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Effects of Photoperiod and Shading on Growth and Yield of Licorice

Sang-Sun Han, Yeon-Bok Kim, Sang-Yong Lee, Kwang-Jin Chang[1], Han-Bum Lee[2], Ki-Cheol Lee[3] and Cheol-Ho Park

College of Agriculture and Life Sciences, Kangwon National University, Chunchon, 200-701 Korea

[1]Korea National Agriculture College, Hwasung 440-885, Korea

[2]Kyonggi-do Agricultural Research and Extension Services, Hwasung 445-970, Korea

[3]Kyonggi-do Agricultural Research and Extension Services, Hwasung 445-970, Korea

ABSTRACT

Growth and yield of licorice were investigated under the different conditions of photoperiod and shading in order to establish its cultural practice for the domestic production with the aim to substitute the import. The photoperiod was adjusted to 8, 10, and 12 h by shielding plants from the light with blackout curtain. Large seedlings(11-20g) appeared to be affected by photoperiod since around 65 days. Most of growth parameters, including plant height, number of leaf, fresh and dry weight of plant and root, were the highest in 12 h photoperiod among all the photoperiod levels, excepting stem diameter which was the highest in 10 h photoperiod(4.5mm). Each photoperiod was similar to each other in root length and diameter. Small seedlings(4-10g) showed a similar trend to large seedlings. The results from field photoperiod experiment demonstrated that 12 h photoperiod was also the best among three photoperiod treatments in plant height, stem diameter, number of leaf, root length, fresh and dry weight of plant and root. The effect of shading was tested under the three levels of control (0%), half-shading (55%), and full shading (90%). Shading remarkably suppressed the growth and yield, compared to no-shading. Although plant height and root length were little affected by the shading, stem and root diameters were heavily reduced.

Key Words : Large seedlings of licorice, small seedlings of licorice, seeds of licorice, photoperiod, shading

INTRODUCTION

Manchurian licorice Root(Glycyrrhiza uralensis Fisch.) is a perennial species, belonging to legume family. It is mostly native to the northern area of China and a part of Siberia. Locorice is grown well in rich and sandy soil in sun and adapted well to slightly alkaline and moisture-retentive conditions. It is propagated by seed sown, division, or stolon cuttings in autumn or spring(Bown, 1995). The spices is a sweet and tonic herb that stimulates adrenocorticol hormones, relaxes spasms, reduces pain and inflammation, is expectorant, and controls coughing. It moderates and harmonizes the characteristics of other herbs. It also neutralizes toxins and balances blood sugar levels. Therefore, it is used

Corresponding author : **Sang-Sun Han**, College of Agriculture and Life Sciences, Kangwon National University, Chunchon, 200-701 Korea

internally for Addison' s disease, asthma, coughs, and peptic ulcer and externally for acne, boils, and sore throat(Bown, 1995).

There were some pharmacological and clinical reports on Licorice Root in China(Bensky and Gamble, 1986). They include mineralocorticoid effect, glucocorticoid effect, anti-allergic effect, anti-inflammatory effect, gastrointestinal effect, treatment of chronic bronchial asthma, treatment of diabetes insipidus, and effect on lipid metabolism etc.

Photoperiod, light intensity, and light quality are very important factors in light environment for the physiology and growth of plants such as photosynthesis. The effects of photoperiod and shading on the growth of plants have been reported on several crops. Ahn et al (1994) reported that the longer photoperiod caused the longer plant height of Angelica gigas Nakai and the increased number of leaf and leaf length, but the decreased weight of root owing to the elevated rate of bolting. It was also reported that the length and diameter of root, the number of lateral roots, and root weight of Angelica sinensis (Oliv) Diels were increased by the longer photoperiod (Yu et al., 2000).

Light intensity has a great influence on the growth of crops, as well as photoperiod. In root crops, the higher light intensity generally increased the growth and yield of underground parts than the lower intensity, as well as those of top (Lim et al., 1998; Choi, 1999). However, some authors reported that shading caused plant growth promoting effects in root crops such as Codonopsis lanceolata, ASARI RADIX, Angelica sinensis (Oliv) Diels, and ginseng (Kim et al., 1994; Lee et al., 1998; Lime et al, 1999; Choi et al., 1999).

Therefore, with the goal to establish the basis of domestic production of G. uralensis, this study was conducted to investigate the effects of photoperiod and shading on the physiological characteristics and yield of Glycyrrhiza uralensis and understand the influence of light on licorice.

MATERIALS AND METHODS

Seedlings of Glycyrrhiza uralensis were classified into large(11～20g) and small(4～10g) ones and transplanted. In May 4 in 2000, five seeds per hole were planted with the planting density of 30×10cm in a plastic house in the field of experimental farm of Kangwon National University. After planting, each of blackout curtain with size of 1.5×1.5×1.0m was set up to shield the light for 8, 10, or 12 h photoperiod treatments and the plants were cultivated for 98 days based on the conventional practice. The seasonal variations in the growth characteristics were investigated during the cultivation period. The plants were harvested at 120 days and the growth and yield were measured. In the shading experiment, the small seedlings of Glycyrrhiza uralensis plants were transplanted and then the light intensity was adjusted to 0, 55, or 90% with shading net. The plants were cultivated for 120 days. All treatments were tried in three replications of completely randomized experiment. At 120 days after transplanting, ten plants were randomly selected for the measuring of plant height, number of leaf, number of branch, root length, root diameter, fresh and dry weight of plant and root etc.

RESULTS AND DISCUSSION

Fig. 1 represents the variation of plant height of Glycyrrhiza uralensis plants from large seedlings(11～20g) under the different photoperiods. By 53 days, the 10 h photoperiod showed the longest height among the treatments. However, the 12-h photoperiod showed the better growth than the 8 and 10 h photoperiods since 65 days. This indicates that photoperiod has an influence on the plant height of Glycyrrhiza uralensis plants.

Fig. 2 represents the variation in number of leaf of Glycyrrhiza uralensis plants from large seedlings under the different photoperiods. By 31 days, the 10 h photoperiod showed the best growth with 6 leaves per plant and the 12 h photoperiod showed the best growth since 44 days. The 8 h photoperiod was similar or more in the number of leaf than the 10h photoperiod.

