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Umezaki, Teruhisa
Laboratory of Crop Science, Faculty of Agriculture, Kyushu University

Yoshida, Tomohiko
Laboratory of Crop Science, Faculty of Agriculture, Kyushu University

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Effects of Shading on the Internode Elongation of Late Maturing Soybean

Teruhisa Umezaki and Tomohiko Yoshida

Laboratory of Crop Science, Faculty of Agriculture,
Kyushu University 46-01, Fukuoka 812

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The present experiment was conducted in order to obtain detailed data on the internode elongation in soybean plants (*Glycine max* Merr.) of a late maturing cultivar in Kyushu area, under shading condition at various growth stages.

The shading treatment during the period from floral differentiation to the beginning of flowering stage was the most effective, followed by the period from the beginning of flowering to the end of vegetative growth stage. For each internode length, the promotion by shading treatment was limited to the elongating internodes on the upper positions. The shading treatment during the period from the floral differentiation to the beginning of flowering stage slightly increased the number of nodes on the main stem. From the results it appears the optimal shading treatments at optimal stages can control the plant height and plant type by increasing the length of internodes and the number of nodes on the stem.

INTRODUCTION

Control of internode elongation of soybean plants (*Glycine* ***max*** Merr.) is important to avoid seed yield reduction caused by the lodging and competition for photosynthate between stem and pods after flowering, and to control the level of the lowest pod set for the mechanized harvesting. Some experiments were carried out by the author to obtain fundamental data on internode elongation pattern and on the physical or chemical control method of plant structure (Umezaki and Matsumoto, 1989; 1990; Umezaki, 1990; Umezaki et ***al.,*** 1991a; 1991b). These results showed that it would be able to control internode elongation by using various external treatments.

The present experiment was conducted in order to obtain detailed data on the internode elongation under shading condition at the various stages of a late maturing cultivar in Kyushu area.

MATERIALS AND METHODS

The present experiment was carried out in the experimental field of Kyushu University campus in 1984 and 1986.

Late maturing cultivar "Fukuyutaka", a leading cultivar in Kyushu area, was used in this experiment.

Six seeds were sown in a 1/2000a Wagner pot on July 2. Each pot contained paddy

soil with 8g compound fertilizer ($N:P_2O_5:K_2O = 3:10:10$) and 5g staked lime, as a basal dressing. No more fertilizer was applied further. Seedlings were thinned to two plants per pot on seven days after sowing, and to one plant per pot on 14 days after sowing.

Each treatmental lot consisted of six plants. The experiment was conducted with two replications.

Shading treatment was carried out by covering the plants with double cheese cloths over the wooden frame made of 2 m × 1 m at the base and 1 m high. At four different growth stages, shading treatments were applied. Period of shading of each treatmental lot is shown in Table 1.

After harvesting, growth characters, including the length and diameter of internodes on the main stem, were measured.

RESULTS

Shading percentage during the treatments is shown in Table 2. Though there was a little difference in shading percentage under the various light intensity conditions, about a half of sunlight was intercepted by the treatment.

Since the results of two year study were nearly the same, only the observations from the experiment in 1986 are presented.

The effects of shading treatment on the growth of soybean plants are shown in Table 3. There was no significant difference between any treatment and control in the number of days from sowing to flowering and to maturity.

Shading treatment during the period from emergence to floral differentiation stage (T-l, T-4) slightly depressed the number of the nodes on the main stem, showing that the effects was large at the early growth stage. The treatment during the period from floral differentiation to flowering stage (T-2) slightly increased it, conversely.

The stem length by shading treatments after floral differentiation stage (T-2, 3, 4) was longer, whereas one of early growth stage treatment (T-l) was shorter than control. The stem weight was affected by shading treatment as same as in stem length.

For the mean internode length (stem length divided by the number of internodes), it was the longest by T-4 and followed by T-2, T-3, and there was no difference between T-l and control.

The length of internodes on the main stem is shown in Fig. 1. Generally, the first internode length between the cotyledonary and primary nodes was the longest, while the 3rd internode was the shortest. The internodes became longer gradually at higher positions but at the uppermost position they again became shorter.

