Korean J. Crop Sci. 48(4): 292~296(2003)

Effect of Fluorescent Light Treatment during Imbibition and Culture on Growth of Soybean Sprout

Jin Ho Kang*, A-Jung Park*, Byung Sam Jeon*, Soo Young Yoon* and Sang Woo Lee*

**College of Agriculture and Life Sci., Gyeongsang Natl. Univ., Jinju 660-901, Korea*

ABSTRACT : The lateral root formation in soybean sprout culture declines its quality. This study was done to measure the effect of fluorescent light treatment during 24 hour imbibition and 6-day culture on seed germination and growth of soybean sprout. After 6 day culture, the sprouts were sorted as normal (>4 cm), abnormal (<4 cm) and non-germination by their hypocotyl lengths, and lateral roots, fresh and dry weights were measured. Lateral roots were less formed in the fluorescent light treatment lasted during the whole period of the imbibition than in the treatment for 50 minutes a day during the culture. The fluorescent light treatment during the imbibition mainly affected the germination and growth compared to the treatment done during the culture. Compared to the dark imbibition, the light treatment during the imbibition resulted in more normal sprouts, thicker diameters of hypocotyl and hook, and more fresh weights in cotyledon, hypocotyl, whole sprout, and economic yield. However, these results were reverse in lengths of hypocotyl and root, and fresh and dry weights of roots. It is concluded that the fluorescent lamp mainly irradiating red and blue lights can be used for the sprout production as an alternative light replacing blue and red lights treated during the imbibition because it blocked the lateral root appearance and stimulated growth of the sprout.

Keywords: soybean, sprout, fluorescent light, growth, morphology.

Soybean sprout can supply various essential nutrients including vitamin C which cereals do not have. Despite of this advantage, its lateral roots extruded on 5 to 6th day after the culture greatly reduce its quality and even use. Many methods to reduce lateral root formation have been proposed so far. Benzylaminopurine (BA) which applied during either imbibition or culture has been most frequently used as a growth regulator. It has been reported that its optimum concentration for treatment during initial 6 hours of imbibition during which soybean seeds absorb most water is 4 ppm (Kang *et al*, 1996), but the treated seeds must be aerated over 2 hours prior to the first watering for culture (Kang *et al.*, 1997). Its application may be issued in the future because it has not been elucidated that BA is harmful to human being or not, and even it is classified as a synthetic pesticide. Therefore, an alternative method must be set up.

Light treatment has been introduced to the culture of soybean sprout because light-mediated phytochrome controls seed germination and sprout growth as well as it is able to reduce the amount of treated BA (Kim *et al.*, 1982; Tajiri, 1981, 1982, 2000). Kang *et al.* (2002) reported that red and blue light treatments during the 24 hours imbibition alleviated formation of lateral roots. In addition to the effects of reducing lateral root formation, Tajiri (1981, 1982) reported that artificial light of 380 to 700 nm treated for 60 minutes everyday during the sprout culture reduced its growth period by one to two days. Although light treatments during both imbibition and culture influenced the sprout growth, the former treatment effect was greater than the latter one (Park *et al*, 2002). Red and blue light treatments during the two periods were more effective than the others.

Red and blue LED plates or artificial sunlight lamp used in the previous reports (Kang *et al.*, 2002; Tajiri, 1981, 1982) were so expensive that they must be replaced to fluorescent lamp irradiating the red and blue light relatively more to reduce treatment cost. This study was, therefore, carried out to examine the effect of fluorescent light treatment during the 24-hours imbibition and the 6 day culture on seed germination, growth and morphology of soybean sprouts.

MATERIALS AND METHODS

Test seed preparation

Seeds of soybean (*Glycine max* L.) cv. Eunhakong and Hannamkong were obtained from Gyeongnam Agricultural Research and Extension Services. After small and large seeds were eliminated by a sieve shaker, the remaining medium-size seeds were placed into plastic boxes held at 3 refrigerator until initiating the experiments.

