水稲生育の光質依存性第1報

誌名	日本作物學會紀事
ISSN	00111848
著者	稲田, 勝美
巻/号	42巻1号
掲載ページ	p. 63-71
発行年月	1973年3月

Proc. Crop Sci. Soc. Japan 42(1) : 63-71 (1973)

Spectral Dependence of Growth and Development of Rice Plant

I. Effects of the selective removal of spectral components from white light on the growth of seedlings*

Katsumi INADA

(*National Institute of Agricultural Sciences, Nishigahara, Kita-ku, Tokyo 114*)

The growth response of rice plant under various qualities of light has been reported by several workers. The first study was made by UEDA[11] who found that the plant height was remarkably enhanced by orange light but depressed by violet and blue ones when natural light was filtered by colored glass. Recently, TAKAHASHI[10] has reported that red light promotes the elongation of leaf blade and leaf sheath but blue light inhibits them, above all the leaf sheath, and that red light brings about a greater dry weight of plant than blue one, using monochromatic lights. BOKURA[1] studied on the varietal difference of growth response under various colored fluorescent lights and showed that all of the Japanese varieties used belonged to a type which showing their elongation of the 2nd leaf sheath in the order of green, red and blue lights.

In the study on the effect of light quality on the growth response of plants, especially in the case for the purpose of practical application for plant production, it is desirable to use the light of a high intensity being sufficient for a normal growth and development. As the method to prepare such high-intensity-lights with different qualities, the removal of a definite spectral band from a continuous white light would be more easy than the isolation of monochromatic lights.

This study was made with the growth response by various qualities of light which eliminated a spectral component from artificial white light, to obtain some basic informations with regard to the selective utilization of daylight during the growth period of rice seedlings.

* Received for publication on August 11, 1972. The outline of this study was presented at the 145th (April, 1968) and 146th (Oct., 1968) meetings of the Crop Science Society of Japan.

MATERIALS AND METHODS

Three experiments were carried out, of which experiment 1 was in 1967 and experiments 2 and 3 in 1968.

Plant cultivation

In all experiments, seeds of rice plant (*Oryza sativa* L., var. Norin No. 25) ware soaked in water for 2 days and sown in plastic pots (16 cm in diameter and 10 or 20 cm in depth) containing soil at the rate of 40 or 47 seeds per pot. A sufficient amount of compound fertilizer was applied to the soil. The pots were placed in growth cabinet having a cycle of 15 hr-light and 9 hr-darkness. Growing conditions were varied among the experiments as follows:

Experiment 1 Light treatments were started immediately after sowing and the plants were harvested 14 days after wards. Air temperatures of day and night were 31 ± 1.5°C and 23.5 ± 1.5°C, respectively, and the soil moisture was kept at near upland condition.

Experiments 2 and 3 Light treatments were started on 3rd day after sowing, when the shoot length above the soil was ca. 1 cm, and the final harvesting was made 22 days after sowing. Day and night temperatures were 29 ± 1°C and 24 ± 1°C, respectively, and the soil was submerged from the 7th day after sowing.

Light treatments

Experiment 1 White light was supplied from beneath by a bank of 21 tubes of 110-W "power line, sun fluorescent lamps" (Toshiba, FLR-110-SUN/a) in a growth cabinet with the dimensions of $105 \times 105 \times 150$(h) cm. To remove near ultraviolet light, a polyvinyl chloride film absorbing shorter wavelengths than about 360 nm was used. To remove

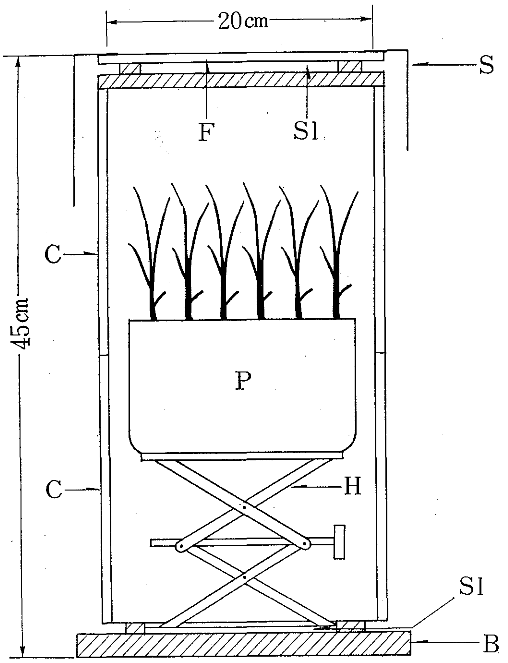

Fig. 1 Sectional diagram of a cylindrical frame for light treatments
B: base C: plastic cylinder F: filter
H: height adjustor P: pot S: shading curtain
Sl: ventilating slit

definite components in visible range, blue-, green- and red-reflecting "dichroic mirrors"[8], which are multilayer films of dielectrics respectively deposited on a plate of clear glass by evaporation in high vacuum, were employed. Green smoke colored (Torayglas No. 268) and clear (Torayglas No. 100) metacrylate sheets were used as neutral filters.

