Original Research Article

Korean J. Plant Res. 23(3) : 228～232 (2010)

Effect of Girdling on the Fruit Quality and Harvest Date of the 'Shigyoku' Grapes

Seok Ho Lee[1]*, Jae Wung Lee[1], Hyun Ju Kim[1], Young Ho Kim[1], Ki Yeol Lee[1], Un Dong Shin[2], and Hag Hyun Kim[2]

[1]Grape Research Institute, Chungbuk ARES, Okcheon 373-881, Korea
[2]Department of Flower·Floral Plant Coordi & Landscape Architecture, Woosong Information College, Daejeon 300-715, Korea

Abstract - The present study was carried out to elucidate the effect of girdling on the quality and harvest date of the 'Shigyoku' grapes. Among girdled vines, the interval from full bloom to harvest date was 77 days; this was as much as seven days shorter in vines receiving a 20% girdling treatment. With regards to fruit characteristics, significant differences were observed in cluster length, berry number, and berry weight in vines that received girdling treatments. There were also significant differences in cluster weight; 468.2 g, 491.6 g and 504.9 g in the control group, 10% girdling group, and 20% girdling group, respectively. Thus, the use of girdling treatments is an effective approach to increasing cluster weight by 5% in the 10% girdling treatment and 8% in the 20% girdling treatment. The 10% girdling treatment showed significant difference in terms of titrable acidity; in fact, the overall titrable acidity was relatively high among all the girdling treatments. The concentration of anthocyanin increased in 20% girdling treatment, but there were no significant differences in anthocyanin concentration among girdling treatments. Berry color developed rapidly in vines that received girdling treatment.

Key words - grape, girdling width, anthocyanin content, Hunter values

Introduction

The girdling of grapevines reportedly improves the development of berry color and stimulates rapid ripening by accelerating maturation; it is widely applied to tetraploid seedless grape cultivars in rain-shelter cultivations, to advance shipping and fruit promotion. It is commonly accepted that girdling at the veraison stimulates berry color development, while girdling at the berry set stage increased berry size (Oiue, 1977; Winkler *et al*., 1974). Girdling before the ripening stage enhanced berry color development and increases soluble solids concentration (Fujishima *et al*., 2005; Yamamoto *et al.*, 1992). In addition to lessening the burden of fruiting, girdling treatments markedly enhanced berry color development and increased soluble solids concentration; it was also effective when used with the 'Aki Queen' variety in the temperate zone (Yamane and Shibayama, 2006; Yamane and Shibayama, 2007). However, girdling the grapevine at an early stage of berry growth could reduce the vigor of trees by blocking the sap flow from the roots. Qiue (1977) reported that girdling shortened the life duration of trees and resulted in senescence of trees unless healing occurred during the defoliation stage. Girdling temporarily halted root growth, and it had been confirmed that even with adequate healing of the girdling site, girdling could reduce tree vigor in the following year (Yamane and Shibayama, 2006).

Inadequate understanding of girdling application method – and the inherent problems therein – have been the main causes of low quality among grapes grown in Korea, but girdling application methods are necessary to enhance fruiting, maturation and the seedless characteristic of 'Shigyoku' grapes cultivated under rain-shelters with short pruning.

Therefore, the present study was carried out to elucidate the effect of girdling on the fruit quality and harvest date of the 'Shigyoku' grapes.

*Corresponding author. E-mail : seokho@korea.kr

Materials and Methods

'Shigyoku' grapes, grown for nine years in the vineyard of the Grape Research Institute in Korea, were used to investigate the effects of girdling treatment on fruit quality and harvest date in 2007. The girdling treatment was applied to five vines in three replications per treatment grown according to Wakeman's training system and under rain-shelter cultivation conditions. The 5BB variety was used as the root-stock. The first growth regulators for seedlessness consisted of GA 12.5mg·L^{-1}+TDZ 5mg·L^{-1} on June 5 at the full bloom stage, and the second growth regulators for berry development consisted of GA 25mg·L^{-1} on June 12. The girdling treatments applied to the vines were no girdling, 5%, 10% and 20% of the external diameter of the trunk after 30 days of full bloom (July 5). Color development and changes in soluble solids concentration were investigated starting in mid-July. Ten clusters per treatment were collected at harvest to determine total soluble solids with a refractometer (PR-32, Atago, Japan). To determine titrable acidity, a solution of 10ml fruit juice in 40 ml distilled water was titrated with 0.1N NaOH, and the titration value was reported as tartaric acid concentration.

The color of berries in the middle parts of five clusters from three replicates was measured with a chromameter (CR-400, Minolta Camera Co, Japan) and reported as Hunter's L, a, and b values. To determine anthocyanin concentration in the berries, 10 berry slices were sampled with a cork borer (Φ 11 mm) immersed in 0.1N HCL 100%: MeOH (15:85, v/v) solution and refrigerated at 5℃ for 24h. The absorbance values were measured with a spectrophotometer (UV-2501 PC, Shimadzu, Japan) at 530 nm; these values were then converted to total anthocyanin concentrations using the methods of Fuleki & Francis (1968) with modifications.