Fig. 3 represents the variation in the number of branch of Glycyrrhiza uralensis plants from large seedlings under the different photoperiods. At 31 days after sowing, no branch was formed in all treatment and then all treatment had the same number of branch at 44 and 53 days after sowing. From 65 days after sowing, the 12 h photoperiod showed the more growth in number of branch than any other treatments. The number of branch in both 8 h and 10 h photoperiod remained the same since 44 days after sowing. These results indicate that the maintaining photoperiod more than 12 h must be favorable to the growth in plant height, and number of leaf and branch.

Fig. 4 represents the variation in plant height of Glycyrrhiza uralensis plants from small seedlings under the different photoperiods. The 12 h photoperiod showed the best growth among the three photoperiods from 31 to 98 days after sowing. From 73 to 98 days the 8 h photoperiod was the better in growth than 10 h photoperiod.

Fig. 5. represents the variation in number of leaf of Glycyrrhiza uralensis plants from small seedlings under the different photoperiods. By 31 days after sowing, the 10 h photoperiod was the highest in number of leaf with 6 leaves per plant among all treatments, since then the 12 h photoperiod plot became the highest in number of leaf from 44 days to 98 days after sowing. Since 44 days after sowing, the 8 h photoperiod was similar or a little more in number of leaf to the 10 h photoperiod.

Fig. 6. represents the variation in number of branch of Glycyrrhiza uralensis plants from small seedlings under the different photoperiods. By 31 days after sowing, no branch was formed in all treatment plots. At 44 days, the 8 h photoperiod was the least in number of branch among all treatments, and all the photoperiods

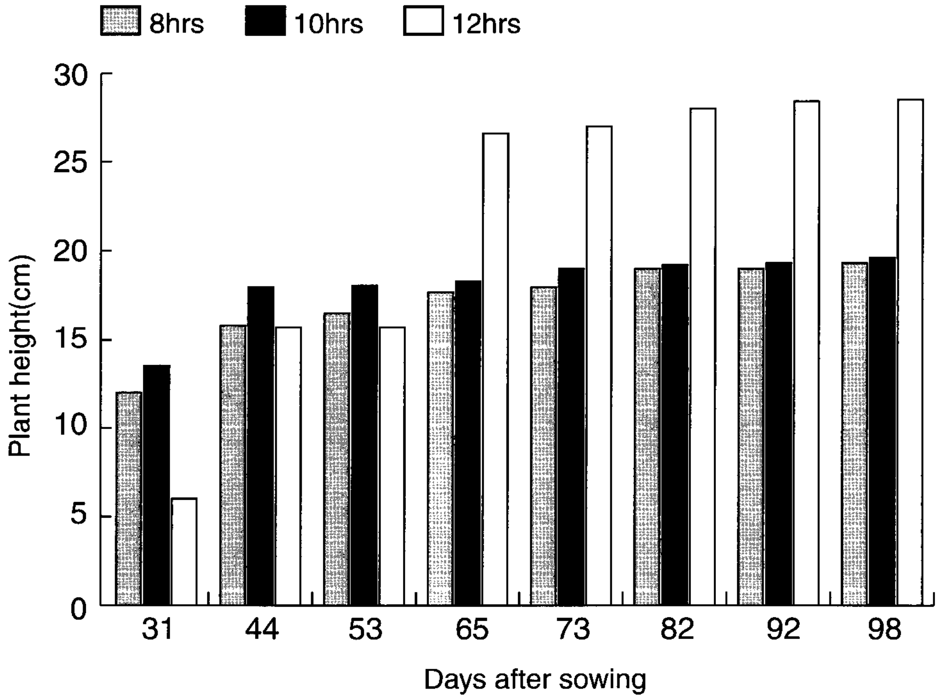

Fig. 1. Variation of plant height of *Glycyrrhiza uralensis* Fisch. plants from large seedling under the different photoperiods.

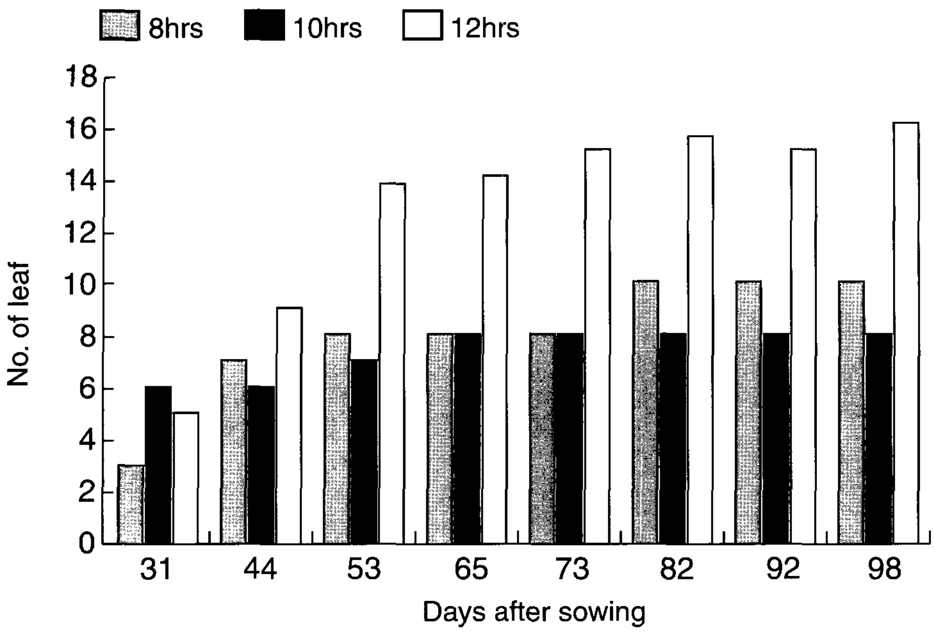

Fig. 2. Variation in number of leaf of *Glycyrrhiza uralensis* Fisch. plants from large seedlings under the different photoperiods.

