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Effects of Ridge Height, Planting Density and Irrigation on Growth and Yield of Licorice

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ABSTRACT

Growth and yield of licorice were investigated under the different conditions of ridge height, planting density, and irrigation in order to establish its cultural practices for the domestic production with the aim to substitute the import. Seedlings were grown under low ridge(20cm) and high ridge(40cm) in low density plot(60 × 30cm) and high density plot(40 × 30cm), respectively. The low ridge cultivation of large seedlings increased plant height and root length under low density, and stem and root diameter under high density compared to the high ridge cultivation. In the high ridge cultivation, high density plot was 1.1 to 1.3 times in plant height, root length, stem and root diameter as high as low density one. Fresh and dry weight of plant and root in high ridge were 1.3 to 1.5 times as high as those in low one. The growth of small seedlings(4～10g) were generally poor compared to that of large seedlings. High density plot in low ridge showed the good growth characteristics including plant height, root length, stem and root diameter, and number of branch. High density plot was 1.4 to 1.6 times in fresh and dry weight of plant and root as high as low density plot. In the seasonal changes of growth under various irrigation regimes, the twice irrigation a day produced the more number of leaf than the other regimes since around 46 days after transplanting. The former irrigation resulted in 1.2 to 1.4 times in plant height as long as the other irrigations around 26 days after transplanting and then the difference was increased to 1.6 to 2.0 times around 64 days after transplanting. Under the twice irrigation a day, plant height, root length, stem diameter, root diameter, number of leaf, fresh plant weight, dry plant weight, fresh root weight, dry root weight were 1.6 to 2.0, 1.1, 1.2 to 1.6, 1.3 to 1.8, 1.9 to 2.7, 1.7 to 8.0, 1.6 to 2.8, 2.0 to 3.0, 1.6 to 2.7 times as high as those under the other irrigation regimes, respectively.

Key Words : Large seedling of licorice, small seedlings of licorice, licorice seeds, ridge height, planting density, irrigation

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INTRODUCTION

Manchurian licorice(*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, 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 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.

Licorice is one of the important resource plants whose roots are used for medicine or food. In general, there are many factors such as ridge height, planting density, and irrigation among factors related to the growth and yield of root crops. In terms of ridge height, high ridge has been reported to be more favorable to growth, yield, and quality of it than low ridge(Kim, 1994; Kim et al., 1999; Park et al., 1999).

The responses of medicinal herb crops to planting density have been reported to differ among species. Paeonia japonica (Makino) Miyabe et Takeda)(Kim et al., 1999) and Astragalus membranaceus var. alpinus Nakai(Cho, 1996; Han, 2000; Jang et al., 1999) showed the better growth and yield in low density but Ligusticum wallichii(Choi et al., 2000) and Cnidium officinale(Chung et al., 1997) showed the better growth and yield in high density.

The required moisture amount for plant growth differ among crops. In general, there are a lot of literature about the water physiology of food crops such as corn, and wheat and barley but little data are found about medicinal herb crops(Kim et al., 1997). In particular, licorice has not been fully investigated about the effects of irrigation on the growth and yield. So, the physiological response and yield of licorice to irrigation need to be investigated in the cultivation of the plants with excellent drought resistance in indigenous area.

Few studies about licorice were reported in Korea. This circumstance called for the studies on appropriate ridge height, planting density, and irrigation which are critical to establish the cultural practices for the basis of domestic production of licorice. Therefore, this study was conducted to investigate these subjects through field experiments.

MATERIALS AND METHODS

Seedlings and seeds of G. uralensis used for this study were supplied by Chonil Medicine Co., Wonju, Korea. The one year-old seedlings were classified into large(9-11g) and small(4-6g) ones based on their fresh weight, and transplanted respectively in the field at Chunchon. Seeds were sown in square pots. The two levels of ridge height were 20cm and 40cm. The two levels of planting density were 60×30cm and 40×30cm. The three levels of irrigation were once a day, twice a day, and once per two day, with 1L of water per irrigation. All treatments were tried in three replications of completely randomized experiment. At 150 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. The seasonal changes

in number of leaf and plant height were measured during 64 days of irrigation and then different growth parameters were measured at 64 days after first irrigation, including plant height, stem diameter, number of leaf, root length, root diameter, fresh plant weight, dry plant weight, fresh root weight, and dry root weight etc.

