波長組成と強度をかえた光条件下における林木のメバエの生長

誌名	日本林學會誌 = Journal of the Japanese Forestry Society
ISSN	0021485X
著者	森川, 靖 浅川, 澄彦 佐々木, 恵彦
巻/号	58巻5号
掲載ページ	p. 174-178
発行年月	1976年5月

論　文

Growth of Pine and Birch Seedlings under Lights with Different Spectral Compositions and Intensities

Yasushi MORIKAWA*, Sumihiko ASAKAWA*
& Satohiko SASAKI*

MORIKAWA, Yasushi, ASAKAWA, Sumihiko & SASAKI, Satohikio: **Growth of pine and birch seedlings under lights with different spectral compositions and intensities J. Jap. For. Soc. 58: 174～178, 1976** Height growth of pine hypocotyl increased with the decreased irradiance of visible light (380～760 nm) in the color boxes used. The height was greatest in the blue box where the irradiance of red light region was appreciably lowered. Height growth of pine and birch epicotyl was optimal around the irradiance of 2 mW/cm^2 except in the case of blue box, where epicotyl height increased with the increased irradiance. Diameter growth, dry matter production, and areal weight of birch leaves also increased with the increased irradiance, and all of those were lowest in the blue box. Ratio of root to total dry matter showed the same tendency. Under the light containing no far-red region there was no appreciable difference in height growth of pine among color boxes. Remarkable height growth in the blue box under an ordinary light source may be attributable to the promotive effect of far-red region.

森川　靖・浅川澄彦・佐々木恵彦: **波長組成と強度をかえた光条件下における林木のメバエの生長　日林誌 58: 174～178, 1976**　温度 25°C, 日長 16 時間に制御した条件下で,可視光域(380～760 nm)の照射エネルギーをかえ,可視光の特定波長域を選択的にへらすことができるカラープラスチックをかけてクロマツとシラカンバのメバエを育てた。赤色光域が少ない光条件下では,照射エネルギーの増加にしたがって上胚軸の伸長生長が促進されたが,青色光域の少ないもの,青色光と緑色光域の少ないもの,いずれの波長域も除去しない人工光のものでは,照射エネルギーが 2 mW/cm^2 より増加すると逆に少なかった。いずれの光条件でも照射エネルギーの増加にしたがって,上,下胚軸の直径は増加したが,同じ照射エネルギーでは赤色光域の少ない光条件下で細かった。これらのカラープラスチックのうえに硫酸銅溶液フィルターをのせて遠赤色光域を除去すると,赤色光域の少ない光による上長生長の促進効果がなくなる。このことから,上長生長に特異的に作用する光条件として,遠赤色光域と赤色光域のバランスをかんがえた。

Effect of light intensity on seedling growth of forest tree species has been studied mainly in relation to natural regeneration or shade tolerance. It is well known that light intensity under the forest canopy is much lower as compared with that in the open area. However, recent studies have also emphasized the spectral difference of light between the outside and inside of the forest(*2, 3*). It is very probable, therefore, that the seedling growth under the forest canopy is affected by light quality as well as by light intensity. In the previous paper, the authors reported the growth responses of some tree seedlings to the lights of different spectral compositions under various growing conditions(*1*). The results indicated that seedling growth could be affected markedly by light quality. But there has been no information on the combined effect of light quality and intensity on forest tree species. In this study, the growth of pine and birch seedlings related to light quality is examined under different intensities, and also preliminarily under the light containing no far-red region.

Materials and Methods

Pinus thunbergii seed cones were collected from clonal grafts of Minamata No. 2 at Takahagi seed orchard in Ibaraki Pref. in fall, 1971. *Betula platyphylla* var. *japonica* seeds were collected from a single tree at Wada National Forest on the foothill of Mt. Yatsugatake in Nagano Pref. in fall, 1972.

* Gov. For. Expt. Sta., Meguro, Tokyo 153　農林省林業試験場

Table 1. Irradiance in visible light region (380~760 nm) through color boxes

Regions decreased in filtered light		Irradiance (mW/cm²)				Red/Far-red ratio*
		A	B	C	D	
Neutral	uniform decrease	5.78	3.42	1.63	0.32	1.18
Blue	Red(+Yellow)	2.99	1.77	0.85	0.17	0.02
Yellow	Blue+Violet	5.46	3.23	1.54	0.30	1.17
Red	Blue+Green(+Violet)	4.12	2.44	1.17	0.23	1.17

* The ratio was calculated from Figure 1.

Four growth cabinets were used in this experiment. Four color boxes were placed in each cabinet. Four shading grades (A, B, C, and D) were prepared by polyvinylchloride films covering color boxes.