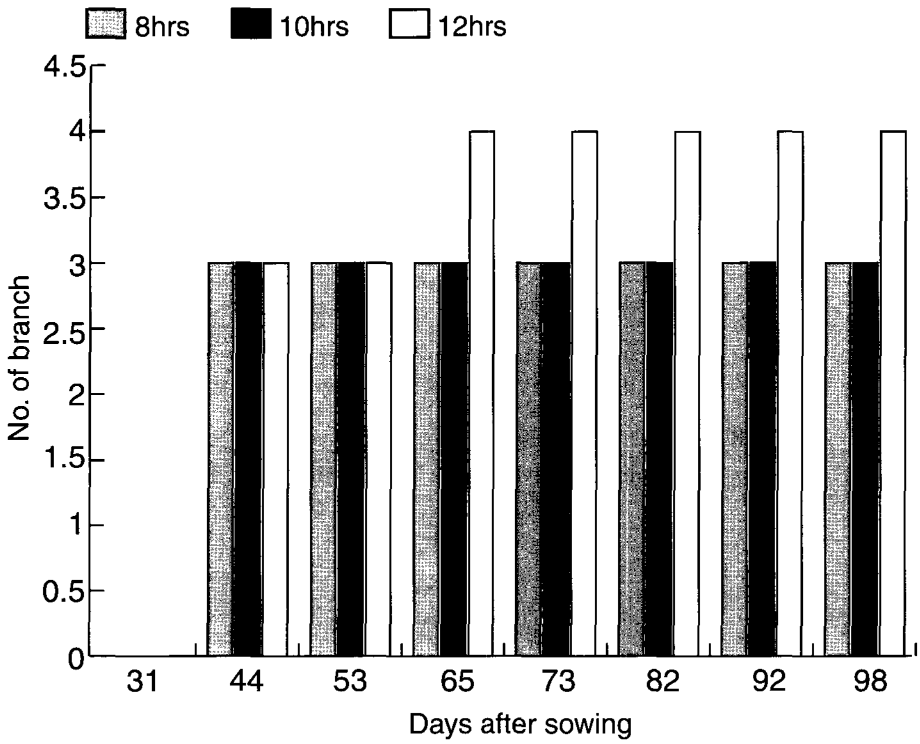

Fig. 3. Variation in number of branch of *Glycyrrhiza uralensis* Fisch. plants from large seedlings under the different photoperiods.

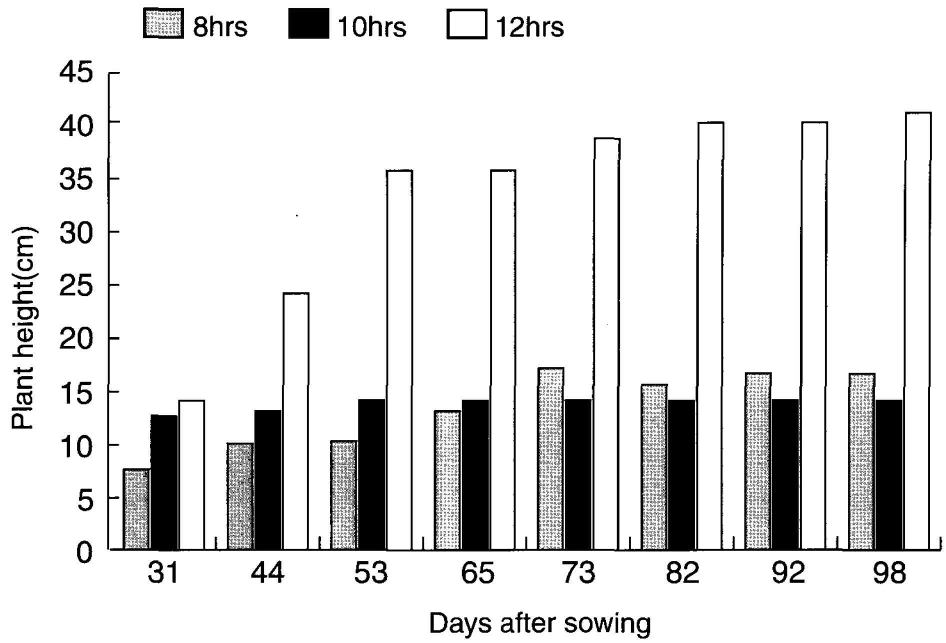

Fig. 4. Variation in plant height of *Glycyrrhiza uralensis* Fisch. plants from small seedlings under the different photoperiods.

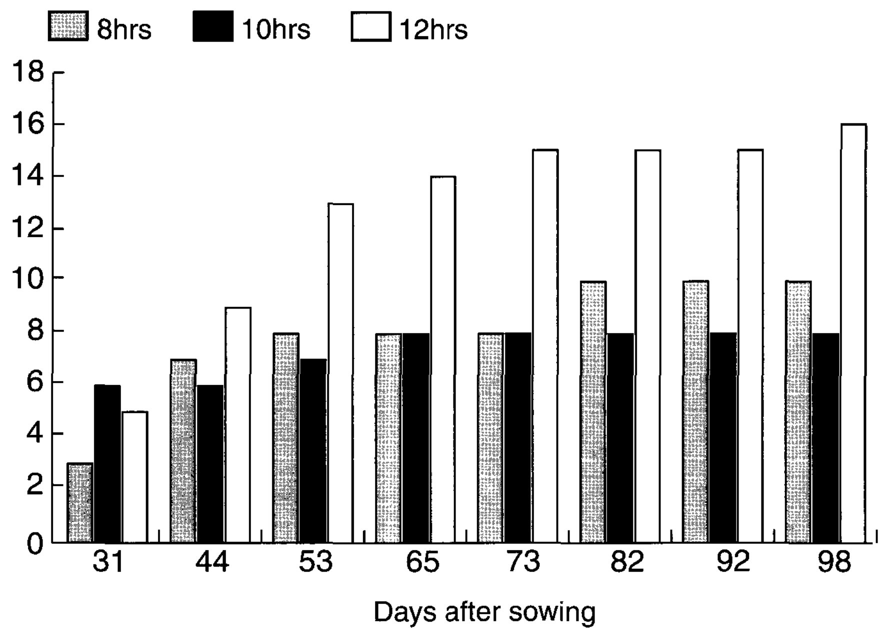

Fig. 5. Variation in number of leaf of *Glycyrrhiza uralensis* Fisch. plants from small seedlings under the different photoperiods.

