Transactions of the Materials Research Society of Japan. Vol. 20

Acoustic Emission Characteristics Generated from Seedling, Adult Tree and Shoot Culture of Conifers

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There is a phenomenon of acoustic emission generated in the xylem of plants by transpiration and water transportation. It is expected that the AE technique is applied to agriculture and forestry, to diagnosis and treatment of trees, and to plant culture. But, the data of AE measurement are few, and the mechanism of AE generation is still indistinct. In this research, the characteristics of AE generated from seedlings of Japanese cedar, adult trees of Himalayan cedar and shoot cultures of larch were examined. Furthermore, the relationship among AE parameters, and the relationship between the condition of plant and the AE characteristic was investigated.

1. INTRODUCTION

It is expected to establish a non-destructive acoustic emission (AE) technique diagnosing the water transportation of a plant, which detects a phenomenon of cavitation in the xylem. In the previous work[1], the AE detected from 2-year-old seedlings of sugi planted in soil acidified artificially was examined. There was scarcely any AE generation in a night, in cloudiness and in rain when there was no solar irradiance. The AE generation of the healthy seedling in the control was concentrated at the initiation of the solar irradiance. In the case of seedlings water stressed by transplanting or soil acidification, the AE generation had low concentration at the initiation of the solar irradiance, and it was spread in the period of the sun shining. Therefore, the AE generated with the cavitation in plants may be related closely to the transpiration at the leaf and the water absorption at the root. Ikeda et al.[2] reported AE generated from a several year old pine seedling related to the solar irradiance and the soil water. However, the former researches have been performed for herbs, seedlings or a tissue of tree such as a small branch or a leaf. In order to apply the AE technique to diagnosis of trees, it is necessary to investigate AE characteristics generated from a mature tree. And, Okushima et al.[3] have developed a new AE sensor to detect AE generated when the root is growing in the soil. Therefore, another AE mechanism is recognized except the cavitation origin.

In this research, the characteristics of AE generated from seedlings of sugi (Japanese cedar), adult trees of Himalayan cedar and shoot cultures of larch were examined. Furthermore, the relationship among AE parameters, and the relationship between the condition of plant and the AE characteristic was investigated.

2. AE CHARACTERISTIC OF SUGI SEEDLING

2.1 Experimental Procedures

A 2-year-old seedling of Japanese ceder sugi (*Cryptomeria japonica* D. Don) was transplanted in the brown forest soil, and it grew in a greenhouse from June 9th to September 1st in 1993. A micro-AE-sensor (NAIS S304μ, resonance frequency of 300 kHz, diameter of 3 mm) was set at a position of 2 cm high from the soil surface on the stem of the seedling with silicone grease as a coupler and it was wound with gauze to fix it (Fig.1). The AE signal was amplified with a pre-amplifier (PAC 1220A, 60 dB) and sent to a 4-channel AE analyzer (PAC 3400) set in a hut next to the glasshouse with BNC cable of 50 m and AE parameters were measured. And, air temperature, relative humidity and intensity of solar irradiance in the glasshouse were measured at 1-hour intervals.

2.2 Result And Discussion

Fig. 2 shows the transition of air temperature, relative humidity and intensity of solar irradiance in the glasshouse on August 23. Fig. 3 show the AE energy generated from the seedling. There was no AE generation in the time zone of no solar irradiance. The generation of AE concentrated at the initiation of the sunshine around 8 o'clock and was not recognized in the afternoon. In Fig. 4, correlation was recognized between the AE energy and the AE retention time, but there is not correlation in the AE energy and the AE peak amplitude. As for this reason, it is guessed that the wave form of AE generated from the seedling was continuous type AE instead of burst pulse type.

3. AE CHARACTERISTIC OF HIMALAYAN CEDAR TREE

3.1 Experiment Procedures

The tree examined was Himalayan cedar (*Cedrus deodara* Loud.) growing in the fuchu campus of Tokyo University of Agriculture and Technology (Fig. 6). The tree has height of 20 m and diameter of breast height of 1.95 m. The bark of trunk at breast height of the tree was removed and AE sensor (NAIS F217M, resonance frequency of 200 kHz) was set with vaseline as a coupler. The AE signal was amplified with a pre-amplifier (PAC1220A, 60 dB), and sent to the AE analyzer (PAC3400) set indo with 50 m of BNC cable. The AE measureme performed for 2 months from October to November 1995.

3.2 Result And Discussion

Fig. 7 shows the transition of air temperatur relative humidity and intensity of solar irradiance o November 17th. Fig. 8 show AE energy generate from the tree. The generation of AE was alwa recognized, and did not correspond to the sol irradiance. The frequency of AE which AE energy w less than 50 was always high.. In the case of Fig. Correlation was recognized between the AE energ and the AE duration time similarly to Fig. However, there were a couple of groups which hav different AE wave form and mechanism of A generation, in the case of the relationship between th AE energy and the AE peak amplitude in Fig. 1(Two groups mean the low energy AE that the plo distributed the AE energy less than 50 and the A peak amplitude from 50 to 85 dB, and the high energ AE that the plots distributed the AE energy more tha 50 and the AE peak amplitude from 40 to 60 dB. Thi tendency was recognized in other measurement day Because the mature tree has more volume of xylem t store up water than the seedling, the generation of A doesn't correspond in the daily change of sol

Fig. 1 AE measurement of sugi seedling.