These filters were mounted on the top of plastic cylinders which was coated with white paint on the inside the wall. Each of the cylindrical frames was covered on a pot and disposed along a circumference on a turn table in the growth cabinet (fig. 1). Experimental plots were made up of white light (W), minus ultraviolet (-UV), minus violet-blue (-VB), minus blue-green (-BG), and minus orange-red (-OR). Spectral distribution of the irradiance at plant level was measured by a Iio's spectral radiometer, SRP 1460-2, and shown in fig. 2.

Total irradiance at plant level was adjusted to 33,000 erg cm^{-2} sec^{-1} in all the plots using a EKO differencial thermal solarimeter.

Experiments 2 and 3 The light from eight 400-W Yōkō lamps (Toshiba D400) per square meter was filtered by a divider consisted of a 6 mm-thick-glass plate and 25 mm-depth-running water, and used as white light. In the experiment 2 the major part of a definite spectral region was removed, while in the experiment 3 only about the half of that was removed. Spectral components removed from the white light in these experiments were mainly violet-blue (-VB in the experiment 2 and -1/2 VB in the experiment 3), blue-green (-BG and -1/2BG), green-yellow (-GY and -1/2 GY), yellow-orange (-YO and -1/2 YO) and orange-red (-OR and -1/2 OR), respectively. To remove those spectral components, colored metacrylate sheets produced by the auther's recipe were used as the filters. They were fixed on the cylindrical frames as described above, and placed on the floor of the growth cabinet. The spectral distribution of irradiance at plant level is shown in fig. 3. The irradiance of each plot including the white light (W) was equalized to 180,000 erg cm^{-2} sec^{-1} in the experiment 2 and 200,000 erg cm^{-2} sec^{-1} in the experiment 3, using the clear and/or green smoke Torayglas sheets. During the treatment horizontal position of the frames on the floor was changed every 2 or 3 days for uniformity of the environmental conditions except light quality.

Determination of pigments

Chlorophyll content One gram of leaf blades was ground in a mortar with 4 ml of water, and 10 ml of water was added into the mortar to obtain 1/15 homogenate. Chlorophyll in the homogenate was extracted by 80% acetone (experiment 1) or 80% ethanol (experiments 2 and 3) in the final concentration, and total chlorophyll content was determined by a Hitachi spectrophotometer, EPU-2A, according to the previous method[6].

Carotenoid content An aliquote of the 80% acetone extract was boiled with barium hydroxide powder to breakdown the chlorophyll. After filtrating, carotenoid fraction was transferred into petroleum ether, and the absorbance at 445 nm was determined by the spectrophotometer to obtain the relative content of total carotenoid.