Culture

Small stainless steel containers made rectangular shape with 9.5 cm in length, 8.5 cm in width and 13 cm in depth

†Corresponding author: (Phone) +82-55-751-5427 (E-mail) jhkang@nongae.gsnu.ac.kr
<Received March 16, 2003>

and having many holes on their bottoms for drainage were used for the culture. Prior to the culture, water imbibition was repeatedly done 4 times for 5.5 hours every 6 hours to prevent imbibition injury. During the final step, however, the seeds were soaked in 4.0 ppm BA solution instead of distilled water to prevent lateral root formation. After 150 imbibed seeds were allocated into each container within dark growth chamber, they were cultured under 25°C constant temperature for 6 days. During that time, about 100 m*l* of 25 distilled water was supplied to each container every 4 hours.

Treatments

Two light treatments, fluorescent light showing the spectrum in Fig. 1 and dark treatments, were done during 24 hour imbibition and 6 day culture. The light treatment was lasted during whole period of the imbibition but 50 minutes everyday during the culture, the result of previous report (Park *et al.*, 2002). The containers placing treated seeds were wrapped with the black fabric and plastic sheet to minimize the effect of light given inevitably during the experiment.

Measurement

Sprouts harvested after 6 day culture were divided into 4 groups on the basis of hypocotyl length and germination; longer than 7 cm (class A), 4 cm to 7 cm (class B), shorter than 4 (class C) and no-germinated seeds (class D), and number of germinated seeds, length of hypocotyl and primary root, diameter of hypocotyl hook and its middle part, number of lateral roots, and dry weight of cotyledon, hypocotyl, and roots were measured. No-germinated seeds and growing sprouts were totally counted but the other characters measured were examined with 20 sprouts selected from above each category. After the germinated sprouts were separated into cotyledons, hypocotyls, and roots, they were desiccated in 70°C for 2 days to measure their dry weights. Total weights and economic yields were expressed as summations of cotyledon, hypocotyl and root weights and weights of the two other organs except cotyledon, respectively.

Statistical analysis

Among the characters of soybean sprouts, lateral roots emerged from the conjunction part of their hypocotyl and

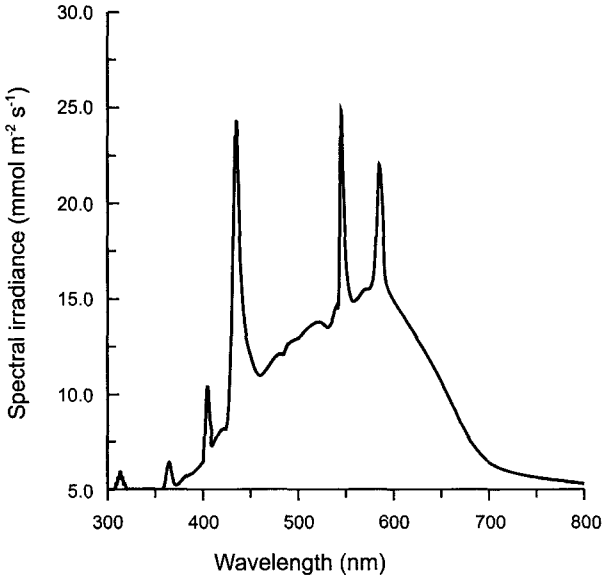

Fig. 1. Spectrum of fluorescent light used for the treatment. Measurement was done by the LI-1800 spectroradiometer (LI-COR Co., USA).

Table 1. Analysis of variance using composition rates of the hypocotyl lengths affected by the light treatments (LT) during 24 hour imbibition and 6 day culture†.

Parameters	Normal		Abnormal	No-germ.	A+B	C+D
	>7 cm (A)‡	4~7 cm (B)	<4 cm (C)	0 cm (D)		
Cultivar (V)	**	**	**	**	*	**
LT during imbibition (I)	**	ns	**	**	**	**
LT during culture (C)	*	ns	ns	ns	ns	ns
V × I	**	**	**	**	**	**
V × C	ns	ns	ns	ns	ns	ns
I × C	ns	ns	ns	ns	ns	ns
V × I × C	ns	ns	ns	ns	ns	ns

†Under darkness or fluorescent light illumination, the seeds were soaked in 4.0 ppm BA solution for 6 hours after three times of aeration for 0.5 hour following 5.5 hour water imbibition. Fluorescent light treatments during the imbibition and the culture were done 24 hours and 50 minutes a day, respectively.
‡Hypocotyl length of soybean sprouts cultured for 6 days after 24 hour imbibition.
ns, *, ** Nonsignificant or significant at 0.05 and 0.01 probability, respectively.

primary root were important as well as the germination rate. After measurement of all the treatment plots, the treatments which induced the lateral roots and lost the commercial value were eliminated from the data analysis.