Seedlings germinated under the same conditions were transplanted into a seedling case filled with vermiculite, which was placed in a larger plastic batt containing water. The plastic batt containing two seedling cases was covered with four kinds of color boxes, each to cut down a certain region of visible light. Spectral distribution through the four boxes is shown in Fig. 1. To obtain a given intensity, three kinds of polyvinylchloride film, UVC-0, N-15, and N-30 were used. Irradiance in visible light region (380~760 nm) through these color boxes is shown in Table 1. Growth cabinets with artificial light source (Koitotron KB-20 S), abbreviated as AL-type, were used for the experiment. The cabinets were kept at 25°C with the day length of 16 hours. Details on color boxes, culture methods, and growth cabinets were described in the previous paper(*1*).

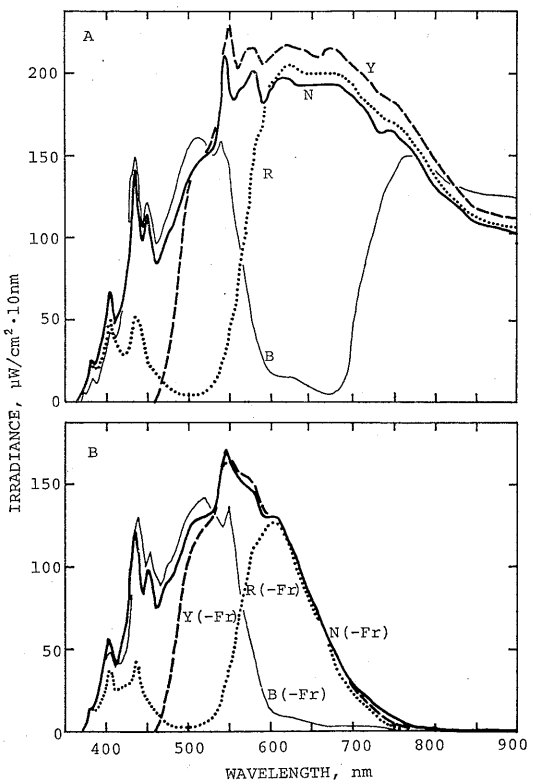

Fig. 1. Spectral distribution of the lights through four color boxes (A) and the boxes with $CuSO_4$ filter (B) measured by the spectroradiometer (Iio SRP-1462)

Results and Discussion

Experiment I

Pine Height growth of hypocotyl (Fig. 2) increased with the decreased irradiance in each color box, but the height was the largest in the blue box and nearly equal in the other three boxes. Height growth of epicotyl was optimal around the irradiance of 2 mW/cm² except in case of the blue box, where epicotyl height increased with the increased irradiance within the intensity range tested in the experiment.

Diameter growth of hypocotyl (Fig. 2) increased with the increased irradiance in each color box, and some difference was observed among color boxes. Hypocotyl diameter was greatest in the red box and smallest in the blue box. Growth of epicotyl diameter (Fig. 2) showed nearly the same pattern as in the case of hypocotyl, and more difference was observed between the blue box and other boxes. Epicotyl diameter was also largest in the red box and smallest in the blue box, and the difference between the blue box and other three boxes was much larger compared with the hypocotyl diameter. Dry matter (Fig. 3) increased with the increased irradiance, but it was highest in the red box and lowest in the blue box under the same irradiance. Less dry matter in the blue box may be due to less irradiance of the effective wavelength region in the action spectrum of photosynthesis in the blue box than in the red box. Ratio of root to total dry matter (Fig. 3) increased with the increased irradiance in all color boxes, but it was the lowest in the blue box. The result indicates that the distribution of assimilates to root is lowered with the light containing little red region, although it is also lowered with decreased light intensity. The relation was reversed with stem as the ratio of stem decreased with the increased irradiance and was higher in the blue box. Ratio of leaves

to total dry matter seemed to be the largest around the irradiance of 1.5～2.0 mW/cm².

Birch Height growth of hypocotyl can not be conclusively discussed because the final length was much shorter than that of pine and also very variable. Height growth of epicotyl showed nearly the same pattern as in the case of pine, but difference between two species was observed under lower light intensity (Fig. 4). Around the irradiance of 1 mW/cm², epicotyl height in blue box was shorter in comparison with pine. Epicotyl growth was optimal around the irradiance of 2 mW/cm² in neutral, yellow, and red boxes, while it did increase with the increased irradiance in the blue box. The result was just the same for the internode length, which is shown in Figure 4. An areal weight of leaves (Fig. 4) increased with the increased irradiance in each color box, but it was highest in the red box.