RESULTS AND DISCUSSION

Growth characteristics of licorice under different conditions of seedling size, planting density and ridge height are shown in Table 1. When large seedlings were cultivated respectively under low ridge (20cm) and high ridge (40cm) with low density(60 × 30cm) and high density(40 × 30cm), plants in high ridge was 1.1 times in stem diameter, root length, and root diameter as high as those in low one. The mean number of branch was about six in low ridge, but it was 7.5 in the high ridge, being 1.3 times as high as that in low ridge. In the experiment of planting density under the low ridge, there was a trend that plant height and root length were a little longer in low density but stem and root diameter were higher in high density. While growth parameters under the high ridge, including plant height, stem diameter, root length, and root diameter, were 1.1 to 1.3 times in high density plot as high as than those in low density plot. There was a significant difference in number of branch of large seedlings between the two planting densities under the high ridge.

The growth of small seedlings were generally poor compared to that of large ones. In both low and high ridge height, the growth parameters, including plant height, stem diameter, number of branch, root length, and root diameter, were poor compared to those of large ones. The cultivation of small seedlings in high ridge resulted in 1.2 times in root length and number of branch as high as that in low ridge. Plant height and stem diameter differed little between ridge heights. Although root diameter appeared 1.1 times in the low ridge as thick as that in the high ridge, it was not significantly different between the two ridge heights. In

Table 1. Growth characteristics of *Glycyrrhiza uralensis* Fisch. plants under the different seedling sizes, planting densities and ridge heights.

Treatment			Plant height	Stem diameter	No. of	Root length	Root diameter
Seedling size	Ridge height (cm)	Plant distance (cm)	(cm)	(mm)	branch	(cm)	(mm)
Large	20	60 × 30	84.0	4.1	6.2	45.6	15.4
		40 × 30	82.7	4.3	6.1	40.6	15.7
		LSD(5%)	10.5	0.7	2.2	7.5	2.5
	40	60 × 30	77.0	4.4	7.5	46.2	16.0
		40 × 30	83.6	4.8	5.7	51.8	16.9
		LSD(5%)	7.5	0.6	1.6	6.9	3.6
Small	20	60 × 30	68.3	3.9	3.8	34.9	12.2
		40 × 30	76.6	4.4	5.9	36.0	14.5
		LSD(5%)	9.4	0.6	2.1	7.1	3.1
	40	60 × 30	73.4	4.5	5.9	42.2	12.0
		40 × 30	71.2	3.8	5.4	43.0	11.5
		LSD(5%)	8.7	0.7	1.8	7.3	3.2

the high ridge, stem diameter was statistically significant. Under the low ridge cultivation, high density was superior to low density in the growth parameters including plant height, stem diameter, number of branch, root length, and root diameter. While low density plot was better in plant height, stem diameter, and number of branch under the high ridge cultivation than high density one, excepting root length.

As shown in Fig. 1, the growth of plants from large seedling was higher in fresh and dry weight of plant and root under high ridge than that under low ridge. The high ridge produced higher fresh plant weights of 104.0g and 103.0g compared to those of 79.0g and 68.0g under the low one. The high ridge was also higher in dry plant weight and fresh root weight by 15.0g than the low ridge. The effect of ridge height was the same on dry root weight as the above growth parameters, being 26.0g and 25.0g under the low ridge but 43g and 41g under the high ridge. Based on the overall results, it was concluded that high ridge and deep ploughing would increase the yield of licorice effectively.

