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学 位 論 文 の 内 容 の 要 約

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【論文の内容の要約】

The purpose of this graduation thesis entitled effect of ectomycorrhization on growth and nutrient uptake of *Quercus serrata* seedlings in dry soil condition is to examine how ectomycorrhizal (ECM) seedlings increased growth, uptake of nutrients, uptake of moisture and physiological characteristics of the seedlings under different levels of soil water content? The graduation thesis is composed of five chapters, each of them dealing with different aspects related to the titles.

Chapter 1 is introductory, describing background of the study and reviewing information regarding the efficiency of ECM and super absorbent polymer (SAP) on various parameters including growth characteristics, colonization rate of ectomycorrhiza (CRE) and physiological performance of *Q. serrata* seedlings, in dry soil condition.

Chapter 2 focuses on impact of CRE on growth and nutrient uptake of *Q. serrata* seedlings at different levels of soil water content under greenhouse condition. We

evaluated various aspects including CRE, growth performance, nutrients uptake, ^{137}Cs uptake and the extension of fungal hyphae of the *Q. serrata* seedlings in different levels of soil moisture. For the understanding of fungal-hyphal-extension and uptake of ^{137}Cs by seedling, ^{137}Cs -contaminated forest leaf litter was used. For this purpose, seedlings were exposed to three levels of soil water content. Each level of soil water content was separated into two sub treatments by using 25 μm mesh net. Half of each water level treatments were covered with ^{137}Cs -contaminated litter that was collected from oak forest at Nihonmatsu city, Fukushima, Japan. The other half did not cover with the contaminated litter, (no ^{137}Cs treatment). Each treatment contained 16 seedlings, placed four by four (columns by rows). The result shows that the growth of *Q. serrata* seedlings increased with increasing soil water content. The highest CRE was observed in the low water content (LW) treatment and was significantly different from the high water content treatment (HW). The LW treatment showed the lowest nitrogen (N) and phosphorus (P) concentration in leaves and roots but no statistical differences were observed compared with the middle water (MW) and HW treatments. Treatments with ^{137}Cs -contaminated litter cover showed increased leaves ^{137}Cs concentration and its leaf per root ratio increased with decreasing soil water content. it suggests that enhanced ^{137}Cs absorption and translocation into *Q. serrata* seedlings is occurred with the aid of ECM fungus except for the seedlings in HW (less than 2% CRE). Concentration of ^{137}Cs in leaves and the leaves / roots ratio of ^{137}Cs increased with increasing CRE. These results, on one hand, indicate that absorption of ^{137}Cs from litter layer and soil surface was greater and its circulation was more rapid in dry soil condition such as the broad leaf forest of the ridge. On the other hand, higher leaves and root ^{137}Cs content in HW might be due to the effect of water on the availability of ^{137}Cs . Further study would be necessary to clarify the

combined effect of water and nutrient on ECM colonization and uptake of ^{137}Cs in *Q. serrata* seedlings.

Chapter 3 addresses the issue why ECM seedlings could not improve growth of *Q. serrata* seedlings although they had higher percentages of CRE? This chapter discover impact of SAP and P cores on CRE, growth and nutrient uptake of *Q. serrata* seedlings in different levels of soil moisture and P. For this purpose, we have conducted pot experiment in the greenhouse. Each pot contained a core filled with either saturated SAP (SAP core) or a mixture of P fertilizer and soil (P core) at the bottom beneath the soil medium. Seedlings were treated with three different P fertilizer media including low P (LPM), middle P (MPM) and high P (HPM) containing media. Seedlings at each one of the media were then separated into three sub-treatments based on water levels. Seedlings in these sub-treatments were receiving low, middle and high levels of water (LW, MW and HW). Various parameters including CRE, seedlings growth, nutrient uptake and leaf water potential of the *Q. serrata* seedlings have been evaluated.

