships between soil water environment, soil saline environment, especially calcium concentration, and growth of licorice, are considered to suggest suitable soil water and nutrient conditions.

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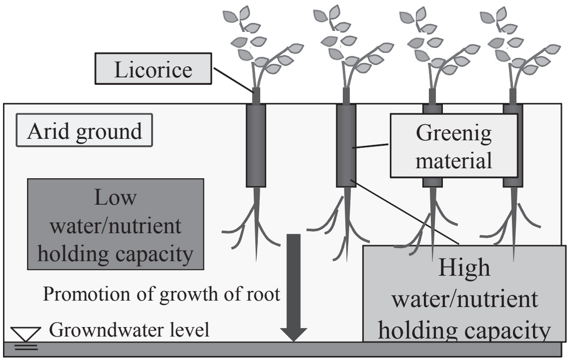


Fig. 2. Conceptual scheme of cultivation in arid land.

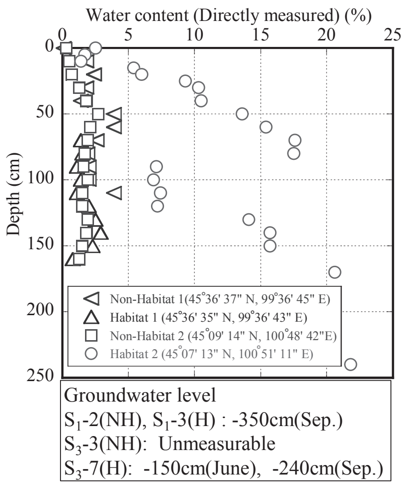


Fig 3. Distributions of water content in soil profiles in southern Mongolia.

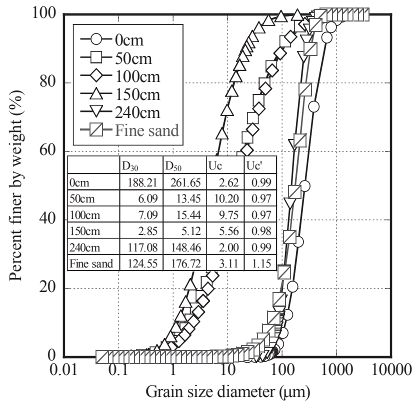
Table 1. Propagation test results in Non-Habitat (Furukawa, 2013).

	Seeds	Rhizome (Vertical)	Rhizome (Horizontal)
Case-1	0%	-	-
Case-2	-	20%	-
Case-3	-	-	50% (5cm is failed, 10cm, 20cm is succeeded)

2. Materials and Methods

2.1. Verification of efficacy of greening method for cultivating licorice

In order to confirm the effects and appropriateness of greening soil material in arid ground, a cultivation experiment was conducted in Non-Habitat 1 (45°09'14"N, 100°48'42"E), Bogd, Mongolia, shown in **Figure 3** (Furukawa *et al*., 2013). Annual precipitation of these areas is about 100-200 mm. The planting depth and direction of the materials (vertical / horizontal) were varied, and propagation rates were confirmed nine month after the start of experiment. As shown in **Table 1**, propagation rate from seeds was 0%, but 20% to 50% of rhizomes were successfully propagated in each condition. These results may be due to the water and nutrient holding capacity of greening soil materials. In order to confirm the details of effects of greening soil materials on plant germination and propagation, various conditions of cultivation experiment were conducted.



	D30	D50	Uc	Uc'
0cm	188.21	261.65	2.62	0.99
50cm	6.09	13.45	10.20	0.97
100cm	7.09	15.44	9.75	0.97
150cm	2.85	5.12	5.56	0.98
240cm	117.08	148.46	2.00	0.99
Fine sand	124.55	176.72	3.11	1.15

Fig. 4. Grain size distributions of habitat and sandy soil.

Table 2. pH, EC and CEC of habitat and materials used in experiment.

	pH	EC	CEC
name/unit	-	mS/cm	meq/kgdry
Southern Mongolia (Habitat, 0cm)	10.26	0.24	5.2
Fine sand	8.81	0.19	1.2
Potting compost (J)	6.35	1.57	21.3

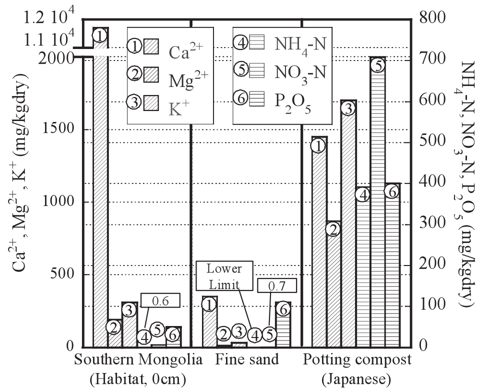


Fig. 5. Chemical compounds of habitat and materials used in experiment.

