A-5.3 Effects of enhanced UV-B on Forest Vegetation and their adaptation mechanisms

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Total Budget for FY1993-FY1995:30,668,000Yen (FY1995:11,915,000 Yen)

Abstract

The spectral radiation transmission model of the canopy(Ohtani et al.,1993) was applied to evaluate UV-B environment in forest canopy. The amount of ultraviolet rays which reached to forest floor was presumed attenuation by about 1/2 orders in rough vegetation(LAI=1) and 2 orders in closed vegetation(LAI=5) compared with strength irradiated on the crown. It was shown that attenuated in vegetation(LAI=10) closely closed more than four orders and UV-B reached the forest floor hardly.

A regional difference of spectral radiation density was large. Evalution of UV-B in alpine area suggested that intense UV-B existed where the altitude was high and showed equivalent larger in alpine.

The UV-B irradiation experiment was executed to the plant influence investigation of ultraviolet rays. Especially, the damage of the leaves was remarkable. Damege with form change and withering of the seedling was received by irradiating strength UV-B in Spruce and Beech. It was clarified that there was a possibility for the ultraviolet rays irradiation to exert the change in the form and the influence of the control of the growth etc. on seedlings by the actual experiment.

Key Words : UV-B, Forest Vegetation, Biological impact

1. Introduction.

The depletion of the stratospheric ozone layer is actualized. Especially influences on living organisms are forecast that the influence is exerted on production, growth or the proliferation of the plant by the ozone layer destruction and a large increase of the amount of the ultraviolet B rays,UV-B.

There is an anxiety to the decline of the forest where buffer action to environmental changes is high and the research concerning the forest where many of biomasses are occupied is attached to importance in the influence evaluation to global ecosystems. Moreover, there are possibilities to receive the influence of ultraviolet rays increase more sensitively in the forest ecosystem postponing distributing even to Alpine area that the altitude is high.

It is thought that the examination of the adaptation mechanism etc. it to be necessary to contribute to the evaluation and measures of the tree influence by ultraviolet rays is pressing needs.

In this research, attention was paid to two following points. The first, ultraviolet rays strength of the presumption of the radiation in the forest canopy environment was estimated for the purpose to clarify the UV radiation given to the forest environment.The second , to evaluate the influences on the forest plant, the irradiation experiment was executed to seedlings of some tree species. In this report, the influences of enhanced ultraviolet rays on forest vegetation and the adaptation mechanism are discussed from these two viewpoints.

2. Evaluation of UV-B radiation in forest environment

(1) Evaluation of UV-B radiation in forest canopy

- Application of Spectral Radiation Transmission Model -

Research Objective

The radiation transmission in forest canopy where a multiple reflection had been considered according to the wave length was calculated. And the characteristic of the UV-B radiation in the canopy was clarified.

The spectral radiation transmission model made by this research is classified into the model of two direction approximation by which a multiple reflection in the canopy is considered.

Research method

The Spectral radiation transmission process handled by two direction approximation model Spectral Radiation Transmission Model in the Canopy(Radiation Transmission Model:Ohtani et al.1993) shown by this research is penetration and a reflection of leaf layer.

The reflectance and the transmittance of the leaf in UV-B band almost correspond to the infrared rays of 2300nm or more smaller than a visible region according to Jones(1992). Random arrangement of the horizontal leaves was assumed and the leaf was given from top (z/h=1.0) to forest floor (z/h=0.0) of the canopy as the same distribution. The incidence spectrum of canopy top assumed as input data was observed in Tateno,Sapporo, Kagoshima, and Naha in December,1990. Albedo of the forest floor was assumed to be 0.2 regardless of the wave length.

Result

- Characteristic of UV-B radiation within a forest canopy -

Fig.1 shows the example of calculation of UV-B radiation in forest canopy. The radiation attenuates by about 1/2 orders in sparse canopy(LAI=1) and 2 orders in closed leaf layer (LAI=5). It is shown more than four orders to attenuate in closely closed canopy (LAI=10) and to hardly penetrate UV-B to forest floor(z/h=0.0).

Fig.2 showed the spectrum which reached the forest floor which had been obtained from the observation data and the model in various places in December, 1990. The wave length is short in this band area, and that provides regional differencesa of the amount of ultraviolet rays. The amount of penetration to the forest floor also reflects this tendency.

Fig.3 showed total amount of UV-B on forest floor. Log(UV-B) decreases in most straight lines as LAI increases.

It is clear also in presumption by the model done by this research that the ultraviolet rays environment does a remarkable change according to the crown structure. In addition, the examination including the measurement will be needed for setting the irradiation examination condition in the future because latitude and the change by the region by the high degree take place, too.