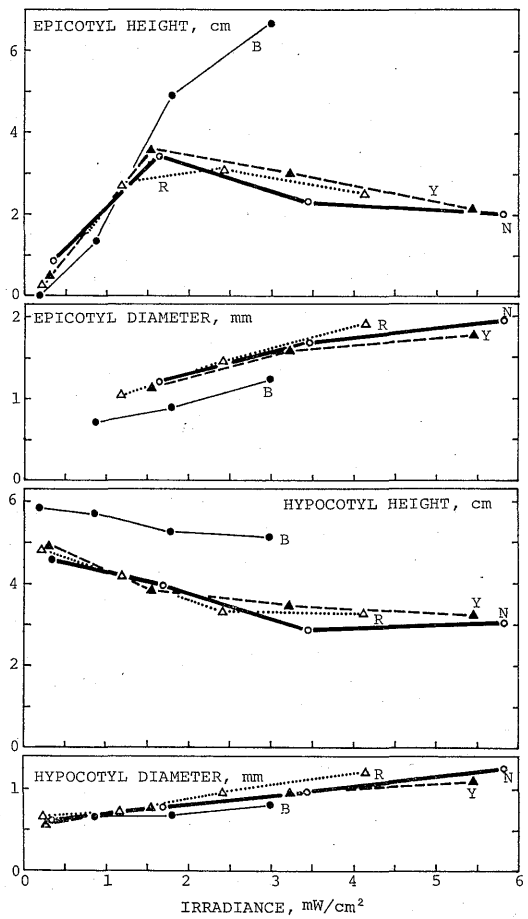

Fig. 2. Height and diameter growth of pine seedlings under different filtered lights
Experimental period: 14 Dec. 1973～15 Feb. 1974
Fourteen seedlings were used for each treatment.

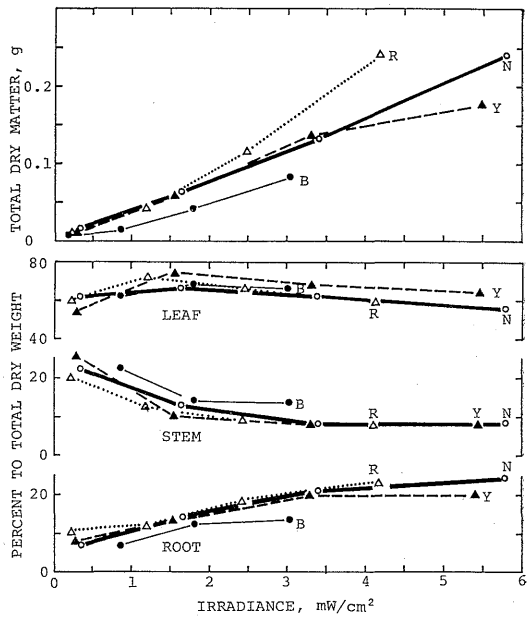

Fig. 3. Dry matter and its distribution of pine seedlings grown under different filtered lights
Experimental period: 14 Dec. 1973～15 Feb. 1974
Fourteen seedlings were used for each treatment.

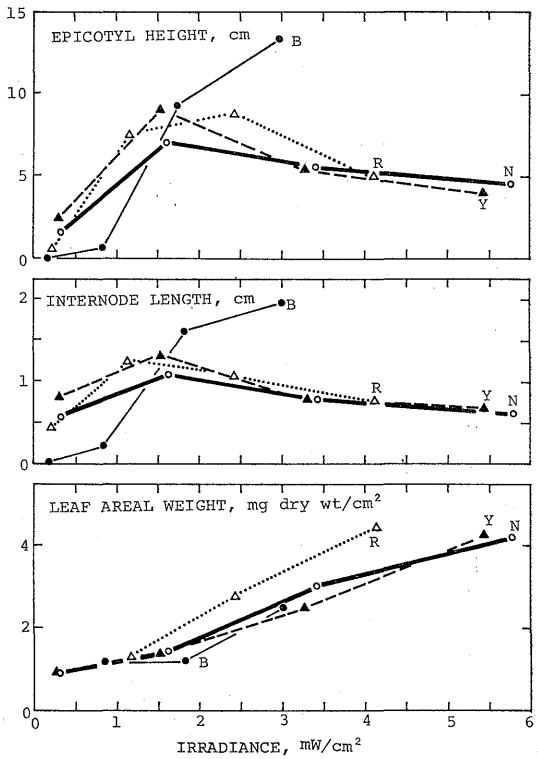

Fig. 4. Growth of birch seedlings under different filtered lights
Experimental period: 14 Dec. 1973～15 Feb. 1974
Fourteen seedlings were used for each treatment.

Table 2. Irradiance in visible light region (380~760 nm) through color boxes

Boxes	First series				Second series			
	N(-Fr)	B(-Fr)	Y(-Fr)	R(-Fr)	N	B	Y	R
Irradiance (mW/cm²)	3.18	1.95	2.44	1.55	5.78	2.99	5.46	4.12

Other experimental conditions such as air temperature and day length were kept the same as conditions used in Experiment I.