In order to quantify the relationships between soil water/calcium environment and growth of licorice, the cultivation experiment was conducted using sandy soil imitating arid environments in conformity. This experiment was conducted at the Cultivation Institute of Herbal Plants in Genkai town, Saga prefecture, Japan. Two greenhouses were used for the experiment, and the grounds of these houses were homogeneous sand from surface to a depth of 250 cm. **Figure 4** shows the grain size distribution curve of fine sand (Silica sand No.7), which was selected as the experimental soil. This Figure also indicates grain size distributions of Mongolian soil at each depth from the surface to depth of 240 cm for comparison. The uniformity coefficient and coefficient of curvature of fine sand were similar to Mongolian arid ground, especially at the surface and 240 cm depth. For these reasons, fine sand was selected as the experimental ground. Greening

Table 3. Conditions of additional compost or lime.

No.	Nutrition conditions	Amount of additional ingredient (g/m²) Calcium carbonate(Ca)		Magnesium (Mg)		Pottasium (K)		Nitrogen (N)		Phosphorus (P)	
		1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
1	Organic compost	7.50	22.50	3.00	9.00	12.60	37.80	8.40	25.20	13.80	41.40
2	Organic compost1/2	3.75	11.25	1.50	4.50	6.30	18.90	4.20	12.60	6.90	20.70
3	Organic compost1/8	0.94	2.81	0.38	1.13	1.58	4.73	1.05	3.15	1.73	5.18
4	Organic compost + Magnesium lime	142.50	427.50	18.00	54.00	12.60	37.80	8.40	25.20	13.80	41.40
5	Magnesium lime	135.00	405.00	15.00	45.00	-	-	-	-	-	-
6	Magnesium lime1/2	67.50	202.50	7.50	22.50	-	-	-	-	-	-
7	Organic lime	133.95	401.85	0.98	2.93	0.26	0.78	0.42	1.26	0.35	1.05

soil materials consisted of potting compost (J), which is manufactured by Takii and Co., Ltd. Young licorice was planted in greening soil materials at a depth of 30 cm. **Table 2** shows pH, EC and CEC of fine sand, potting compost (J) and the natural habitat of licorice in Mongolia.

As shown in Table 2, potting compost (J) has 10 times higher CEC than imitated arid sand, therefore potting compost (J) could provide sufficient nutrition for plants. And the CEC of imitated arid sand was similar to that of the actual ground.

Furthermore, **Figure 5** shows the amounts of calcium carbonate ($CaCO_3$), exchangeable cations (Mg^{2+}, K^+, Na^+) and organic components (NH_4-N, NO_3-N, P_2O_5). Potting compost (J), which has significant organic components and nutrition, appeared to be suitable for propagating young licorice as the plants grew about one month after planting.

Using these greening soil materials and fine sandy ground, two types of water conditions were prepared in order to reveal the relationships between growth of licorice and soil water environment. These conditions are described in Section 3.1. Moreover, in order to clarify the relationships between growth of licorice and nutrition, several kinds of fertilizers were added in the ground as shown in **Table 3**. The types of fertilizers included an organic manure, which is a mixture of compost and bokashi (extended slow acting fertilizer) as well as two types of calcium carbonate, which were organic calcium and magnesium lime which mainly included $CaCO_3$. These were added to mimic the soil saline environment in arid areas. Under these soil water and saline conditions, licorice had been grown for seven months and nineteen months. Root growth can be measured as length, weight, and diameter. In this paper, root length (RL) was selected as one of the indices of growth because root lengths are more important considering groundwater level in arid areas. In addition, for the pharmaceutical use of licorice root, glycyrrhizin (GC), which is an effective herbal ingredient in the root of licorice, was selected as one of the important indices. Therefore, the product of GC content and length of root (GC*RL) was used as a parameter of plant performance.

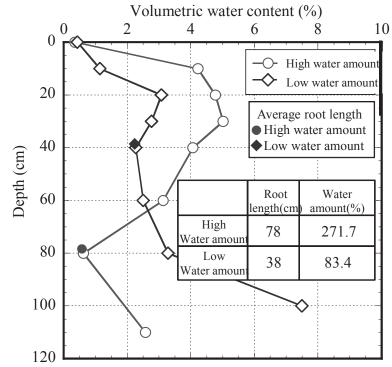


Fig. 6. Distributions of volumetric water content of experimental ground.

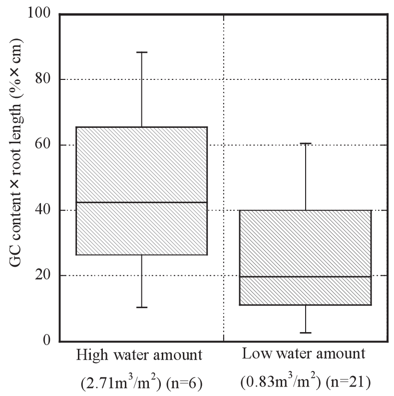


Fig. 7. Relationships between water amount and growth of licorice.