Absorption spectrum Absorption spectra of

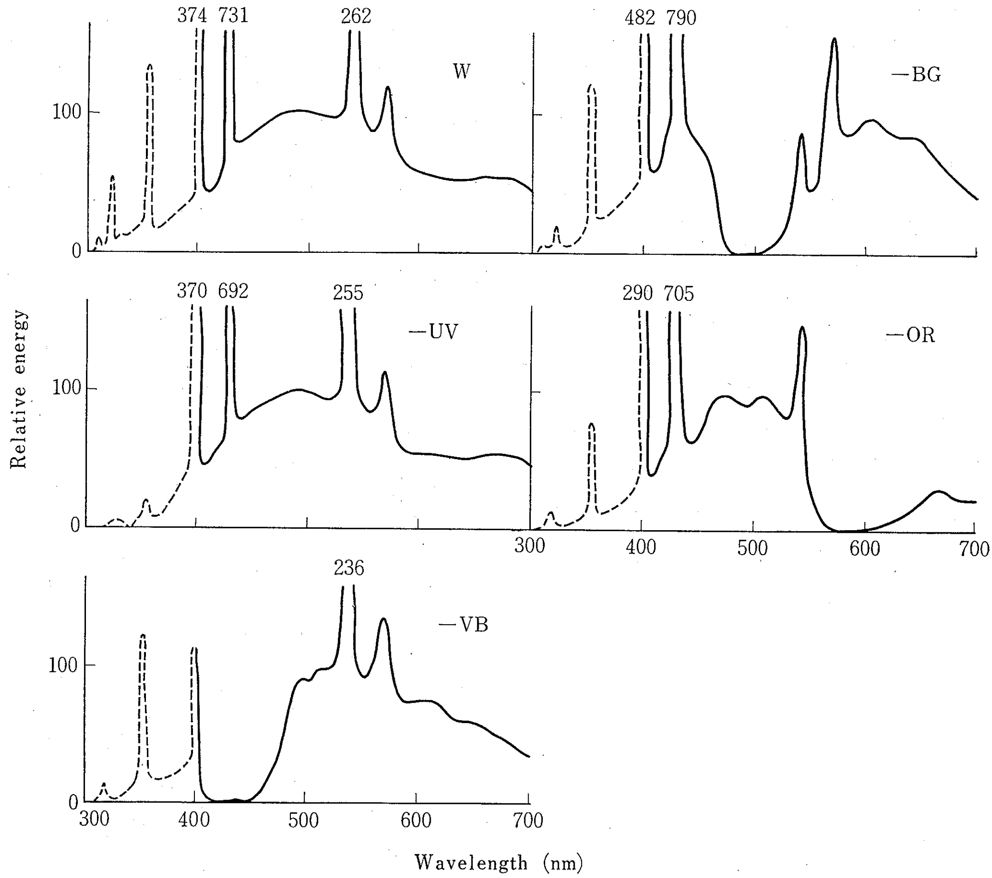

Fig. 2 Spectral distribution curves of lights used for the experiment 1
- - - - - ultraviolet region, which was calculated from the lamp emission and filter transmission in each of the wavelengths

the 80% ethanol extract of leaf blades was measured by a Hitachi recording spectrophotometer, EPS-3T in the range from 340 to 700 nm.

RESULTS

Experiment 1

The growth responses of plant are shown in table 1. In -VB plot the plant height and leaf sheath length were distinctly increased but chlorophyll and carotenoid contents were decreased, as compared with those of the white light control. Plants in both plots, -UV and -BG, appeared a somewhat longer leaf sheath and a remarkably high dry weight and dry matter in top. The ratio of carotenoid to chlorophyll content was distinctly high in -UV plot. In -OR plot the content of pigments and dry matter production were considerably decreased, though leaf width was significantly increased.

In this experiment, it was seen that the elongation of plant was promoted considerably under the light which removed shorter wavelength components, so far as visible range was concerned.

Experiments 2 and 3

The results are shown in tables 2 and 3. The plant height and the length of leaf sheath and leaf blade were promoted in -VB and -BG plots, but inhibited in -YO and -OR plots, as compared with the white light control, whether the spectral removal was perfectly (experiment 2) or partially (experiment 3). This also indicates that the removal of shorter spectral regions enhances the elongation of rice plant, as described in the experiment 1. The