As shown in Fig. 2, fresh plant weight of plants from small seedlings in low density was 64.0g under low ridge cultivation, which was higher than 38.0g in high density. Fresh and dry root weight in high density were 32.0g and 20.0g, respectively, which were low than 21.0g and 14.0g in low density(Fig. 2). Under high ridge cultivation, the mean of fresh plant weight, dry plant weight, fresh root weight, and dry root weight were 51.0g, 35.0g, 28.0g, and 19.5g, which were higher than 51.0g, 31.5g, 26.5g, and 17.0g under low ridge cultivation.

In the results of Park(1999), the fresh root weights in

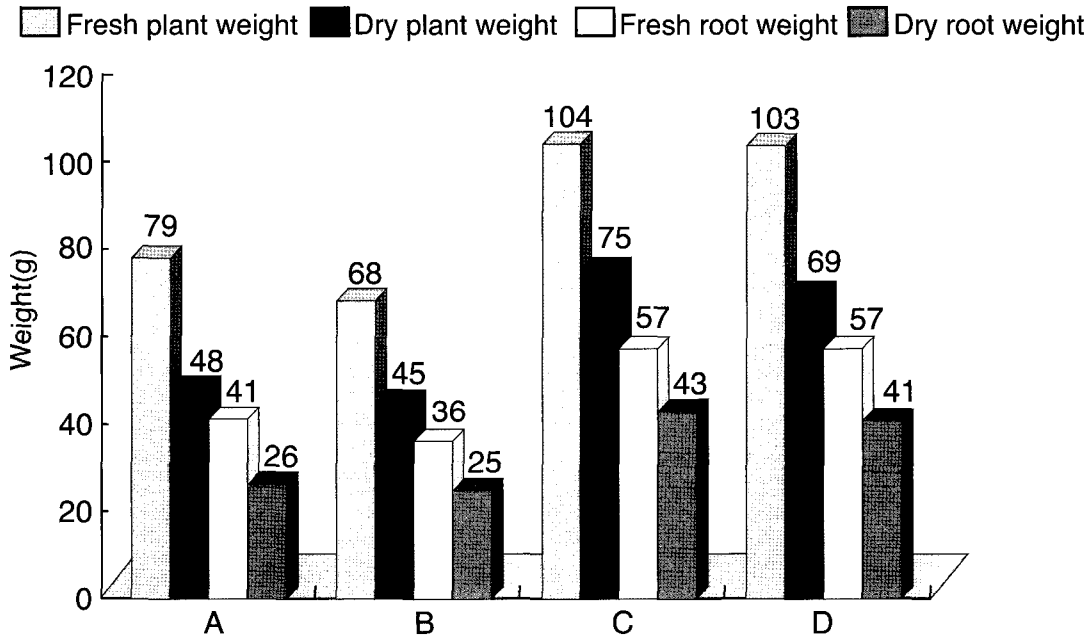

Fig. 1. Comparison of fresh and dry weight of plant and root of *Glycyrrhiza uralensis* Fisch. plants from large seedlings under the different planting densities and ridge heights.

* A - Planting density of 60 × 30cm and ridge height of 20cm

B - Planting density of 40 × 30cm and ridge height of 20cm

C - Planting density of 60 × 30cm and ridge height of 40cm

D - Planting density of 40 × 30cm and ridge height of 40cm

30×(10~30)cm planting density were 9.3~17.0g, being 2~3 times less than 32.0g in 40×30cm planting density, and the fresh root weight in 50×(10~30)cm planting density were 12.0~25.0g, resulting in similar or less than 21g in 60×30cm planting density.

Table 2 shows the seasonal changes of number of leaf under the different irrigations. The plot with twice irrigation a day produced similar number of leaf to the plot with once irrigation a day. The former produced 3 leaves more than the plot with once per two day with no significance between treatment regimes. There was a little difference among irrigation regimes after 46 days after sowing with no significance.

Table 3. shows the seasonal changes of plant height under the different irrigation regimes. The plant heights under the irrigation of twice a day were 10.2, 15.1, 17.9, 20.0, and 26.7cm at 29, 37, 46, 58, and 64 days after seeding, respectively, showing the beneficial effect of

Table 2. Seasonal changes in number of leaf of *Glycyrrhiza uralens* Fisch. plants under the different irrigations.