(2) Evaluation of UV-B radiation in alpine area

Research method

Potential strength of ultraviolet rays in alpine area was estimated by comparing the observation of global radiation spectrum of alpine and low land which had been done since 1993 term using spectral radiation meter.

Result

Spectra at the top of Mt.Daikoku(Mt.Norikura) of the autumn of 1995 and Kukizaki were compared from among the observed data set simultaneously.

Fig.4 shows difference of the relative spectrum distribution in Kukizaki and Mt.Norikura.

It is shown to have a relatively high spectrum radiation of UV-B in Mt.Norikura when the radiation of the same visible region spectrum is given at Kukizaki.

When assuming of an amount's of the visible light radiation the same as mentioned above, it is forecast that the amount of the UV-B irradiation increases considerably in the alpine area. The estimated value of Mt.Norikura has increased by about 1.3 times in the total amount and 1.8 times when UV-B be (Caldwell,1971) are multiplied with. It is clear that the amount of the radiation of UV-B is very large in the alpine area.

3. Evaluation of influence on forest vegetation by enhanced UV-B

Research Objective

The UV-B irradiation experiment was executed to the plant influence investigation of ultraviolet rays. It is thought that the examination of the adaptation mechanism etc. it to be necessary to contribute to the evaluation and measures of the tree influence by ultraviolet rays is pressing needs.

Examination method

The UV-B irradiation examination to seedling was done with a ultraviolet rays irradiation device set up in artificial weather room and outdoor.

The influence evaluation by which the reaction of seedlings immediately after germination was done by the result of the irradiation examination for a short term done in artificial weather room.

The long period irradiation examination for seedling was provided and was tried was with a ultraviolet rays irradiation device in outdoor.

Mainly, species of Glehn's spruce Picea glehnii Mast.,White fir Abies mayriana,M.et K. and Seibold's beech Fagus crenata Bl. were treated in these experiments. Artificial UV-B sources were supplied by ultraviolet lamps(F40UVB). Irradiation strength was set from 0.15Wm-2 between 1.21Wm-2 of the strongest processing level in indoor.

The UV-B irradiation examination to seedlings was done with a ultraviolet rays irradiation device set up in outdoor. The processing level where the amount of about 35,000J/m2 expectation and the irradiation of about 2.5-3 times was given was set as the strongest processing with the multiplication natural light UV-B value observed at the summer fine weather of the experimental field.

Result

Influence appearance of seedlings by UV-B irradiation

The remarkable, visible influence appearance on seedlings was admitted in growth and the form. Especially, the form change in the seedling according to UV-B irradiation strength took place soon in spruce after germinating.

The leaves hanged downwards according to the increase of irradiation strength of UV-B while the developing leaves turned to the upper side in the control where ultraviolet rays was not irradiated.

Abnormality of the development leaf was confirmed to the strong irradiation level.

Remarkable visible influence appearance was also admitted in growing and the form of beech seedlings. The influence on leaf area per single leaf because of the form change of the expansion growth and the leaf of the leaf was shown in Fig.5 as an example of the influence of the ultraviolet rays irradiation to growth of beech seedlings.

Influences of long-term UV-B irradiation on young trees are shown in Fig.6 as differences in relative growth. The relative height growth was suppressed (The contcol level received damage by the pest in summer in beech). UV-B has accelerated diameter growth except White Fir.