Experiment II

To determine the effective wavelength region on height growth, a trial was done with pine seedlings. In one series, the lights through color boxes were additionally filtered through 2 cm deep $CuSO_4$ solution (12.5 g/*l*) to cut off the far-red region. Spectral distribution is shown in Figure 1 comparing the lights used in Experiment I. Another series was the control with no additional filter. The irradiance under each color box is shown in Table 2.

Results in the second series did not significantly differ from those in treatment A in Experiment I. As shown in Figure 5, height growth of epicotyl decreased in all boxes under the light containing no far-red region. In Figure 6 the results in the first series were plotted to account for light intensity. With the light containing no far-red region, hypocotyl height decreased markedly in the blue box and slightly in the other three boxes. Remarkable height growth in the blue box (obtained in Experiment I) may be attributable to the promotive effect of far-red light region. The results also indicate that the height growth is affected by light quality depending on light intensity. There is nearly the same tendency in the length of both hypocotyl and epicotyl. Less difference was observed in hypocotyl growth, which should be greatly dependent upon megagametophyte.

Measurement of diameter and dry matter was prolonged at about 90 th day after transplanting in Experiment II to observe whether or not the decreased height growth affected by the light containing no far-red region continues for the long period. Therefore, direct comparison of diameter and dry matter growth between Experiment I and

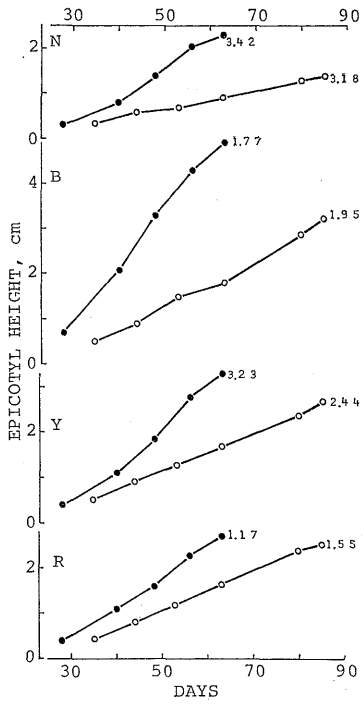

Fig. 5. Effect of light containing no far-red region on the growth of epicotyl after transplanting

Circles; growth under the light containing no far-red region, Solid circles; growth under the light containing far-red region obtained in Experiment I.

Numerals beside each curve represent the irradiance used (cf. Table 1 and 2). Fourteen seedlings were used for each treatment.

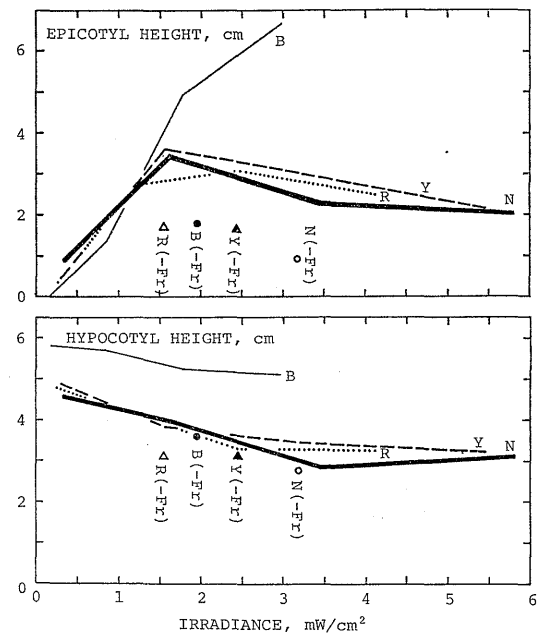

Fig. 6. Height growth of pine seedlings in four color boxes under the light with or without far-red region

Four kinds of line were transcribed from Fig. 2.
Experimental period: 8 July~9 Sept. 1974
Fourteen seedlings were used for each treatment.

II may not be made. However, we may conclude from the experiments described above that the far-red light region affects the height growth, but does not affect the dry matter increment.

Literature cited

(1) Asakawa, S., Sasaki, S. & Morikawa, Y.: Growth of tree seedlings under the lights of different spectral compositions. J. Jap. For. Soc. **56**: 441~447, 1974

(2) Federer, C. A. & Tanner, C. B.: Spectral distribution of light in the forest. Ecology **47**: 555~560, 1966

(3) Vézina, P. E. & Boulter, D. W. K.: The spectral composition of near ultraviolet and visible radiation beneath forest canopies. Can. J. Bot. **44**: 1267~1284, 1966

(Received October 9, 1975)