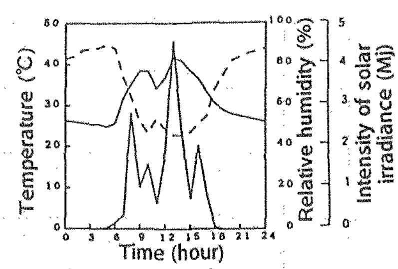

Fig. 2 Transition of air temperature, relative humidity and intensity of solar irradiance on August 23.

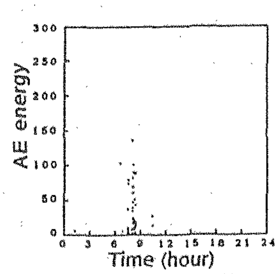

Fig. 3 AE energy of seedling on August 23.

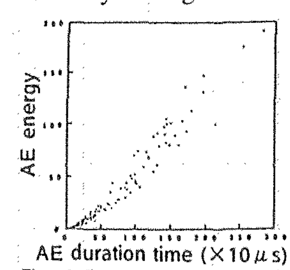

Fig. 4 Relationship between AE energy and AE duration time (seedling).

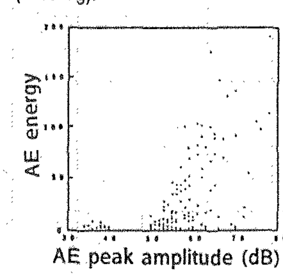

Fig. 5 Relationship between AE energy and AE peak amplitud (seedling).

irradiance. Then, it is necessary to examine the AE related to the weather condition such as solar irradiance and the precipitation in a long term.

4. AE CHARACTERISTICS OF LARCH SHOOT CULTURE

4.1 Experiment Procedures

For rooting, shoots of larch (*Larix Leptolepis* Gordon) were put on the modified MS medium (1/2-nitrogen) supplemented with 1.5 μM NAA, 1.5 μM IBA, 30 g/l sucrose, 3 g/l gellan gum, and cultured at 25℃, 4000 lux, 16-hour photoperiod. The AE sensor (NAIS F217M, resonance frequency of 200 kHz) was set at a bottom of test tube with silicon grease as a coupler as shown in Fig. 11, and the AE signal was amplified 60 dB with a pre-amplifier, and sent to the AE analyzer (PAC3400).

4.2 Result And Discussion

Fig. 12-14 show the AE energy of AE generated from 0 o'clock to 23 o'clock for shoot culture A which has one adventive root , shoot culture B which has one adventive root and leaves color changing in yellow caused by water stress, and shoot culture C which has three adventive roots, respectively. All adventive roots of shoot culture A, B, C were reached to the bottom of test tube. Since the generation time of AE from each shoot culture was different at all, it wasn't regarded as environment noise. Though the light was turned off from 0 o'clock to 8 o'clock, the AE generation was not under the influence of the light. The frequency of AE generation from each shoot culture was different from each other, therefore, the formation of adventive root and the water condition of the culture might affect on the AE generation. And, Fig. 15-18 show the AE energy of AE generated from 0 o'clock to 24 o'clock for shoot culture D which has one adventive root reaching to the bottom of test tube, shoot culture E which has formed no adventive root, shoot culture F which has two adventive roots not reaching to the bottom, and control G which has only medium cultured no shoot, respectively. The AE generation of shoot culture D was similar to the shoot culture A. And, AE hardly generated in the shoot culture E which has no adventive root, and in the control G. In the case of the shoot culture F, for adventive roots didn't reach to the bottom, an AE signal which generated at the adventive root diminished before its arrival at a sensor, it resulted in low AE energy and low frequency of AE generation. Fig. 19 and 20 show the relationship among AE parameters of AE generated in shoot culture D. Correlation is recognized between the AE energy and the AE duration time.

Fig. 6 Himalayan cedar tree.

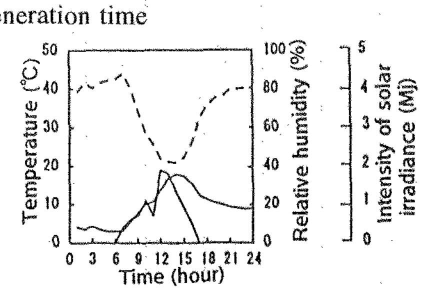

Fig. 7 Transition of air temperature, relative humidity and intensity of solar irradiance on November 17.

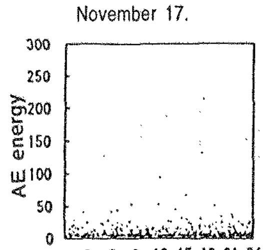

Fig. 8 AE energy of tree on November 17.

