The effects of drought to the utilization and transport of non-structural carbohydrates in *hinoki* cypress

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1. Background

In recent global warming, clarifying the carbon utilization of trees under drought is important to consider about how trees survive and function as carbon sinks. In this study, I investigated the following points in order to clarify the carbon distribution, utilization, and transportation as sugar and starch under drought and how these contribute to tree death. First, I focused on the morphological and quantitative changes of non-structural carbohydrates (NSC) in each organ under drought. NSC is an indispensable substance for metabolism of plants, and I used ^{13}C pulse labeling to examine the use of NSC in trees in detail. By this method, the carbon assimilated in the early drought can be distinguished, and carbon utilization under drought can be observed in detail. Secondly, I focused on the change in the phloem due to drought. The phloem is an important tissue for transporting photosynthetic products as sucrose to each sink organ of the plants. I discussed the change in carbon transport under drought based on the change in phloem structure and NSC concentrations.

2. Material and Method

The plant material was young *hinoki* cypress that is an important forestry species in Japan. Firstly, I divided plant materials into four groups for the drought experiment: short-term drought stress group (SD group: n = 5), long-term drought stress group (LD group: n = 5), and two control groups corresponding each drought group (SD control group: n = 3, LD control group: n = 2 respectively). The two drought groups were protected against the rain. Then these four groups were labeled using $^{13}CO_2$. Seven days after labeling, SD group and SD control group were harvested. 86 days after labeling when all the leaves had turned brown, LD group and LD control group were harvested. After harvesting, each organ (leaf, green branch, brown branch, stem, fine root, coarse root) was sorted, freeze-dried, and their dry weight was measured. To determine the quantitative changes in NSCs from these samples under drought, soluble sugars (from leaves, green branches, fine roots) and starch (from all organs) were extracted, and those concentrations and isotope ratios were determined. Furthermore, I observed the phloem structure in stems of trees from each treatment and identified their sieve cells. After that, I evaluated the number and the area of sieve cells.

3. Result and Discussion

(1) NSC concentration and percentage of remaining ^{13}C

Under short drought, mono-sugar concentrations tended to increase in hinoki and starch concentrations decrease, especially in leaves. This result highlighted that hinoki performed an osmotic adjustment by increasing mono-sugar concentrations under short term drought. Under long drought, labeled carbon (^{13}C) assimilated in early drought tended to remain, despite the decrease of sugar concentration in the leaves, green branches, and fine roots. Furthermore, when comparing the starch of SD group and LD group, the concentration and ^{13}C ratio hardly decreased regardless of the duration of the drought period. This suggests that the carbon obtained in the early stage of drought tends to be stored rather than being mobilized for metabolic use.

(2) Changes in phloem structure

There was no significant change in the individual sieve cell area between SD group and SD control group. In contrast, under long drought, the sieve cells tended to shrink, which indicated that phloem transport has been impaired.