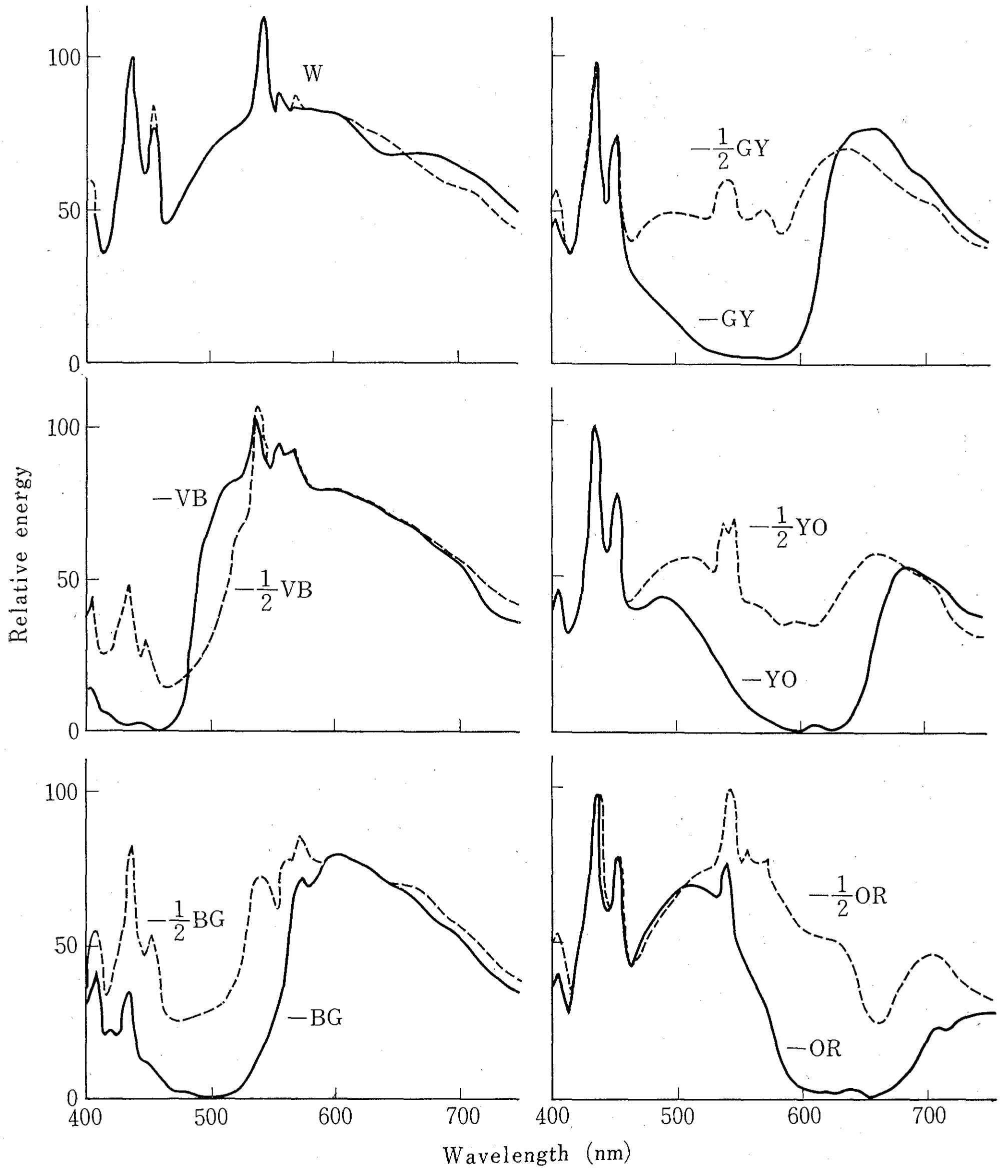

Fig. 3 Spectral distribution curves of lights used for the experiments 2 and 3
—— Experiment 2 ······ Experiment 3

leaf width was, however, rather increased when the longer spectral components were removed. The change in leaf area affected by various light qualities was something like that in the elongation growth, particularly the leaf blade length, in the experiment 2, but no clear difference was observed in the experiment 3. The number of leaves produced was not affected greatly by the removal of any spectral regions in both experiments.

The inclination angle of 2nd and 3rd leaves determined to the vertical line was promoted in -OR plot but inhibited in -BG plot, especially in the experiment 2. The chlorophyll content of leaf blades was greatest in -GY plot and least in -VB plot in the experiment 2, whereas that was greatest in -1/2 BG plot in the experiment 3.

The absorption spectra of ethanol extracts of leaf blades in the experiment 2 are shown in fig. 4. A

Table 1 Effects of the removal of various spectral components from white light on the growth and pigment contents (Experiment 1)

	Light treatment				
	W	−UV	−VB	−BG	−OR
Plant height (cm)	24.9±2.1[b]	25.7±1.6[b]	29.8±2.3[a]	26.8±3.0	24.2±1.8[b]
Number of leaves produced	3.2±0.2	3.2±0.2	3.1±0.1	3.2±0.2	3.2±0.2
Length of LS (cm)	12.6±1.3[b]	14.0±1.0[b]	16.3±1.7[a]	14.3±2.4	13.3±1.1[b]
Length of LB (cm)	12.6±1.4	11.7±0.9[b]	13.5±1.2[a]	12.8±1.1	12.2±1.2
Width of LB (mm)	2.3±0.2[b]	2.4±0.3[b]	2.3±0.2[b]	2.4±0.2[b]	2.7±0.1[a]
Chlorophyll content in LB (mg/gFW)	1.45	1.23	1.11	1.51	1.35
Carotenoid content in LB (relative value)	0.209	0.208	0.154	0.204	0.182
Ratio of carotenoid to chlorophyll	0.144	0.169	0.139	0.135	0.135
Dry weight of top (mg/plant)	12.4	17.8	13.1	17.2	10.3
Dry matter content of top (%)	12.4	16.9	13.1	15.0	11.1

Irradiance was 33,000 erg cm^{-2} sec^{-1} for all of the treatments. Measurements were made 14 days after sowing and the values are expressed as mean±SD of 20 plants each or simple mean. The difference between the values followed by different letters is significant at 1% level, whereas that between the others including unmarked ones is not significant each other. The 3rd leaf was used for the measurement of the length of LS (leaf sheath) and LB (leaf blade) and the width of LB.