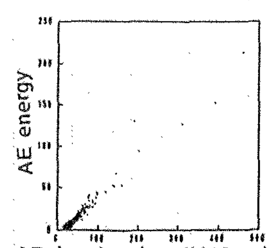

Fig. 9 Relationship between AE energy and AE duration time (tree).

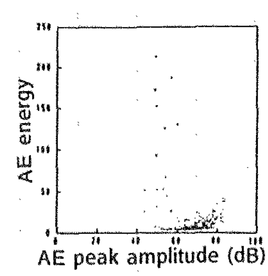

Fig. 10 Relationship between AE energy and AE peak amplitude (tree).

5. CONCLUSION

The AE generated from plants was of continuous type, and there was correlationship between the AE energy and the AE duration time. In the case of the sugi seedling, AE caused by the solar irradiance and the water condition of the seedling, there was no AE generation in the time zone of no solar irradiance. Because a seedling has small capacity of xylem storing up the water, the water transportation maybe corresponds to the change of solar irradiance sensitively.

On the other hand, the Himalayan cedar tree has much capacity of xylem in the trunk, the generation of AE was always recognized not to correspond to the solar irradiance. Then, it is necessary to examine the AE related to the weather condition such as solar irradiance and the precipitation in a long term. Two kinds AE were detected from the tree, they were considered to be different in mechanism of AE generation.

The AE generation from larch shoot culture was not under the influence of light. The frequency of AE generation was affected by the formation of adventive root and the water condition of the culture. It is necessary to investigate the AE generation mechanism in future research, that is, how the AE is caused by the water absorption or by growth of root.

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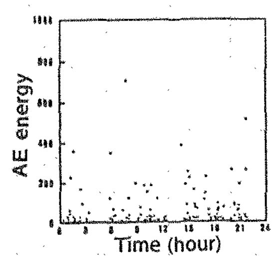

Fig. 12 AE energy of shoot culture A (one adventive root).

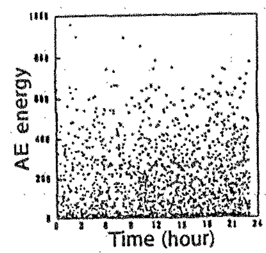

Fig. 13 AE energy of shoot culture B (one adventive root, water stressed).

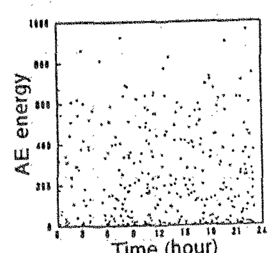

Fig. 14 AE energy of shoot culture C (three adventive roots).

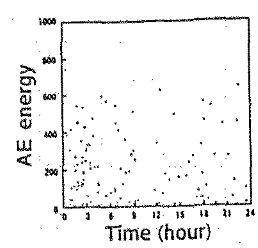

Fig. 15 AE energy of shoot culture D (one adventive root).

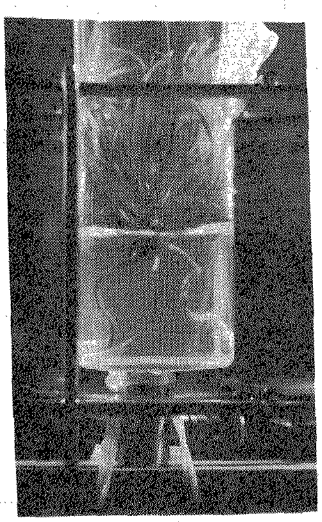

Fig. 11 AE measurement of larch shoot culture.

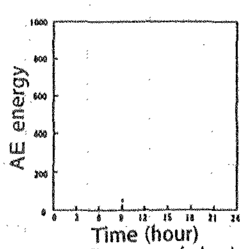

Fig. 16 AE energy of shoot culture E (no adventive root).

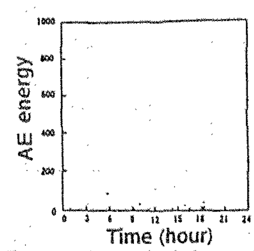

Fig. 17 AE energy of shoot culture F (two adventive roots not reaching to bottom of test tube).

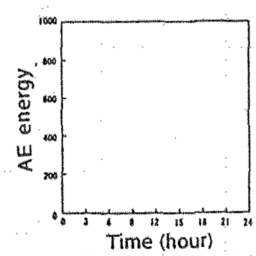

Fig. 18 AE energy of control A (no shoot culture).

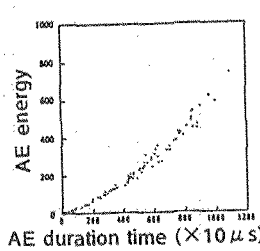

Fig. 19 Relationship between AE energy and AE duration time (shoot culture D).

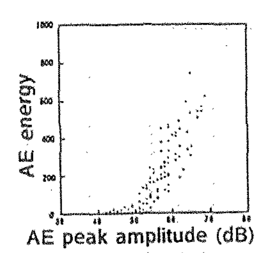

Fig. 20 Relationship between AE energy and AE peak amplitude (shoot culture D).