Treatment	Days after sowing				
(days)	29	37	46	58	64
once a day	6	7	7	8	9
twice a day	6	7	8	10	10
once two days	5	6	6	7	7
LSD(5%)	3.5	3.5	6.1	9.3	9.3

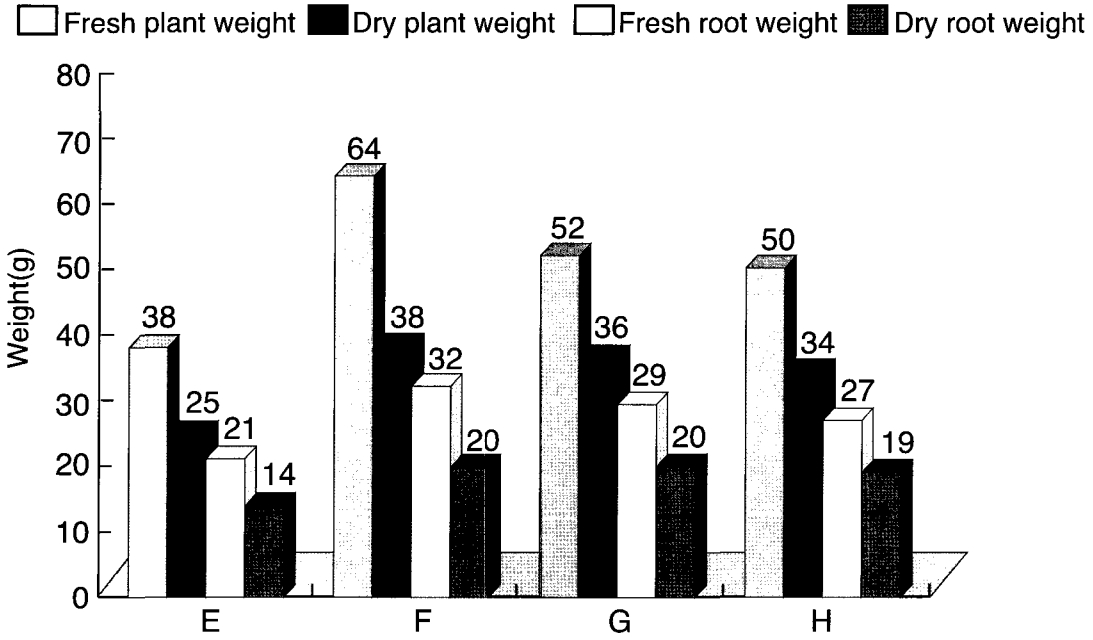

Fig. 2. Comparison of fresh and dry weight of plant and root of *Glycyrrhiza uralensis* Fisch. plants from small seedling under the different planting densities and ridge heights.

* E - Planting density of 60×30cm and ridge height of 20cm

F - Planting density of 40×30cm and ridge height of 20cm

G - Planting density of 60×30cm and ridge height of 40cm

H - Planting density of 40×30cm and ridge height of 40cm

Table 3. Seasonal changes in plant height of *Glycyrrhiza uralensis* Fisch. plants under the different irrigations.

Treatment	Days after sowing				
(days)	29	37	46	58	64
Once a day	8.5	11.3	12.3	14.0	17.3
Twice a day	10.2	15.1	17.9	20.0	26.7
Once two days	7.4	8.5	8.8	10.5	13.6
LSD(5%)	8.6	20.1	27.9	29.2	31.0

Table 4. Growth characteristics of *Glycyrrhiza uralensis* Fisch. plants under the different irrigations.