3. Results

3.1. Influences of soil water conditions on licorice growth

Figure 6 indicates distributions of volumetric water content in imitated grounds. Two types of water levels (High and Low) were prepared. Water amount was defined by integral calculus of volumetric water content and depth. Average root length of the condition of "High" was about 78 cm whereas in the "Low" it was about 40 cm. In addition, **Figure 8** shows the relationships between water amount and GC*RL. As shown in **Figure 7**, it could be revealed that in the case of the "High" water amount, the depth of root length was high and GC*RL was higher than the case of the lower water amount. Therefore, it can be assumed that licorice needs supplemental water when in initial stages of growth and a supply of water in dryland areas will be needed.

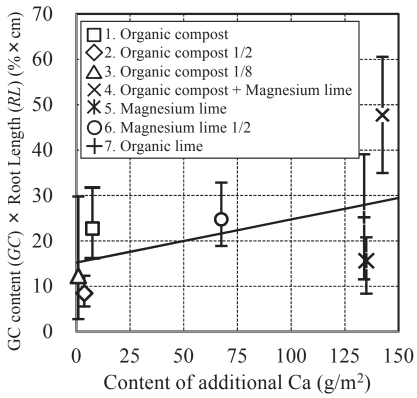


Fig. 8. Relationships between additional calcium and growth of licorice (cultivated for seven months).

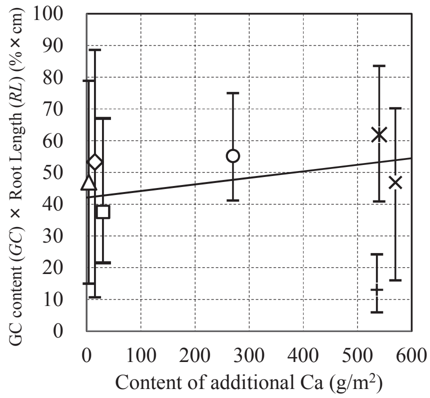


Fig. 9. Relationships between additional calcium and growth of licorice (cultivated for nineteen months).

3.2. The relationships between calcium content in the sand and growth of licorice

Based on the relationships between additional $CaCO_3$ and growth of licorice shown in Figure 8, it was found that GC*RL tended to be higher when content of additional $CaCO_3$ was higher, though other kinds or amount of additional nutrition, such as nitrogen and phosphorous, which was added at the same time was different. Therefore it could be assumed that growth of licorice will be higher if calcium content in the soil is higher. Moreover, several cultural experiments of licorice using various kinds of calcium compounds whose pH or EC was different were conducted (Kameoka *et al*., 2013), and revealed that licorice could grow better in an acidic environment though licorice lives naturally in alkaline ground. According to these results, growth of licorice was affected by content of calcium in the soil rather than content of manure and value of pH in the soil.

3.3. Influences of soil calcium environment on growth of licorice over time

Figure 9 depicts the relationships between additional calcium and growth of licorice. These results were measured nearly two years after the cultivation experiment started, and additional composts or limes were added as indicated in Table 2. The tendency of growth remained the same. And the trend line was gentler in the second year when compared to the first year. From these results, it is implied that additional calcium may not be necessary when licorice cultivation is conducted in arid environments when the distance between individuals is around 30 cm.

4. Conclusions

This research was aimed to evaluate the relationships between soil water and calcium environment in an experiment in Mongolia and Japan. The following results were revealed:

1) From the results of cultural experiments in the Mongolian arid, non-habitat area, the soil had about 3% water content. In addition, licorice could survive using greening soil material because of the material's high water and nutrient holding capacity.
2) Licorice at the initial stage of growth requires more water as indicated by the fact that growth of licorice was two times higher when water content was three times higher.
3) The higher additional calcium content in the soil resulted in more licorice growth within the limits of 600 g/m^2. This tendency was same regardless of cultural year.
4) The relationship between geo-environmental factors and growth of licorice, can be described by the function:

$$GC \times RL = f(w, Ca, \alpha) \qquad (1)$$

where GC is content of glycyrrhizin (%), RL is Root length (cm), Ca is content of calcium in the soil, and α is weather factors such as air temperature, relative humidity, amount of precipitation.

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References

Furukawa Z., Yasufuku N., Omine K., Kameoka R. (2013): A Study about evaluation method of the relationships between soil water/ calcium environment and growth of licorice aimed at combating desertification. *Proceedings of 10th JGS Symposium on Environmental Geotechnics*, 55-58.

Kameoka R., Yasufuku N., Omine K., Furukawa Z. (2013): The fundamental research about geo-environment of dryland which licorice grows wildly in southern Mongolia and cultivation experiment of licorice which paid attention calcium contents. *Proceedings of 10th JGS Symposium on Environmental Geotechnics*, 59-6.

Shoyama Y. (2002): Wisdom and nature of Asia. *KUARO*, 35-48.

UNEP (1992): *Status of Desertification and Implementation of the United Nations Plan of Action to Combat Desertification*.