Table 2 Effects of the removal of various spectral components from white light on the growth and chlorophyll content (Experiment 2)

	Light treatment					
	W	−VB	−BG	−GY	−YO	−OR
Plant height (cm)	33.2±1.6[b]	36.8±1.6[a]	36.8±2.0[a]	30.2±1.4[c]	25.2±1.6[d]	24.1±1.8[d]
Number of leaves produced	4.8±0.1[a]	4.5±0.2[b]	4.6±0.2[b]	4.6±1.0[b]	4.5±0.2[b]	4.8±0.1[a]
Length of LS (cm)	13.3±0.9[b]	15.3±0.7[a]	16.1±1.0[a]	12.6±0.9[b]	10.3±0.7[c]	9.3±0.7[d]
Length of LB (cm)	19.4±1.2[b]	21.7±1.1[a]	20.0±1.4[b]	17.1±0.9[c]	14.5±1.1[d]	14.0±0.8[d]
Width of LB (mm)	3.9±0.2	3.6±0.2[b]	3.7±0.3[b]	3.9±0.1[a]	3.8±0.2	3.9±0.3
Leaf area (cm^2/plant)	13.2	15.2	12.6	12.1	9.5	10.4
Chlorophyll content in LB (mg/gFW)	2.28	2.19	2.35	2.60	2.42	2.41
Dry weight of plant (mg)	66.8	76.4	65.3	54.2	43.0	44.9
Dry matter content (%)	15.4	16.2	16.1	15.3	15.3	16.0
Dry matter distribution (%) in						
LB	45.4	42.2	42.3	43.9	47.6	49.0
LS+Stem	44.6	45.7	47.8	44.5	42.2	42.1
Root	10.0	12.1	9.9	10.6	10.2	8.9

Irradiance was 180,000 erg cm^{-2} sec^{-1} for all of the treatments. Measurements were made 22 days after sowing. The 4th leaf was used for the sizes of LS and LB. Refer to table 1 for the others.

considerable difference in the relative spectra is seen in the near ultraviolet region, namely, the shorter regions of visible light were removed, the higher absorbance observed. In the experiment 3, however, no clear difference was seen among the treatments.

The dry weight of plant was greatest in -VB plot and decreased gradually with the removal of longer spectral regions in the experiment 2. In the experiment 3, however, dry weight of plant was greatest in -YO plot and no considerable difference was observable among the other plots. In the both experiments a close relationship between the dry weight and the leaf area was observed.

Table 3 Effects of the removal of various spectral components from white light on the growth and chlorophyll content (Experiment 3)

	Light treatment					
	W	−1/2 VB	−1/2 BG	−1/2 GY	−1/2 YO	−1/2 OR
Plant height (cm)	31.9±1.4[b]	36.5±2.2[a]	35.7±2.2[a]	34.9±3.7	33.3±1.8	30.4±1.4[b]
Number of leaves produced	4.8±0.1[b]	4.9±0.1[b]	4.9±0.1[b]	5.0±0.1[a]	5.0±0.1[a]	4.9±0.1[b]
Length of LS (cm)	13.7±1.1[b]	15.2±0.6[a]	14.8±0.5[a]	12.8±0.7[b]	11.0±0.5[c]	12.9±0.7[b]
Length of LB (cm)	17.2±1.1[b]	19.2±1.2[a]	19.3±1.0[a]	17.3±1.0[b]	15.6±0.8[b]	16.3±1.1[b]
Width of LB (mm)	3.7±0.3	3.6±0.2	3.5±0.2[b]	3.8±0.2[a]	3.8±0.2[a]	3.9±0.2[a]
Leaf area (cm^2/plant)	13.6	13.0	13.0	13.1	14.6	13.4
Chlorophyll content in LB (mg/gFW)	2.15	2.03	2.22	2.05	2.00	2.00
Dry weight of plant (mg)	77.0	79.7	76.9	79.1	84.3	75.5
Dry matter content (%)	16.6	15.8	16.4	16.0	16.5	16.2
Dry matter distribution (%) in						
LB	41.5	42.6	42.9	41.7	41.8	42.3
LS+Stem	46.6	45.9	43.4	46.0	46.7	44.3
Root	11.9	11.5	13.7	12.3	11.5	13.4

Irradiance was 200,000 erg cm^{-2} sec^{-1} for all of the treatments. Measurements were made 22 days after sowing. The 4th leaf was used for the sizes of LS and LB. Refer to table 1 for the others.