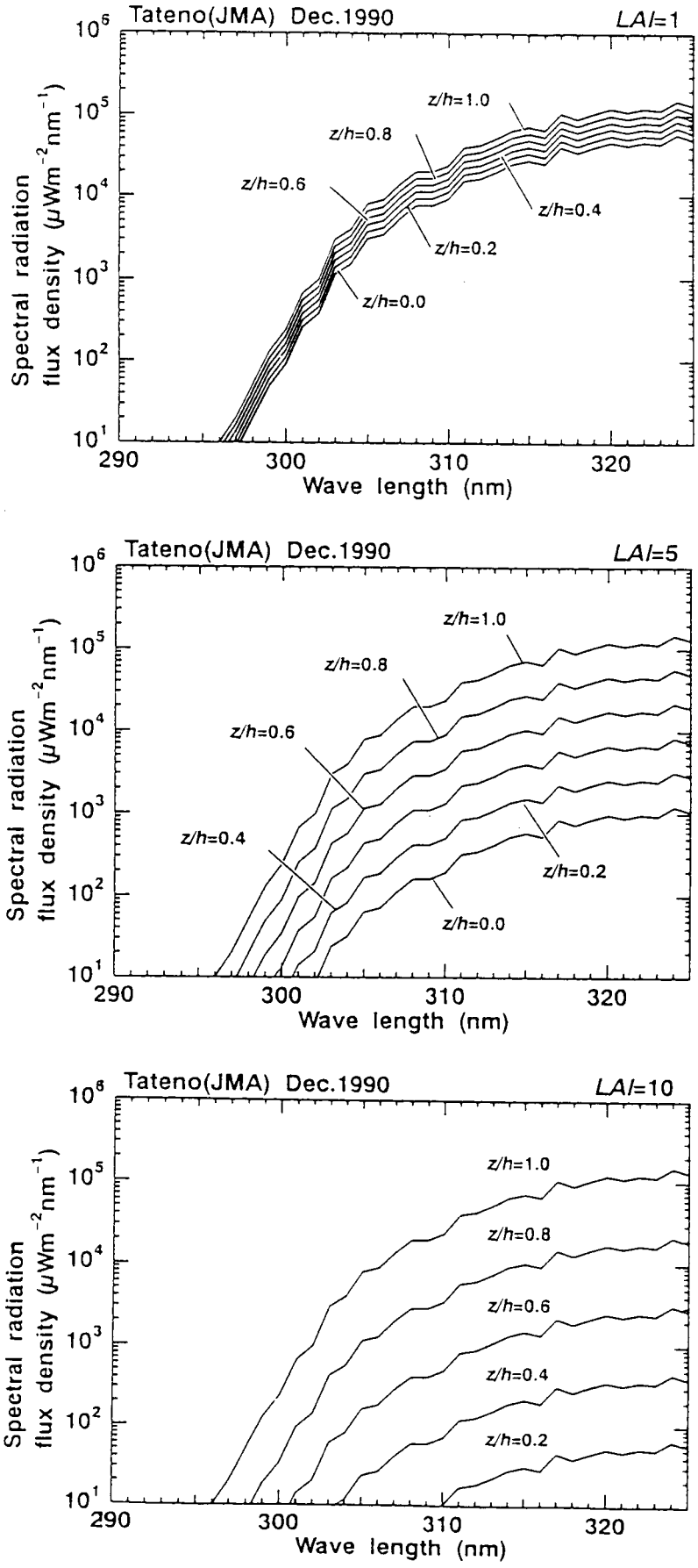

Fig.1 Relationships between evaluated value of UV-B radiation density in canopy and LAI