RESULTS AND DISCUSSION

As the result of the analysis of variance, the cultivars showed significant differences in composition rate of soybean sprouts classified by their hypocotyl length after germination. There were significant differences between dark and light treatments during the imbibition in the ratios except B class (4~7 cm) but was significant one between the two treatments during the culture only in the ratio of A class (>7 cm). On the other hand, significant interactions were shown between cultivar and light treatment during the imbibition in the composition rate classified by the hypocotyl length after germination, indicating that the light treatment during the imbibition was more important than that during the culture (Table 1).

Fluorescent light treatment during the imbibition hindered the formation of lateral roots in both cultivars regardless of dark and light treatments during the culture. Many lateral roots were formed in the dark imbibition although the light treatment during the culture after the dark imbibition somewhat reduced their formation (Fig. 2). The fluorescent light is able to replace the red light used in the previous reports (Kang *et al.*, 2002; Park *et al.*, 2002) so that the production cost can be reduced, and the best sprouts could be raised under the light treatment during imbibition and culture.

The following data were analysed with the results of the light treatment for 50 minutes everyday during 6 day culture because the treatment was more effective than the dark one (Table 1, Fig. 2). Eunhakong was not significantly different in the ratios of A+B class (>4 cm) but A class (>7 cm) of 2 cultivars were higher in the light treatment during the imbibition than in the dark one, which resulted from the increment of A class (>7 cm) (Table 2). The dark imbibition of both the cultivars increased hypocotyl, root, their mean and total lengths of all the categories except the hypocotyl length of 4 to 7 cm. The imbibition, however, reduced the diameters of hypocotyl and hook (Table 3). Tajiri (1982) reported that light treatment during the culture also had the same

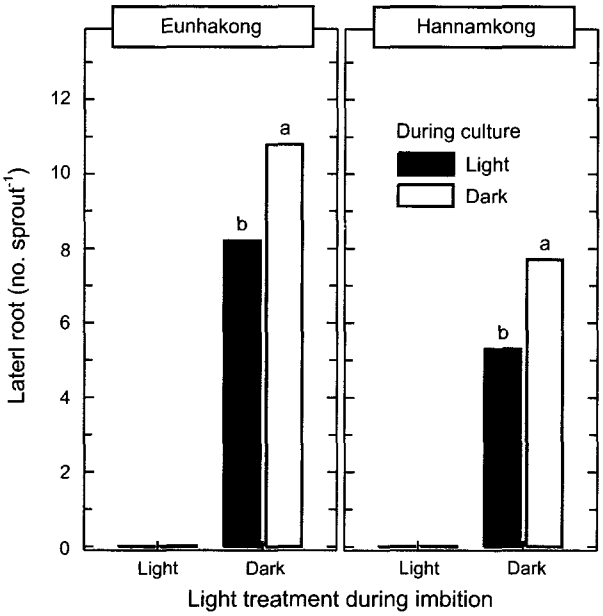

Fig. 2. Effect of fluorescent light treatment during 24 hour imbibition and 6 day culture on lateral root formation of soybean sprouts. Light treatments was lasted during the imbibition but done 50 minutes a day during the culture. Bars having different letters within the same cultivar and light treatment during the imbibition are significantly different at LSD.05.

Table 2. Effect of fluorescent light treatment during 24 hour imbibition on composition rate of soybean seed germination and sprout development†.