Result of the study shows that: in SAP core treatments; the CRE decreased with the increasing water levels at each one of the P concentration media. Phosphate fertilizer also affects the CRE negatively and it decreased with increasing soil available P. In LPM media, LW seedlings had the highest CRE and it was significantly different than HW seedlings. In MPM media, LW seedlings also had the highest values of CRE. However, the CRE were not significantly different among water levels. In P cores treatments; CRE was not different among water levels at each one of the media. LW seedlings had the lowest CRE compared to the MW and HW at each one of the media.

Seedlings in SAP core treatments had higher CRE than those seedlings grown in the P core treatments and this was significantly higher in the LW treatments of the LPM and

MPM media. This is because, seedlings and ECM fungi need somewhat moisture in order to make association that is why high CRE observed in LW of the SAP core treatments.

Regarding the growth characteristics of the seedlings, in SAP core treatments, LW seedlings had higher growth parameters and leaf water potential than LW seedlings of the P core treatments. Seedlings in the LW of the SAP core treatments had higher leaf water potential almost twice of the seedlings grown in the LW seedlings of the P core treatments. SAP core, in LW, produce seedlings with higher shoot dry weight, root dry weight and total biomass. this might be due to the higher CRE and its efficiency in absorbing moisture form the SAP core.

In MPM and HPM media, LW seedlings of the SAP core had significantly higher leaves P concentration compared to the P core treatments. While in LPM media, leaves P concentration of the seedlings in all three water levels was significantly higher in P core treatments compared to the SAP core treatments. It is suggested that in LW treatments, P diffused form P core to the LPM media and help seedlings growth but in the media fertilized with available P (MPM and HPM), SAP core uptake P from the media by both ECM root and fine root as the seedlings were highly colonized with ECM fungi.

Chapter 4 deals with the effect of different usage of SAP (core, amendment) and ECM (natural and artificial) inoculation on morphology and physiology of *Q. serrata* seedlings in dry soil condition. For this purpose, a study was conducted on *Q. serrata* seedlings in the phytotron where both temperature and humidity were controlled. Result of the study indicates that CRE increased in artificially inoculated (A-ECM) treatment and it was significantly higher than naturally inoculated (N-ECM) and soil sterilized treatments. The A-ECM treatment with the highest CRE had the highest growth parameter and leaves nutrient concentration compared to the N-ECM and soil sterilized treatments. It is due to

the effect of ECM colonization on seedlings physiological activity as seedlings in A-ECM treatment had higher stomatal conductance and net photosynthetic rate. A-ECM seedlings could control their stomatal conductance on the first two days after irrigation to recover from water stress. But on day third and fourth after irrigation they were able to continue stomatal conductance significantly higher than other treatments. It is also suggested that SAP as an amendment had the lowest CRE and this might be due to the SAP as it covered seedlings root when the media irrigated which prevents roots and fungi to make association. Between SAP treatments, SAP core was more effective in terms of increasing CRE and survival rate of *Q. serrata* seedlings compared to the SAP amendment treatment. This might be due to the swelling and shrinking property of the SAP which influenced seedlings growth during pre-irrigation (media shrunk) and post-irrigation (media swelled). Therefore, in order to use SAP for the production of seedlings in dry condition, the SAP-core method is better than the SAP-amended method. In addition, regarding those SAPs which are not biodegradable, SAP-core treatment is better than SAP amended treatment in terms of SAP waste.

General discussion is drawn in chapter 5. In which effects of ECM on *Q. serrata* seedlings, factors influencing ECM colonization of the root and efficiency and precaution of using SAP in dry soil condition have been addressed. High moisture and available soil P in the media discussed as a limiting factors for seedlings root colonization by ECM fungi. In addition, the supportive role of SAP core or water patch for seedlings growth and association between seedlings root and ECM fungi have been discussed too. Furthermore, in this chapter, the role of P core in the diffusion of P to the media in P deficient environment illustrated. Moreover, different usage of SAP and its effect on CRE, growth, nutrient uptake and survivorship of the seedlings have been concentrated.