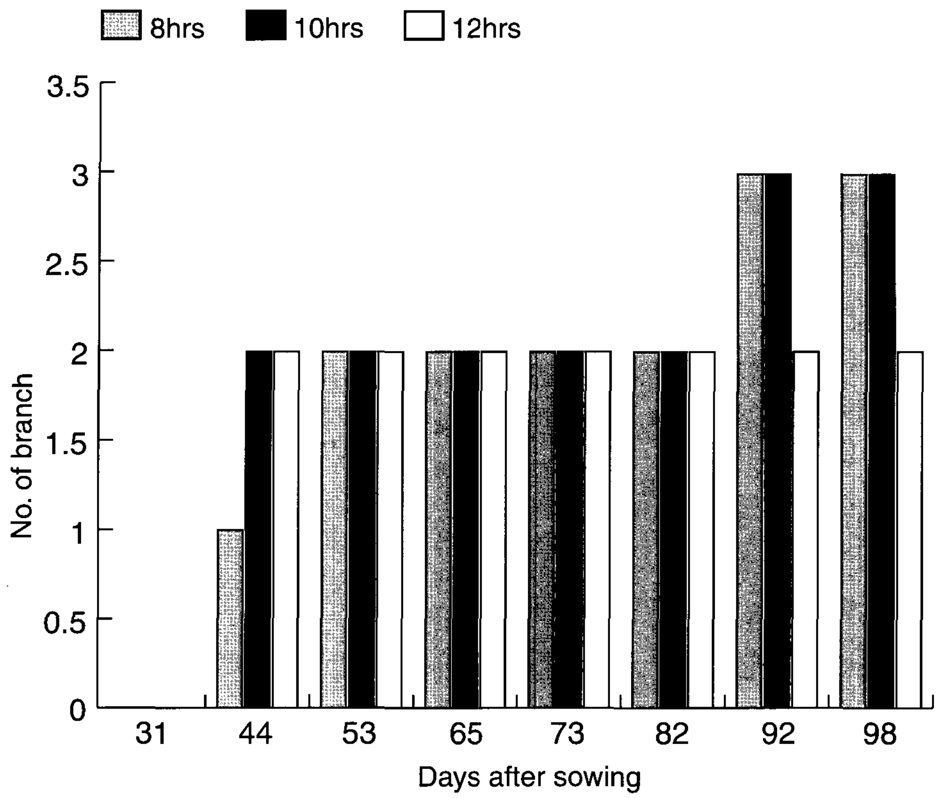

Fig. 6. Variation in number of branch of *Glycyrrhiza uralensis* Fisch. plants from small seedlings under the different photoperiods.

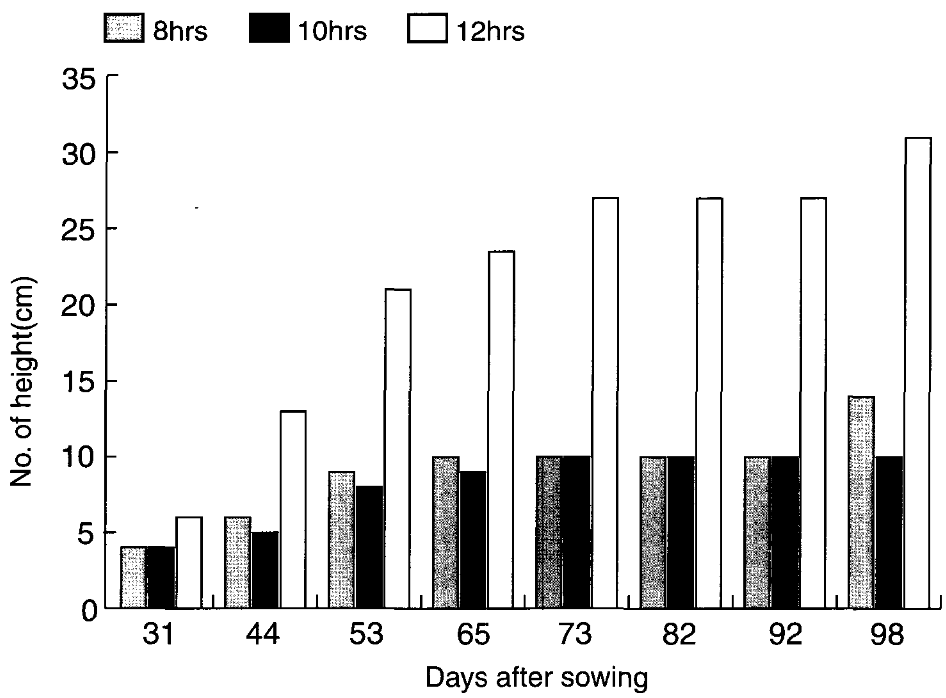

Fig. 7. Variation in plant height of *Glycyrrhiza uralensis* Fisch. plants from seeds under the different photoperiods.

were the same in number of branch from 53 to 82 days after sowing. From 92 to 98 days both the 8 h and the 10 h photoperiods were similar in number of branch each other.

These results indicate that the 12 h photoperiod was favorable to the growth of plants from large seedlings in plant height, and numbers of leaf and branch, and that the same photoperiod was also favorable to the growth of plants from small seedlings in plant height and number of leaf, though the number of branch of plants from small seedlings was exceptionally least in the 12 h photoperiod. The numbers of branch of plants from large and small seedlings remained 4 and 2, respectively. It was thought that there might be no significance between photoperiod and number of branch

Fig. 7. represents the variation in plant height of Glycyrrhiza uralensis plants from seeds under the different photoperiods. The plant height in the 12 h photoperiod was much longer than those in both 8 h and 10 h photoperiods. In the comparison between 8 h and 10 h photoperiods, the latter was a little higher in plant height than the former from 44 to 73 days after sowing. From 82 and 92 days the 8 h and 10 h photoperiods were similar to each other in plant height but the 8 h photoperiod appeared longer in plant height than the 10 h photoperiod at 98 days after sowing.

Fig. 8 represents the variation in number of leaf of Glycyrrhiza uralensis plants from seeds under the different photoperiods. There was little difference between 10 h and 12 h photoperiods by 31 days after sowing and then the 12 h photoperiod became more in number of leaf than the 10 h photoperiod from 44 days after sowing. Though the 8 h photoperiod became more in number of leaf than the 10 photoperiod at 65 days after sowing; thereafter, similar numbers of leaf were found in the two photoperiods.