Cultivars	Light treatments	Normal		Abnormal	No-germ.	A+B	C+D
		> 7 cm (A)‡	47 cm (B)	< 4 cm (C)	0 cm (D)		
		%					
Eunhakong	Fluorescent	51.7	17.3	6.0	25.0	69.0	31.0
	Dark	44.7	21.3	20.0	14.0	66.0	34.0
Hannamkong	Fluorescent	57.7	14.6	9.0	18.7	72.3	27.7
	Dark	46.6	10.5	5.6	37.3	57.1	42.9
	LSD.05	3.0	4.1	2.3	5.4	5.0	4.9

†Under darkness or fluorescent light illumination, the seeds were soaked in 4.0 ppm BA solution for 6 hours after three times of aeration for 0.5 hour following 5.5 hour water imbibition. Fluorescent light treatments during the imbibition and the culture were done 24 hours and 50 minutes a day, respectively.
‡Hypocotyl length of soybean sprouts cultured for 6 days after 24 hour imbibition.

Table 3. Effect of fluorescent light treatment during 24 hour imbibition on hypocotyl length and its diameter of soybean sprout†.

Cultivars	Light treatments	Length									Diameter					
		Hypocotyl			Root			Total			Hypocotyl			Hook		
		>7†	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean
		cm sprout^{-1}									mm sprout^{-1}					
Eunhakong	Fluorescent	9.7	5.9	8.8	1.5	1.3	1.5	11.2	7.3	10.2	1.8	2.0	1.9	1.9	2.1	2.0
	Dark	11.6	6.2	9.8	3.0	1.7	2.6	14.6	7.9	12.4	1.6	1.8	1.7	1.8	1.8	1.8
Hannamkong	Fluorescent	9.7	6.0	8.9	2.3	1.6	2.2	12.0	7.6	11.1	1.7	1.8	1.8	2.1	2.0	2.0
	Dark	12.0	5.9	10.8	4.3	2.3	3.9	16.2	8.2	14.7	1.6	1.8	1.7	1.9	1.7	1.8
	LSD.05	0.5	ns	0.5	0.2	0.2	0.1	0.5	0.5	0.5	0.1	0.1	0.1	0.1	0.2	0.1

†Under darkness or fluorescent light illumination, the seeds were soaked in 4.0 ppm BA solution for 6 hours after three times of aeration for 0.5 hour following 5.5 hour water imbibition. Fluorescent light treatments during the imbibition and the culture were done 24 hours and 50 minutes a day, respectively.
‡Hypocotyl length (cm sprout^{-1}) of soybean sprouts cultured for 6 days after the 24 hour imbibition.
ns Nonsignificant or no-interaction between treatments or treatment factors.

Table 4. Effect of fluorescent light treatment during 24 hour imbibition on cotyledon, hypocotyl, root, total fresh weights and economic yield of soybean sprout†.

Cultivars	Light treatments	Cotyledon			Hypocotyl			Root			Total			Economic yield		
		>7‡	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean
		mg sprout^{-1}														
Eunhakong	Fluorescent	391	365	385	437	334	411	24	31	26	852	730	822	461	364	437
	Dark	353	311	340	387	271	349	31	37	33	771	619	722	418	308	383
Hannamkong	Fluorescent	399	329	385	355	224	328	38	27	36	791	580	749	393	251	364
	Dark	332	305	327	330	201	306	40	35	39	702	540	672	370	236	345
	LSD.05	11	38	14	28	27	22	4	4	3	32	48	27	30	27	23

†Under darkness or fluorescent light illumination, the seeds were soaked in 4.0 ppm BA solution for 6 hours after three times of aeration for 0.5 hour following 5.5 hour water imbibition. Fluorescent light treatments during the imbibition and the culture were done 24 hours and 50 minutes a day, respectively.
‡Hypocotyl length (cm sprout^{-1}) of soybean sprouts cultured for 6 days after the 24 hour imbibition.

Table 5. Effect of fluorescent light treatment during 24 hour imbibition on cotyledon, hypocotyl, root, total dry weights and economic yield of soybean sprout‡.