Treatment	Characteristics				
(days)	Plant height (cm)	Stem diameter (mm)	No. of leaf	Root length (cm)	Root diameter (mm)
Once a day	17.3	1.2	13.5	16.9	3.7
Twice a day	26.7	1.4	25.4	19.0	4.9
Once two days	13.6	0.9	9.4	17.5	2.7
LSD(5%)	3.7	0.2	3.6	1.3	0.6

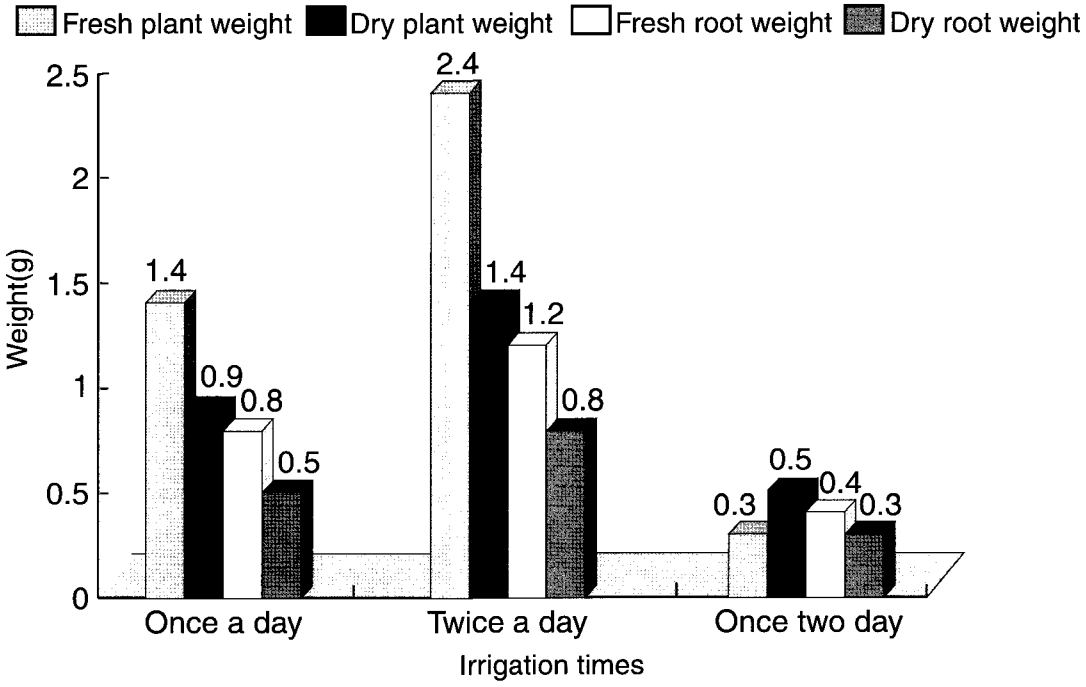

Fig. 3. Fresh and dry weight of plants and roots of *Glycyrrhiza uralensis* Fisch. plants under the different irrigations.

irrigation. The plant heights under the irrigation of once a day appeared a little longer than those under the regime of once per two days through the full growing period, with no significance.

Table 4 shows the growth characteristics of licorice under the different irrigation regimes. After 64 days after sowing, mean plant height under the irrigation of twice a day was 26.7cm, being prominently higher than

those under the other regimes of once a day (17.3cm) and once per two days (13.6cm). The irrigation regime of twice a day showed a excellent growth in stem diameter(1.4mm), root length(19.0cm), root diameter(4.9mm), and number of leaf(25.4). Its growth was 2 to 3 times as high as those of the others. Plant height, number of leaf, stem and root diameter, and root length were significant among treatments.

The irrigation of twice a day was eight times in fresh plant weight as high as the irrigation of once per two days, and it was also higher in dry plant weight(1.4g), fresh root weight(1.2g), and dry root weight(0.8g) than the other irrigation regimes with significances among treatments(Fig. 3).

Kim et al.(1997) reported that the growth of Bupleurum faluctum in the plot with six times irrigations at 10 days interval was the highest in stem diameter, stem length, and yield among three irrigation regimes including the former treatment, four times at 15 days interval and two times at 30 days interval. Kim et al.(1998) reported that the irrigation at 1 day interval produced the longest plant height of Atractyloades macrocephale Koidz. and the irrigation at 3 day interval produced the thickest root diameter among the all four irrigation regime including the continuous irrigation and the irrigations at 1, 3, and 5 days interval, showing the similar trend to this study.

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