Table 1 represents the growth characteristics of Glycyrrhiza uralensis plants grown under the different photoperiods during 120 days. In the experiment using large seedlings, the plant height(51.5cm) in the 12 h

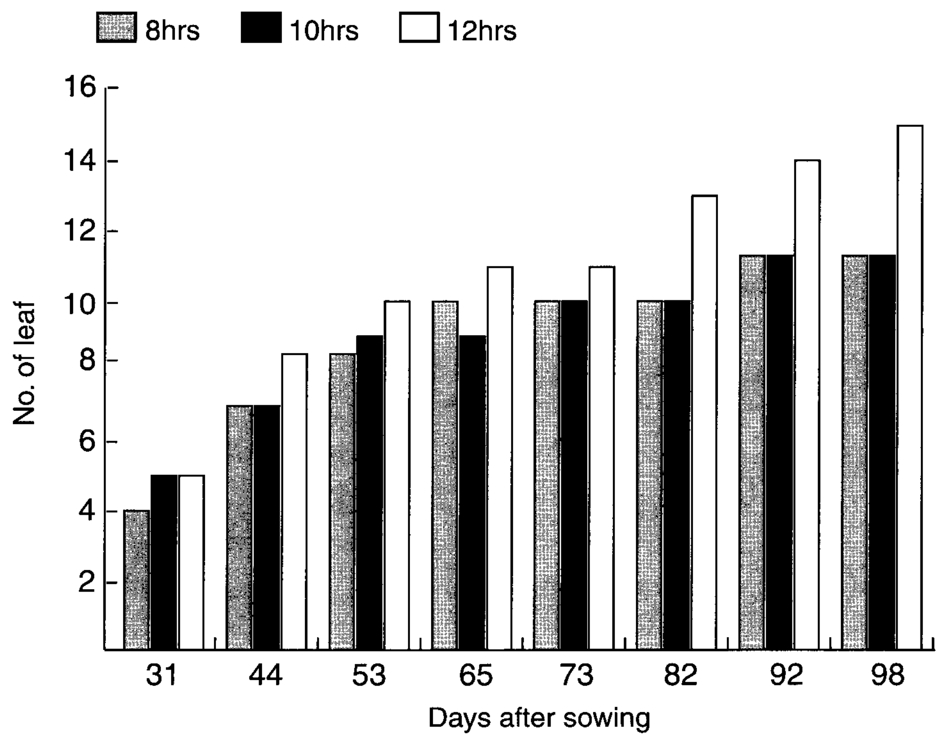

Fig. 8. Variation in number of leaf of *Glycyrrhiza uralensis* Fisch. plants from seeds under the different photoperiods.

Table 1. Growth characteristics of *Glycyrrhiza uralensis* Fisch. under the different photoperiods.

Seedling size	Day length (hrs)	Plant height (cm)	Stem diameter (mm)	No. of leaf	Root length (cm)	Root diameter (mm)
Large	8	22.3	2.1	72.5	24.2	11.8
	10	22.8	1.7	69.1	27.6	11.2
	12	51.5	2.3	216.9	30.8	11.0
	LSD(5%)	12.8	0.6	154.0	5.0	2.1
Small	8	15.8	1.4	59.3	26.3	9.3
	10	15.7	1.4	48.9	26.1	9.2
	12	61.9	2.6	186.9	30.810.6	
	LSD(5%)	6.2	0.4	50.0	10.7	1.4

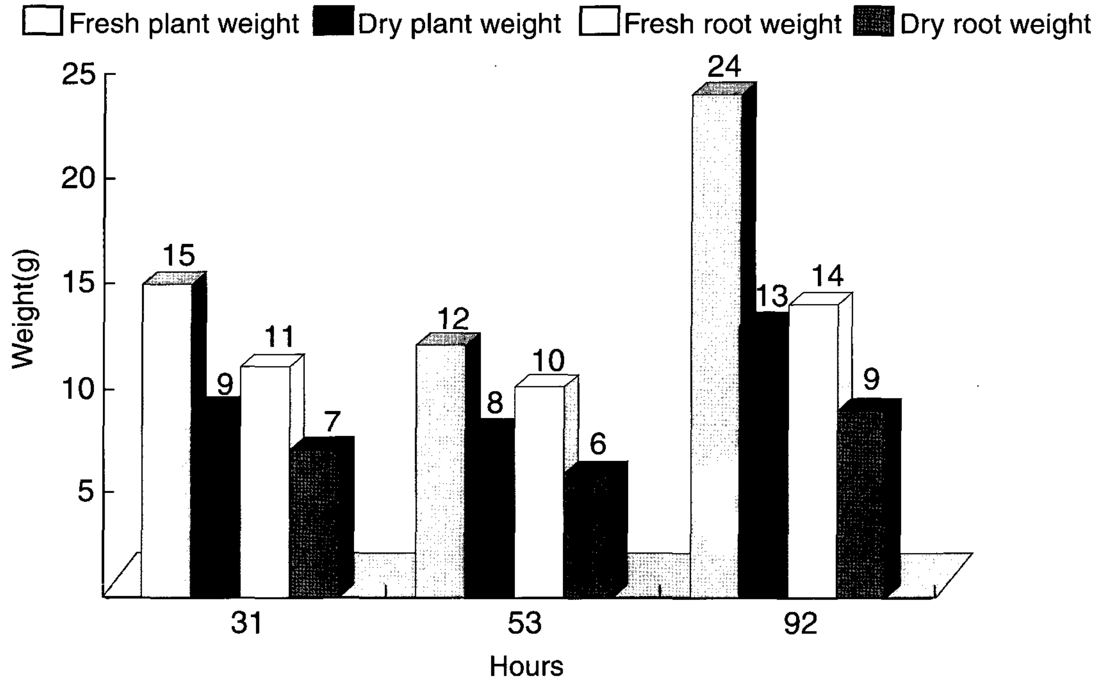

Fig. 9. Fresh and dry weight of plant and root of *Glycyrrhiza uralensis* Fisch. plants from large seedlings under the different photoperiods.

photoperiod was above two times as long as those in the 8 h(22.3cm) and the 10 h(22.8cm) photoperiods. The 12 h photoperiod was also thicker and more in stem diameter and number of leaf, respectively. In particular, it was above three times in number of leaf as many as the other photoperiods(8 h and 10 h). Root length was also longest(30.8cm) in the 12 h photoperiod.

In the experiment using small seedlings, the plant height(61.9cm) in the 12 h photoperiod was four times as long as those in the 8 h(15.8cm) and the 10 h(15.7cm) photoperiods. In particular, the number of leaf in the 12 h photoperiod was 186.9, being above four times as many as those in the other photoperiods. The 12 h photoperiod was also the best in root diameter(10.6cm) and root length(30.8cm).