The distribution of dry matter in the plant parts varied among the treatments in the experiment 2. The longer of spectral regions were removed, the greater the distribution rate in leaf blades became.

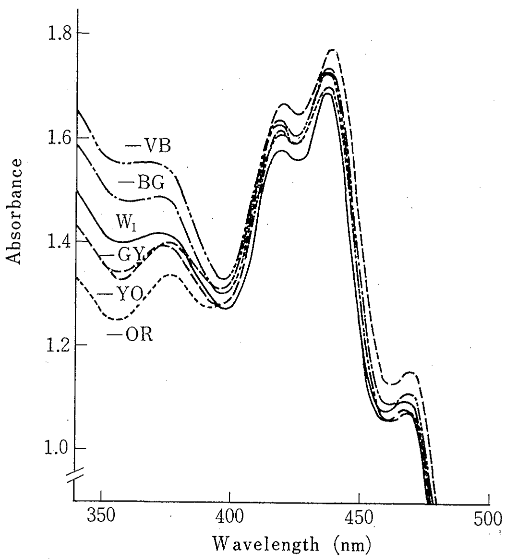

Fig. 4 Effect of the removal of various spectral components on the absorption spectrum of leaf extract (Experiment 2).
Each curve was normalized at the peak absorbance in red region.

Discussion

In this study, it is evident that the plant height and the leaf length of rice seedlings are enhanced by the removal of blue region from white light but rather depressed by the removal of red region, compared with those of the equienergetic white light. Similar results have been reported in rice[11] and many other species[7,9], when grown in various spectral glass houses under daylight. The effects of the removal of blue and red region of light were consistent whether the irradiance was low (experiment 1) or high (experiments 2 and 3) and whether the removal was almost completely (experiments 1 and 2) or partially (experiment 3). This demonstrates that blue component which involved in white light inhibits the elongation while red one rather promotes it. Thus, it is proved that the inhibitory effect of blue light and promotive effect of red light on the growth of rice plant can be seen not only under monochromatic lights as has described previously[1,2,10] but also under polychromatic lights as employed in this study.

To make clear the effect of spectral balance on the growth of plant, the relative energy of irradiated lights was divided into 3 regions of blue (400–500 nm), green (500–600 nm) and red (600–700 nm), and the relation between the red/blue (R/B) ratio and the plant height or the leaf length was examined. The result showed evidently that relative values of the growth, especially of the length of leaf sheath increased with increase of the R/B ratio, and that the increase in its rate was high up to around 2 but low above that (fig. 5). This tendency was seen in any of the 3 experimental conditions applied. This may suggest that the plant height and leaf length depend mainly on the balance of blue and red components in the irradiated light, regardless of the quantity of ultraviolet and green components involved. In this connection it has been reported that the effect of green light added to a combination of blue and red lights was not evident in the growth of tomato plant[3].

On the other hand, the width and inclination angle of leaf blade increased with the removal of yellow-orange and orange-red components. These results correspond to the previous findings obtained by the use of monochromatic lights that blue light was most effective to the unrolling of leaf and the increase of leaf width[10] and to the leaf inclination[4]. The inclination angle of leaf blade as the function of the R/B ratio indicated the just opposite curves against those of the elongation growth, as shown in fig. 6. These suggest that the increase of leaf inclination angle is caused not only by monochromatic blue light but also by polychromatic lights involved more blue than red.

The effect of light quality on the chlorophyll content of leaf blade was not consistent among the experiments, but its content was generally low under the removal of violet-blue component which caused the greatest plant height and leaf length. The change in the ultraviolet absorbance of leaf extract by the light quality suggests that the ratio of ultraviolet-absorbing substances to chlorophyll in the leaf blade may be different with the spectral quality of irradiated light. From table 1 and fig. 4, it is assumed that the ultraviolet-absorbing substances may be including carotenoids and the increase of which may be