Cultivars	Light treatments	Cotyledon			Hypocotyl			Root			Total			Economic yield		
		>7†	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean	>7	4~7	Mean
		mg sprout^{-1}														
Eunhakong	Fluorescent	65.1	70.1	66.4	22.6	20.3	22.0	2.3	2.1	2.3	90.0	92.5	90.7	24.9	22.4	24.3
	Dark	60.1	61.2	60.4	20.0	17.7	19.2	3.4	3.7	3.5	83.6	82.6	83.2	23.4	21.4	22.8
Hannamkong	Fluorescent	69.1	62.7	67.8	18.2	13.5	17.2	3.1	3.1	3.1	90.4	79.2	88.1	21.3	16.6	20.3
	Dark	58.4	59.2	58.6	16.3	12.1	15.6	4.3	3.8	4.2	79.0	75.1	78.3	20.6	15.9	19.8
	LSD.05	3.6	4.2	3.0	1.5	1.1	1.3	0.3	0.3	0.3	3.0	5.0	2.6	1.5	1.1	1.4

†Under darkness or fluorescent light illumination, the seeds were soaked in 4.0 ppm BA solution for 6 hours after three times of aeration for 0.5 hour following 5.5 hour water imbibition. Fluorescent light treatments during the imbibition and the culture were done 24 hours and 50 minutes a day, respectively.
‡Hypocotyl length (cm sprout^{-1}) of soybean sprouts cultured for 6 days after the 24 hour imbibition.

effect on lengths of hypocotyl and root, and diameter of hypocotyl. It could be inferred from the above result and Tajiri's report that the light treatments during both periods might induce shorter hypocotyl and root but thicker hypo-

cotyl.

Fluorescent light treatment increased fresh weights of cotyledons and hypocotyl in all categories sorted by hypocotyl length but decreased that of roots, although was less obvious in cv. Hannamkong than in cv. Eunhakong. Their total fresh weights and economic yields due to increment of the cotyledon and the hypocotyl weights were inclined in the light treatment (Table 4). Moreover, the similar results were observed in the component and total dry weights, and economic yield (Table 5), indicating that fluorescent light treatment during the imbibition stimulates growth of soybean sprouts as well as blocks the formation of lateral roots. Tajiri (1981, 1982, 2000) reported that artificial sunlight treated during the culture improved the sprout growth and quality. In our above results, the fluorescent light treatment during imbibition was more effective than during culture and even the dark imbibition so that it could be used as a lighting source alternative to LED and artificial sunlight lamps.

ACKNOWLEDGMENTS

The authors are grateful to the Korean Research and Development Promotion Center for Agriculture and Forestry for the financial support.

REFERENCES

Kang, C. K., D. W. Yun, Y. K. Kim, and H. T. Choe. 1996. Determination of minimum concentration and dipping time for inhibition of lateral root and growth stimulation in soybean sprouts as influenced by benzyladenine. *J. Korean Soc. Hort. Sci.* 37(6) : 773-776.

Kang, C. K. and Y. K. Kim. 1997. Effect of plant growth regulators on growth sprouts. *J. Korean Soc. Hort. Sci.* 9(2) : 103-106.

Kang, J. H., A. J. Park, B. S. Jeon, S. Y. Yoon, and S. W. Lee. 2002. Light quality during seed imbibition affects germination and sprout growth of soybean. *Korean J. Crop Sci.* 47(4):292-296.

Kim, K. S., S. D. Kim, J. K. Kim, J. N. Kim, and K. J. Kim. 1982. Effect of blue light on the major components of soybean sprouts. *Korean J. Food Nutrition.* 11(4) : 7-12.

Park, A. J., J. H. Kang, B. S. Jeon, S. Y. Yoon, and S. W. Lee. 2002. Effect of light quality during imbibition and culture on growth of soybean sprout. *Korean J. Crop Sci.* 47(6) : 427-431.

Tajiri, T. 1981. Effect of application of artificial light on the growth of hypocotyl and vitamin C (reduced ascorbic acid) content of bean sprouts. *Nippon Shokuhin Kogyo Gakkaishi* 28(8) : 430-436.

Tajiri, T. 1982. Improvement of bean sprouts cultivation by application of artificial sunlight lamp. *Nippon Shokuhin Kogyo Gakkaishi* 29(6) : 359-365.

Tajiri, T. 2000. Effect of dipping in mixed phytohormone solution intermittently combined with application of artificial sunlight lamps on growth and quality of thick bean sprouts. *Nippon Shokuhin Kogyo Gakkaishi* 47(3) : 233-240.