The 12 h photoperiod caused significant plant height,

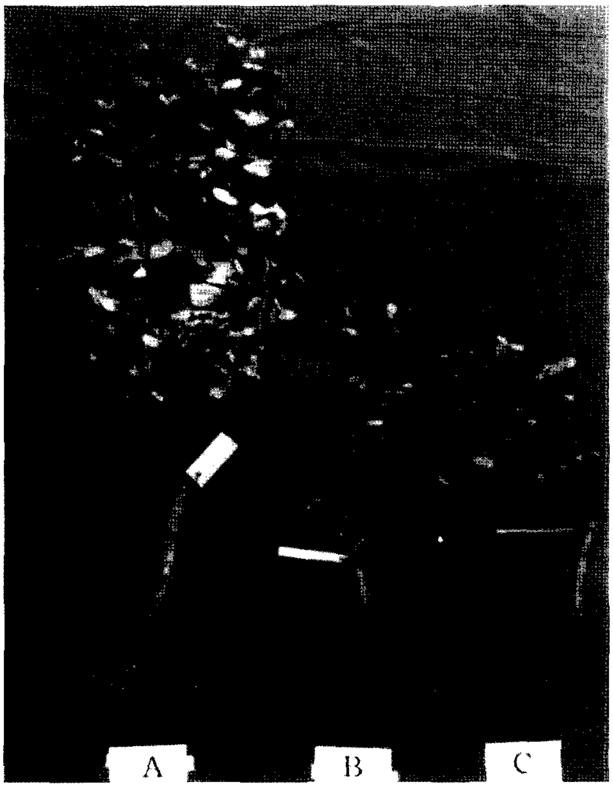

Fig. 10. Whole plants of *Glycyrrhiza uralensis* Fisch. grown from large seedlings under the different photoperiods (A=12 hrs, B=10 hrs, C=8 hrs).

stem diameter and root length in plants from large seedlings, and significant plant height, stem and root diameter, and number of leaf in plants from small seedlings.

Fig. 9. represents the fresh and dry weight of plant and root of Glycyrrhiza uralensis plants from large seedlings under the different photoperiods. The fresh weight of plant in the 12 h photoperiod was 23.6g, being 1.6～2.0 times as high as those in 8 h(14.6g) and 10 h(12.1g) photoperiods. And the dry weight of plant in the 12 h photoperiod was 13.1g, being 1.5～1.7 times as high as those in 8 h(8.7g) and 10 h(7.6g) photoperiods. The fresh weight of root in the 12 h photoperiod was 14.3g, being 1.3～1.4 times as high as those in 8 h(11.2g) and 10 h(10.0g) photoperiod. And the dry weight of root was 8.9g, being 1.3～1.5 times as high as those in 8 h(7.1g) and 10 h(5.9g) photoperiods. Yu et al.(2000) reported that the longer photoperiod caused the higher growth in root length, root diameter, number of lateral roots of Angelica sinensis plants, showing the similar trend to this study.

Fig. 11 represents the fresh and dry weight of plant

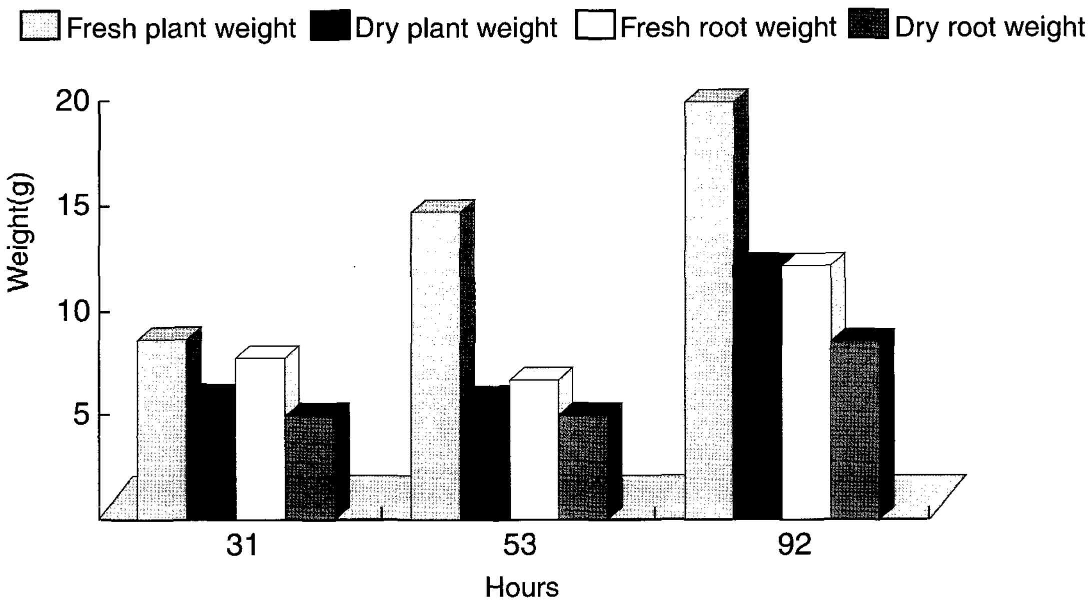

Fig. 11. Fresh and dry weight of plant and root of *Glycyrrhiza uralensis* Fisch. plants from small seedlings under the different photoperiods.

and root of Glycyrrhiza uralensis plants from small seedlings under the different photoperiods. The fresh weight of plant in the 12 h photoperiod was 19.3g, being higher than those in 8 h(8.3g) and 10 h(14.1g) photoperiods. The dry weight of plant in the 12 h photoperiod was 10.9g, being two times as high as those in 8 h(4.8g) and 10 h(4.8g) photoperiods. The fresh weight of root was 11.4g in the 12 h photoperiod, being about 1.7～1.8 times as high as those in 8 h(6.8g) and 10 h(6.3g) photoperiods. And the dry weight of root was 7.5g in 12 h photoperiod, being about two times as high as 8 h(4.1g) and 10 h(3.8g) photoperiods.