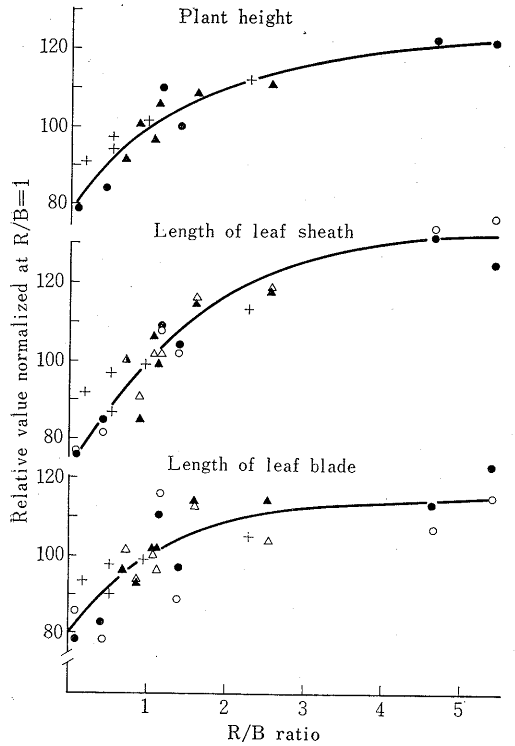

Fig. 5 Relationship between the R/B ratio of light and the plant height or leaf length
Upper curve: + expt. 1, ● expt. 2, ▲ expt. 3
Middle and lower curves: + 3rd leaf in expt. 1, ○ 3rd leaf and ● 4th leaf in expt. 2, △ 3rd leaf and ▲ 4th leaf in expt. 3

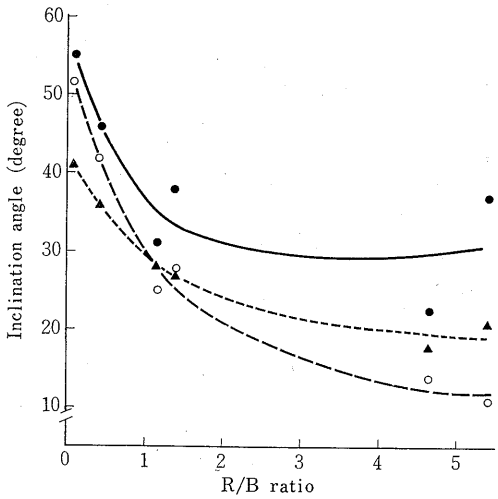

Fig. 6 Relationship between the R/B ratio of light and the inclination angle of leaf blade (Experiment 2)
○ : 2nd leaf of 7 day-old plant
● : 2nd leaf of 19 day-old plant
▲ : 3rd leaf of 19 day-old plant
Each value indicates average of 20 plants.

related to the decrease of ultraviolet component, as well as the increase of the R/B ratio in the irradiated light.

The dry weight of plant decreased considerably under the minus yellow-orange and minus orange-red components but rather increased under the minus violet-blue component, when the spectral removal was almost perfectly. This result will be supported by a previous report obtained by monochromatic light[10]. The enhancement of growth, especially dry matter production, under the removal of ultraviolet and blue-green components in the experiment 1 coinsides well with a work by KLEIN et al.[5], but no such a effect was observed under the minus blue-green component in the other experiments.

From the above results, it was confirmed that the rice seedlings which are tall and relatively rich in dry matter can easily be obtained by the light quality with a high ratio of the R/B.

ACKNOWLEDGMENT

The author thanks Mr. Tatsuo KAMIHAMA, the Saitama Prefectural Horticultural Experiment Station, for technical aid given to him during the course of the experiment 1.

SUMMARY

The growth response of rice seedlings grown under various light qualities which removed definite spectral components from artificial white light was studied with different 3 experimental conditions.

The plant height and leaf length were enhanced by the removal of blue region but retarded in most cases by the removal of orange-red region, as compared with those of the equienergetic white light control, regardless of the irradiance and the removed rate of these regions. The leaf inclination was, however, promoted by the removal of orange-red region. Both the elongation growth and the leaf inclination showed a close relationship to the R/B latio of irradiated light, respectively, indicating the reverse courve each other.

The chlorophyll content of leaf blade was rather low in the plots which effective to the elongation growth and the ratio of ultraviolet-absorbing substances to chlorophyll in leaves increased with the removal of ultraviolet component and with increasing the R/B ratio of irradiated light.

The dry matter production of plant decreased considerably when the orange-red component was removed. The light quality which was effective to increase the dry weight of plant varied according to the experimental conditions. The dry weight of plant showed a correlationship with the leaf area, whereas the distribution rate of dry matter in leaf blade was decreased with increasing the dry weight of plant when the major part of spectral components was removed.