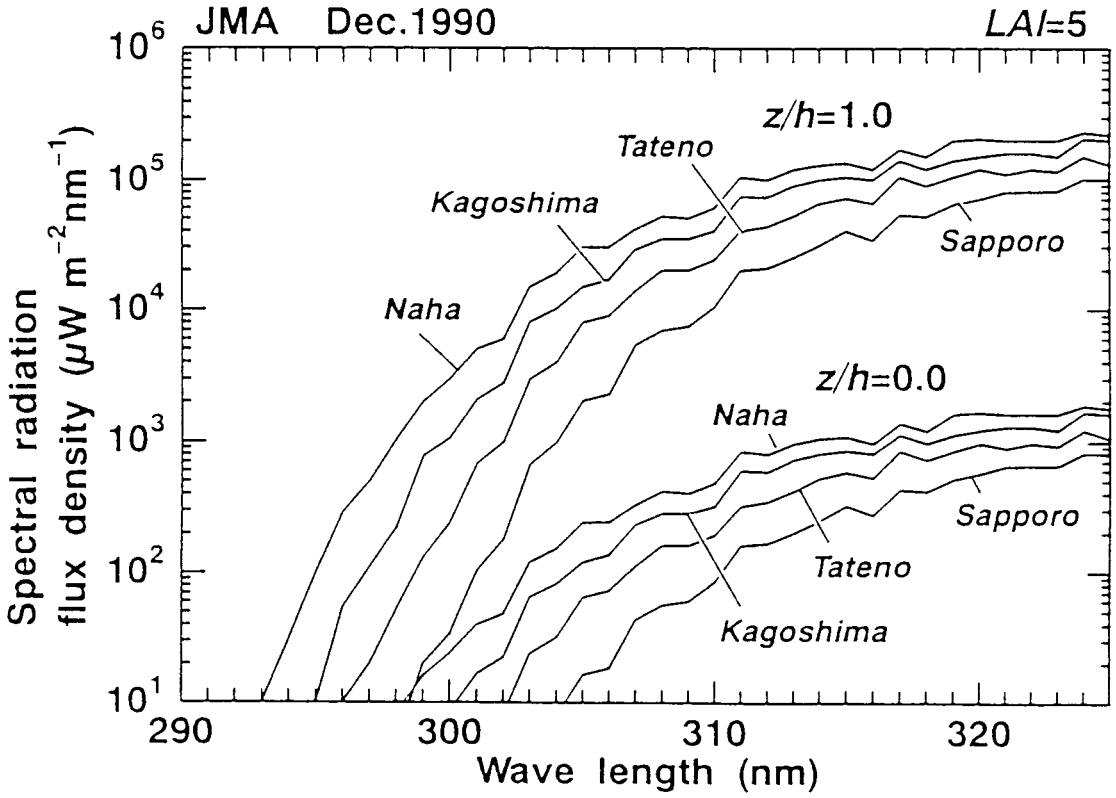

Fig.2 Regional difference of amount of UV-B that reaches forest floor

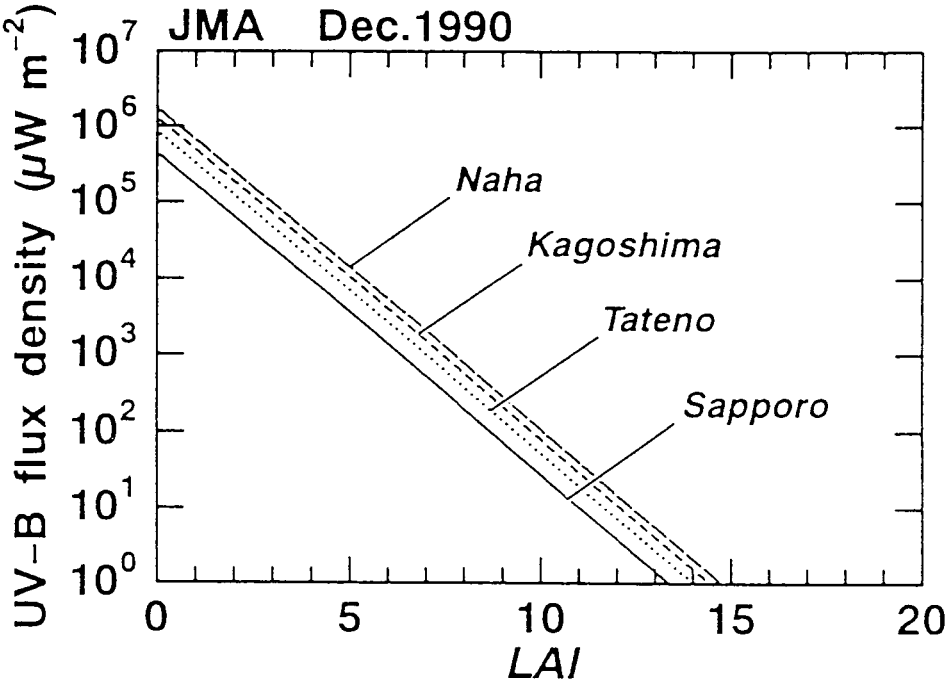

Fig.3 LAI and amount of UV-B penetration

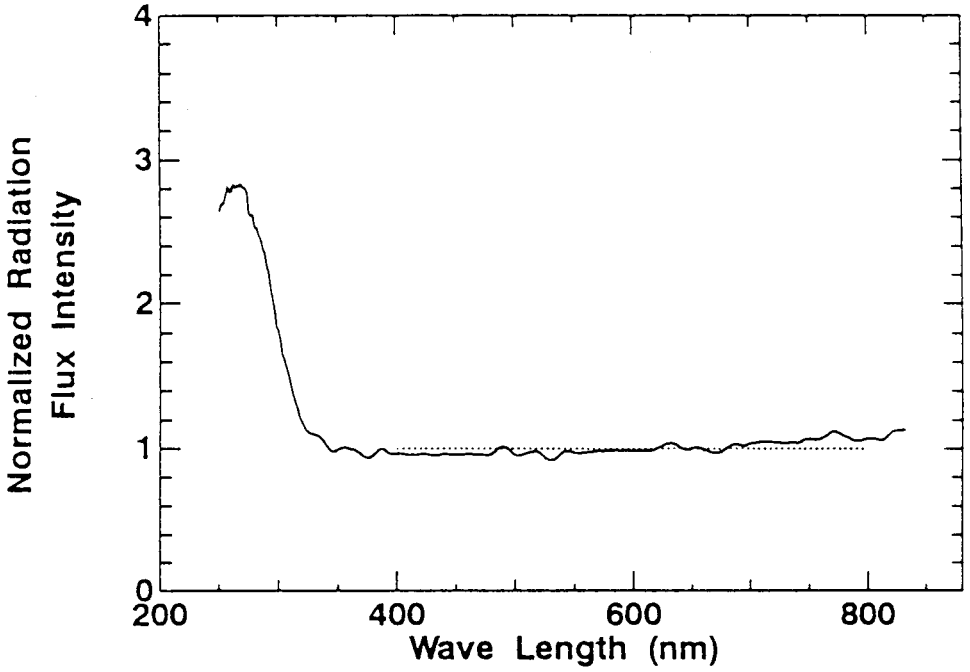

Fig.4 Difference in normalized UV-B flux intensity between Mt.Norikura and Kukizaki.