The internodes which elongated in treatmental period were affected by shading treatment. The internodes from the first to 5th were promoted by T-l and T-4, those from the 6th to 13th were by T-2 and T-4, and those from the 13th to 17th were by T -3 and T-4, respectively.

The diameter of internodes on the main stem is shown in Fig. 2. Generally, the second internode was the thickest and the internodes above the thickest internode became thinner gradually, the uppermost being the thinnest. The diameter of internodes was hardly affected by shading treatment.

Table 1. Plant growth stages treated with shading.

Treatment	Growth stage	Treatment period	
		1984	1986
T - 1 Emergence *	-Floral differentiation	July 2 -July 23	July 2 -July 24
T - 2 Floral differentiation	-The biginning of flowering	July24 -Aug. 13	July25 -Aug. 16
T - 3 The biginning of flowering	-The end of vegetative growth	Aug.14 Sept.12	Aug.17 -Sept.15
T - 4 Emergence *	-The end of vegetative growth	July 2 Sept.12	July 2 Sept.15

*Treatment began st sowing date.

Table 2. Shading percentage in the treatments.

Date (Growth stage)	Light intensity *	Shading percentage
Aug. 14, 1984		
Period of flowering	at high light intensity (13.9-14.4klux)	47.9%
	at low light intensity (2.9-3.9klux)	53.4%
Aug. 17, 1986		
Period of flowering	at high light intensity (10.3-11.0klux)	41.5%

*Light intensity was measured at noon with the illuminometer (Digital Illuminometer IM-3 ; Tokyo Optical Company Ltd.).

Table 3. Effects of shading on the growth of soybean plants in 1986.

Treatment	Days from sowing to flowering	Days from sowing to maturity	No. of nodes on the main stem			Stem length (cm)	Stem weight (g/pl.)	Mean internode length***
			July 25*	Aug.16-18**	at maturity			
T - 1	46.9	121.5	6.9	14.2	16.9	45.6	15.3	28.8
	(0.14)	(0.71)	7.2	(0.21)	(0.64)	(3.11)	(0.54)	(0.78)
T - 2	45.3	122.0	(0.21)	15.3	17.8	51.6	17.8	30.8
	(0.35)	(0)		(0)	(0.49)	(0.99)	(0.49)	(0)
T - 3	46.1	121.0	7.2	15.2	17.5	50.9	16.4	30.9
	(0.14)	(0)	(0.21)	(0.21)	(0.28)	(1.98)	(0.30)	(0.64)
T - 4	46.1	121.0	6.9	15.4	17.4	57.0	17.3	34.8
	(0.35)	(0)	7.1	(0.21)	(0.14)	(0.42)	(0.52)	(0.85)
Control	46.0	121.5	(0.14)	15.0	17.3	46.9	16.1	28.9
	(0.28)	(0.71)		(0)	(0.07)	(0.57)	(0.61)	(0.21)

*Plants reached floral differentiation stage.
**Plants reached flowering stage, T - 1: Aug. 18, T - 2: Aug. 16, T - 3, T- 4 and Control: Aug. 17.
***Mean internode length was computed by (stem length/number of internodes).
Each value indicates mean with standard deviation (in parentheses) of 2 replications.

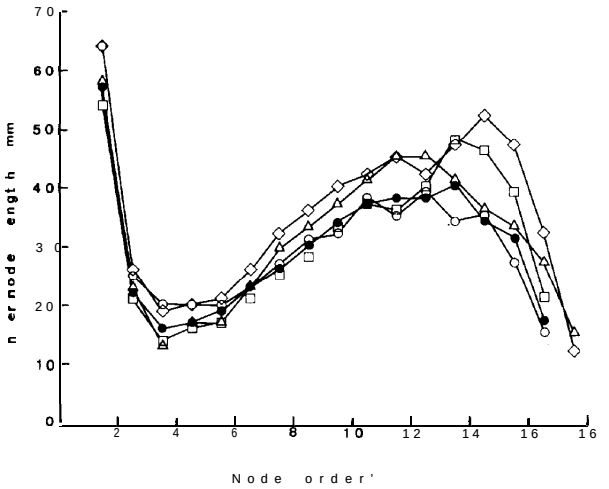

Fig. 1. Effects of shading on the length of internode on the main stem.
○: T-l, A: T-Z, □: T-3, ◇: T-4, ●: Control.
*1,2 and the number (N) over 2 indicate the cotyledon node, primary leaf node and (N -2)th trifoliolate node, respectively.