LITERATURE CITED

1. BOKURA, T. 1967. Photo-growth reaction of leaf in rice plants (*Oryza sativa* L.). Bot. Mag. Tokyo, **80**: 272–278.
2. BOKURA, T. 1970. Studies on effects of light quality on the rice plant by using cylindrical type of growth cabinet. Environ. Control in Biol., **8**: 19–20.
3. HORIGUCHI, I. 1969. Effects of the combination fluorescent colour lamps on the growth of tomato plant. Environ. Control in Biol., **6**: 94–97.
4. INADA, K. 1969. Effect of blue light on the photonastic reaction of rice leaves. Plant and Cell Physiol., **10**: 845–854.
5. KLEIN, R. M., P. C. EDSALL, and A. C. GENTILE 1965. Effects of near ultra-violet and green radiations on plant growth. Plant Physiol., **40**: 903–906.
6. MACKINNEY, G. 1941. Absorption of light by chlorophyll solutions. J. Biol. Chem., **140**: 315–322.
7. POPP, H. W. 1926. A physiological study of the effect of light of various ranges of wave length on the growth of plants. Amer. J. Bot., **13**: 706–736.
8. SATO, T. and H. KUBOTA 1953. On dichroic mirrors (in Japanese). Television, **7**: 27–38.
9. SHIRLEY, H. L. 1929. The influence of light intensity and light quality upon the growth of plants. Amer. J. Bot., **16**: 354–389.

10. TAKAHASHI, N. 1964. Photomorphogenesis in rice plants, *Oryza sativa* L. Part 1. Formative response to monochromatic light in leaves. Bull. Inst. Agr. Res., Tohoku Univ., **15**: 185–197.

11. UEDA, S. 1934. Effect of monochromatic light on the growth of rice plant (in Japanese). Proc. Crop Sci. Soc. Japan, **6**: 411–427.

〔和 文 摘 要〕

水稲生育の光質依存性

第1報 幼植物の生長に及ぼす特定波長帯を除去した光の影響

稲 田 勝 美
（農林省農業技術研究所）

光質に対する植物反応の研究には多くの場合単色光が用いられるが，植物の正常な生育を保証するに足る十分な強度をもつ種々な光質の光を得るには，単色光よりも白色光から特定の波長帯を除去した混合色光を用いる方が有利である．本研究は，水稲の育苗時における自然光の選択的利用に関する基礎的知見を得るため，人工白色光から種々の波長帯を除去した光に対する生育反応を調査した．

実験はグロース・キャビネット内で行ない，光処理条件の異なる3実験を実施した．実験1は紫外部除去（−UV），紫青部除去（−VB），青緑部除去（−BG）および橙赤部除去（−OR）とし，植物面での照射エネルギーは 33,000 erg cm^{-2} sec^{-1} とした．実験2は −VB, −BG, −GY（緑黄部除去），−YO（黄橙部除去）および −OR で 180,000 erg cm^{-2} sec^{-1} とし，実験3は実験2とほぼ対応する波長帯を約 1/2 除去し 200,000 erg cm^{-2} sec^{-1} に調整した．3実験ともそれぞれ等エネルギーの白色光標準区（W）を設けた．水稲農林25号を土耕栽培し，日長15時間，昼夜変温下で光処理を行ない，播種後14日目または22日目に生育反応を比較した．

草丈，葉鞘長および葉身長は，等エネルギーの白色光と比較して −VB, −BG 区で明らかに増大し，−YO, −OR 区でむしろ抑制された．この傾向は照射エネルギー強度および波長帯除去程度の多少にかかわらず認められた．これに対して，葉身幅および葉身傾斜角度は長波長帯除去によつて増大し，ことに葉身角度は −YO および −OR で著しく大となつた．

照射光中の青色光域（B, 400−500 nm）に対する赤色光域（R, 600−700 nm）のエネルギー比（R/B 比）と生育反応の関係を検討した結果，草丈，葉長などの伸長生長は R/B 比とともに2次曲線的に増大し，ことに葉鞘長でその変化の幅が大きかつたが，葉身角度は伸長生長と反対の曲線を示した．

葉身の葉緑素含量は伸長生長を促進した −VB 区で概して低かつた．また，葉緑素含量に対する紫外線吸収物質の割合は光質によつて変化し，紫外部除去光で増大するとともに R/B 比の増加にともなつて増大した．

乾物重は，帯域の除去がほぼ完全な −YO および −OR 区で明らかに低かつたが，白色光よりも乾物生産に効果の高い光質は実験によつて異なつていた．実験1では −UV と −BG 区で著しく効果が大であつたが，実験2では −VB 区，実験3では −YO 区で若干増加したに過ぎなかつた．乾物重は葉面積が大きい区で高く，両者の間に密接な関係がみられたが，葉身への乾物の分配率はむしろ植物の全乾物重の増加とともに減少することが実験2で認められた．

以上から，R/B 比の大きい光の照射によつて，草丈ことに葉鞘長が長くその割に乾物重の大きい苗が容易に得られることが明らかになつた．