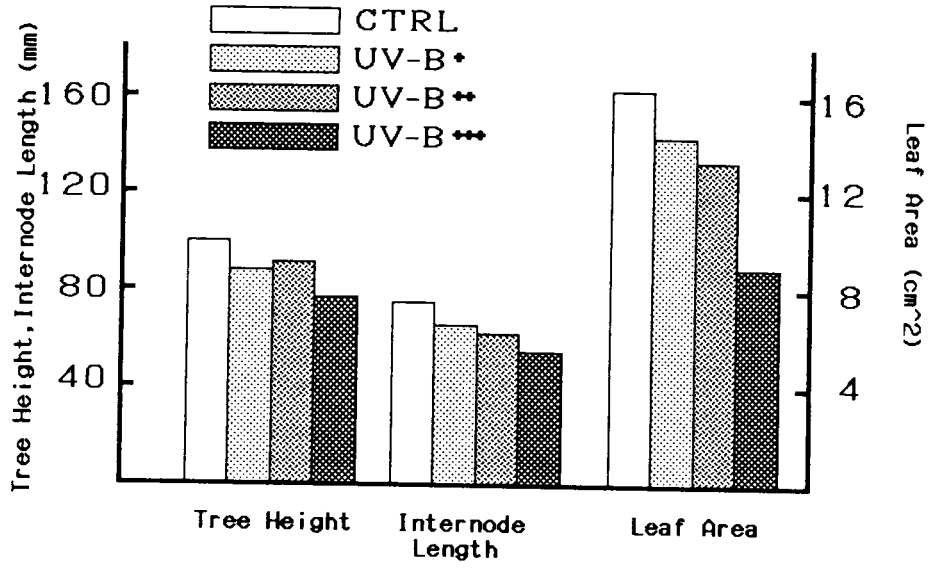

Fig.5 Influence of UV-B on leaf area and height of beech seedlings

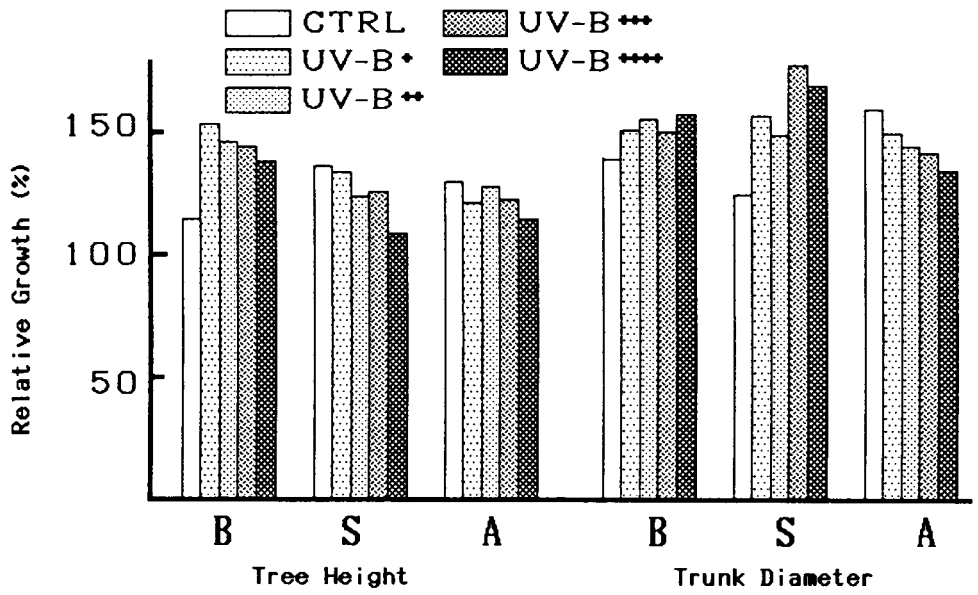

Fig.6 Long-term Influence of UV-B on height and diameter growth of young trees from 1994 to 1995.

B: Beech , S: Glehn' spruce , A : White fir