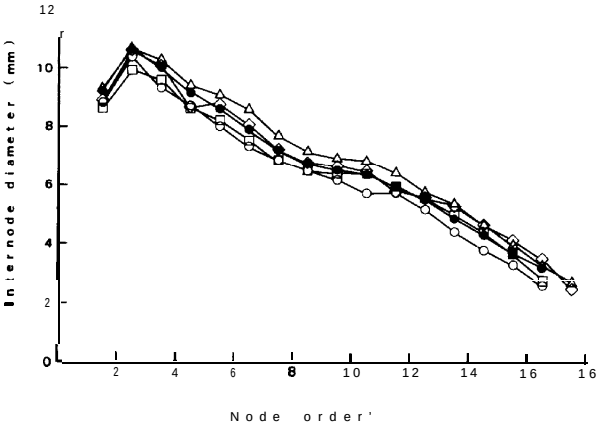

Fig. 2. Effects of shading on the diameter of internode on the main stem.
○: T-1, △: T-2, □: T-3, ◇: T-4, ●: Control.
*See Fig. 1.

DISCUSSION

The shading treatments at various growth stages increased stem length. Especially, large increase was observed by the shading treatment during the period from floral differentiation to the beginning of flowering stage, followed by the period from the beginning of flowering to the end of vegetative growth stage. The treatment during the period from emergence to floral differentiation stage rather depressed stem

elongation.

For each internode length, the promotion by shading treatment was limited on the upper elongating internodes and the internodes which had already stopped their elongation were hardly affected.

Tabuchi and Ishida (1983) reported that the shading treatment at the early stage depressed vegetative growth including the stem elengation, and one at just before the beginning of flowering was the most effective. Asanuma (1977) reported that the earlier the shading treatment was carried out, the more stem length promoted by shading treatment at the period from floral differentiation to the beginning of flowering stage. These results are the same as this experiment. The author reported that the period from floral differentiation to the beginning of flowering stage was the most sensitive for mechanical stimulation, which depressed internode elongation (Umezaki and Matsumoto, 1990), and that the floral differentiation stage was the most sensitive for chemicals, such as gibberellic acid, which promoted internode elongation (Umezaki et al., 1991a), and gibberellin biosynthesis inhibitors, which depressed (Umezaki et al., 1991b). These results confirmed that the period from floral differentiation to the beginning of flowering stage was the most sensitive time for environmental changes or external treatments.

On the other hand, significant effects of shading treatment on the diameter of internode on the main stem were not found in this experiment, whereas some researchers reported the diameter of internode was reduced by shading treatment (Asanuma, 1977; Nakamura et ***al.***, 1986; Tabuchi and Ishida, 1983). Popp (1926) mentioned the relation between the thickness of the stem and light intensity, the former was directly promotional to the latter in the range from 26 to 4285 foottcandles. The difference between the results of others and this experiment seemed to be caused by the difference of shading intensity and by the difference of the degree of recovery after the end of treatment.

The shading treatment during the period from the floral differentiation to the beginning of flowering stage slightly increased the number of nodes on the main stem. Nakamura et al., (1986) reported the same phenomenon. And the author (1991a) reported the increase of the number of nodes on the main stem of the plant applicated with gibberellic acid at the floral differentiation stage, whereas the application at any other stage did not increase it. From these phenomena, it seems that shading or gibberellic acid application affected the change of growth stages at growth point.

The lack of sunlight induced spindly growth, but the optimal shading promoted proper internode elongation. From the results it appears the optimal shading treatments at optimal stages can control the plant height and plant type by increasing the length of internodes and the number of nodes on the stem.

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