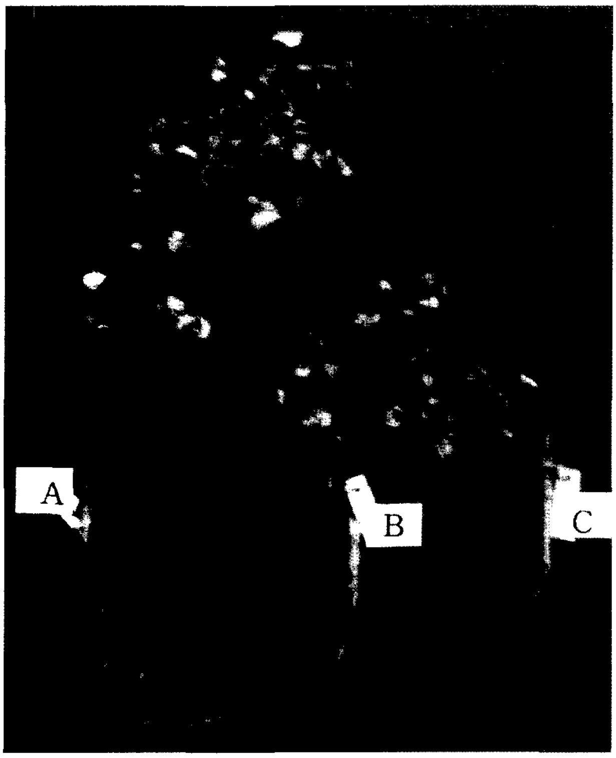

Fig. 12. Whole plants of *Glycyrrhiza uralensis* Fisch. grown from small seedlings under the different photoperiods (A=12 hrs, B=10 hrs, C=8 hrs).

The influence of photoperiod on the growth of Glycyrrhiza uralensis plants grown from seeds is shown in Table 2. After 120 days after sowing in May 4, 2000, the plant height was 63.2cm in the 12 h photoperiod, being 3～4 times as high as those in 8 h(17.0cm) and 10 h(21.9cm) photoperiods. The number of leaf in the 12 h photoperiod was 86.6, being 4～5 times as high as those in 8 h(16.7) and 10 h(22.3) photoperiods. Stem diameter in the 12 h photoperiod was 2.5mm, being more than two times as thick as those in 8 h(1.1mm) and 10 h(1.0mm) photoperiods. Root length in the 12 h photoperiod was 25.1cm, being 1.4 times as long as those in 8 h(18.2cm) and 10 h(17.9cm) photoperiods. Also root diameter in the 12 h photoperiod was 7.2mm, being 1.5～1.8 times as thick as those in 8 h (4.7mm) and 10 h (4.0mm) photoperiods. There was a significance among the photoperiods.

Fig. 13 represents the fresh and dry weight of plant and root of Glycyrrhiza uralensis plants from seeds under the different photoperiods. The fresh weight of plant in the 12 h photoperiod was 7.6g, being 3.5～5.4 times as high as those in 8 h(1.4g) and 10 h(2.2g) photoperiods. And the dry weight of plant in the 12 h photoperiod was 4.3g, being 3.6～4.8 times as high as those in 8 h(0.9g) and 10h(1.2g) phhotoperiods. The fresh root weight in the 12 h photoperiod was 3.3g, being 2.8～3.3 times as high as those in 8 h(1.0g) and 10 h(1.2g) photoperiods. And the dry root weight in the

Table 2. Growth characteristics of *Glycyrrhiza uralensis* Fisch. plants from seeds under the different photoperiods.

Treatment (hrs)	Plant height (cm)	Stem diameter (mm)	No. of leaf	Root length (cm)	Root diameter (mm)
8	17.0	1.1	16.7	18.2	4.7
10	21.9	1.0	22.3	17.9	4.0
12	63.2	2.5	86.6	25.1	7.2
LSD(5%)	9.6	0.6	41.5	5.8	1.6

Table 3. Growth of *Glycyrrhiza uralensis* Fisch. plants from small seedlings under the different shadings.

Treatment of shading(%)	Plant height (cm)	Stem diameter (mm)	No. of branch	Root length (cm)	Root diameter (mm)
Natural sun	65.6	4.2	6.3	34.3	10.6
55	65.7	2.9	4.9	33.1	8.6
90	45.3	1.7	1.1	26.7	4.3

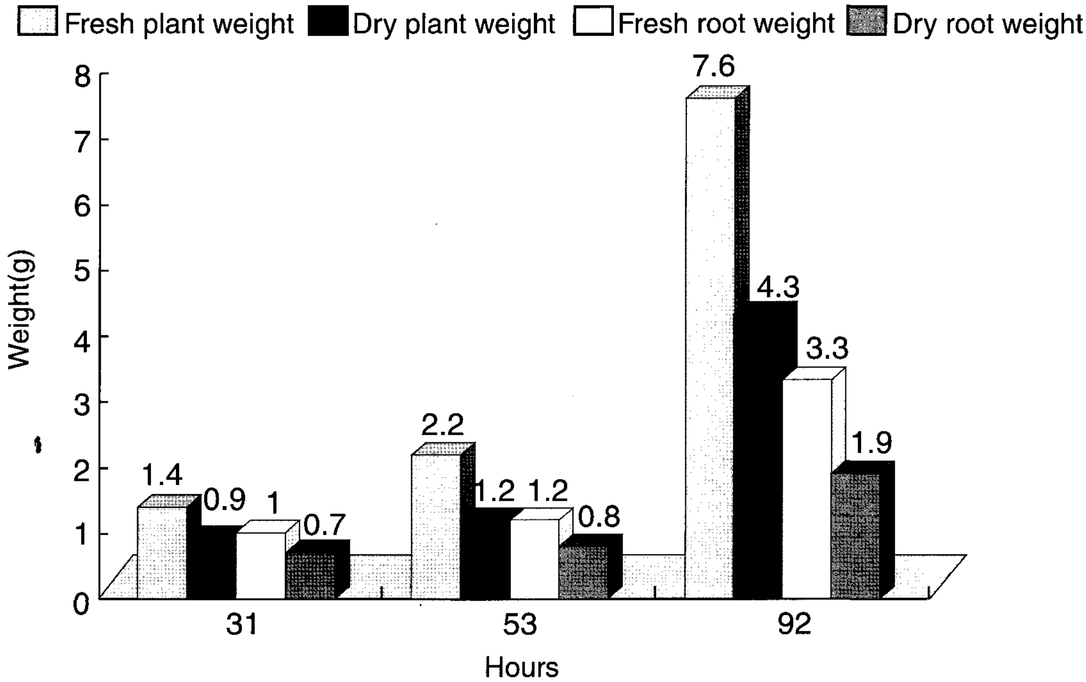

Fig. 13. Fresh and dry weight of plant and root of *Glycyrrhiza uralensis* Fisch. plants from seeds under the different photoperiods.

12 h photoperiod was 1.9g, being 2.4~2.7 times as high as those in 8 h(0.7g) and 10 h(0.8) photoperiods. There was a significance among the photoperiods.

Table 3 shows the influence of shading on the growth of Glycyrrhiza uralensis plants cultivated from small seedlings. The plant height and root length in 55% shading and no shading were about 66cm and 33~34cm, respectively, showing little difference between two treatments and then the amount of growth in the two shading was 1.5 times as much as that in 90% shading. Stem diameter and root length in no shading were 4.2mm and 6.3mm, being 1.4~2.5 times as high as those in 55% and 90% shading. The number of branch in no shading was 6.3, being 1.3~5.7 times as high as those in 55%(4.2mm) and 90%(6.3mm) shading. There was a significance among shading treatments.

Choi et al.(1999) cultivated Angelica polymorpha under the different shading treatments, resulting in better root weight under white vinyl shading and no shading. And Lim et al.(1998) reported that the higher rate of shading caused the poorer growth of snaked beard in top and underground part, showing similar results to this study. The poor growth of licorice root under the increased rate of shading could be thought to be caused by the lack of assimilation products from

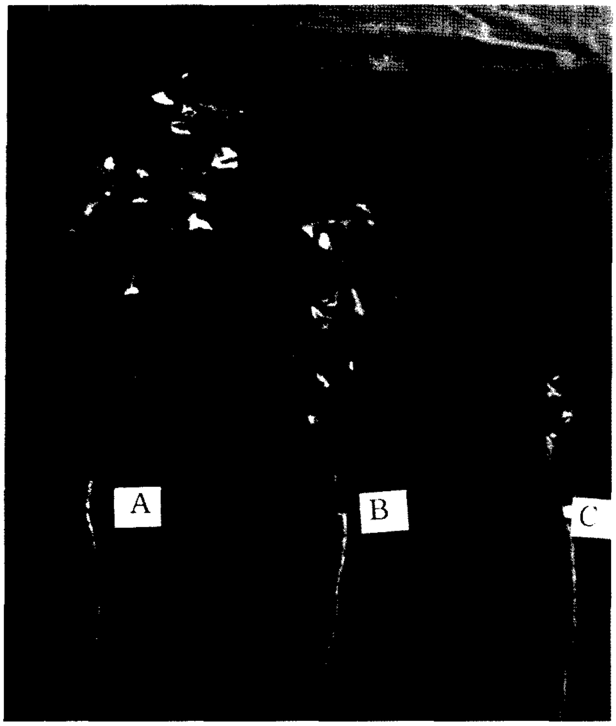

Fig. 14. Whole plants of *Glycyrrhiza uralensis* Fisch. grown from seeds under the different photopeirods (A=12 hrs, B=10 hrs, C=8 hrs).

poor photosynthesis.

As shown in Fig. 15, the fresh weight of plant grown from small seedlings was 34g in no shading, being about two times as high as 15g in 55% shading plot, and the dry weight of plant was 19g in no shading, being above two times and above 19 times as high as those in 55% and 90% shading treatments, respectively. The fresh and dry root weights in no shading were 18.0g and 11.0g, respectively, being above two times and 18 times as high as those in 55% and 90% shading treatments, respectively.

Lee et al.(1998) investigated the growth characteristics of Codonopsis lanceolata under 0, 15, 35, 55, and 75% shading and reported that 75% shading treatment plot was the best in plant height, number of leaf, leaf length, leaf width, and fresh root weight among all the shading treatments, the growth and yield of Codonopsis lanceolata showing a negative correlation with photoperiod, contrary to this study. Lim et al.(1999) reported that licorice, Ligusticum chuanxiong, and Chinese bellflower showed the best

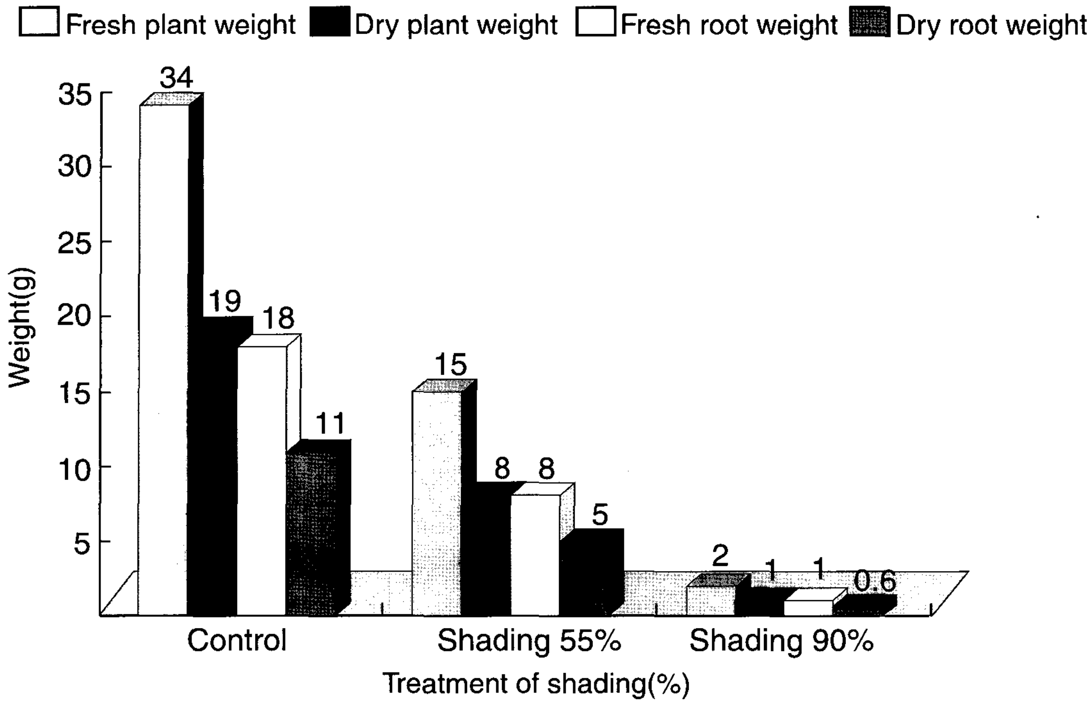

Fig. 15. Fresh and dry weight of plant and root of *Glycyrrhiza uralensis* Fisch. plants under the different shading.

growth in 0% shading among 0, 30, 60, and 90% shading in their experiment on the cultivation of various medicinal herb crops under trees, their results being consistent with this study. In conclusion, licorice is thought to be a long-day plant with a sensitivity to long photoperiod and the higher rate of shading caused the poorer growth by the lack of assimilation products from poor photosynthesis, resulting in a reduced yield.

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