Results and Discussion

The harvest dates of 'Shigyoku' grapes with girdling treatments are shown in Table 1. The initial coloration date of the 'Shigyoku' grapes was accelerated by five days to July 14 in vines receiving the 20% girdling treatment compared to the control vines lacking any girdling. For those receiving the 20% girdling treatment, the first harvest date was Aug. 14 while the harvest date of the control vines was August 21. The interval from full bloom to harvest date was 77 days in the girdled vines; this interval was as much as seven days shorter

Table 1. Effect of girdling treatment on harvest date of 'Shigyoku' grapes

Girdling treatment[z] (%)	Initial coloration date	First harvest date	Interval from bloom to harvest date (days)	First harvest rate (%)	Yield (kg/10a)
0	July 19	Aug. 21	77	10.4	1,718
5	July 17	Aug. 21	77	13.7	1,721
10	July 16	Aug. 17	73	33.8	1,802
20	July 14	Aug. 14	70	56.1	1,850

[z]Applied to the vines as no girdling, 5%, 10% and 20% an external diameter of the trunk after 30 days of full bloom.

Table 2. Fruit characteristics of girdling treatment on 'Shigyoku' grapes at the first harvest

Girdling treatment[z] (%)	Cluster length (cm)	Cluster weight (g)	Number of berries	Berry weight (%)
0	15.4 c[y]	468.2 d	42.0 a	10.7 c
5	15.4 c	469.4 c	41.2 b	11.0 bc
10	15.8 b	491.6 b	40.4 c	11.2 b
20	16.2 a	504.9 a	40.2 c	11.9 a

[z]Applied to the vines as no girdling, 5%, 10% and 20% an external diameter of the trunk after 30 days of full bloom.
[y]Mean separation within columns by Duncan's multiple range test at 5% level.

in vines receiving the 20% girdling treatment compared to the control vines.

The harvest rate for vines receiving 20% girdling treatment increased by 56.1%, therefore, more than half of the vines could be harvested at the first harvest date. The estimated yields were 1,718 kg/10a in the control group, 1,721 kg/10a in the 5% girdling group, 1,802 kg/10a in the 10% girdling group, and 1,850 kg/10a in the 20% girdling group. The overall yields increased by 10.7% in the 20% girdling group as compared to the control group.

With regards to fruit characteristics, significant differences were observed in cluster length, berry number and berry weight in vines that received girdling treatments. There were significant differences in cluster weight according to girdling of which cluster weight was 468.2 g, 491.6 g and 504.9 g in the control group, 10% girdling group, and 20% girdling group, respectively. Thus, girdling treatments were effective in increasing cluster weight by 5% in the 10% girdling treatment and by 8% in the 20% girdling treatment (Table 2).

The fruit quality, anthocyanin content and Hunter's value of the fruit skin of 'Shigyoku' grapes receiving girdling treatments are shown in Table 3. No significant differences were observed in soluble solids in berries between vines treated with girdling and untreated vines in the DMRT 5%. In these results, girdling treatments accelerated berry color development and induced an earlier harvest date, but had no significant effect on soluble solid concentration. The 10% girdling treatment showed significant difference in terms of titrable acidity; in fact, the overall titrable acidity was relatively high among all the girdling treatments. The soluble solid-acid ratio significantly increased among the girdling treatments, similar to titrable acidity and high soluble solid-acid ratios resulting in lower quality berries.

The concentration of anthocyanin increased among all girdling treatments; compared to the control vines, these increases were all statistically significant. According to Jacob (1928), to improve color and hasten ripening, the girdle should be applied just before ripening starts, when the first traces of color appear in the fruit. The lightness of fruit coloration in the sample undergoing girdling at 23.4~25.1, redness at 0.22~4.32, and yellowness at 0.67~2.08 were significantly different, compared to that from control vine. Berry color developed rapidly in vines that received girdling treatment, and girdling effects were likely due to stopping the downward movement of organic materials – especially growth regulating substances – past the wound until after healing. These results are similar to those of reports showing that girdling treatments accelerate color development (Fishler *et al*., 1983; Jensen *et al*., 1976; Weaver, 1952).

Seasonal changes in soluble solids and tartaric acid content are shown in Figure 1. With respect to the concentration of soluble solids in the fruits, this value increased with broader girdling and with late maturity. Kim and Chung (2000) reported that in their study, the soluble solid-acid ratio increased with girdling treatment, and the harvesting date was accelerated by five days. Choi *et al*. (1993) also reported that an increased anthocyanin concentration could accelerate color development and result in accelerated ripening of the outer fruit skin color.

The titrable acidity decreased with broader girdling treatment near harvest time. The low berry quality in the girdling treatment group resulted from premature harvesting based on

Table 3. Comparison of girdling treatment on fruit quality and Hunter's values of fruit skin in 'Shigyoku' grapes at the first harvest

Girdling treatment[z] (%)	Soluble solids (°Bx)	Titratable acidity (%)	Soluble solids / Acidity (%)	Anthocyanin content (mg/kg)	Hunter's values[y]		
					L*	a*	b*
0	15.4 c[x]	0.77 a	20.0 c	335.1 d	25.1 ab	4.32 a	2.08 a
5	15.5 c	0.79 a	19.7 c	377.2 c	25.3 a	3.46 b	1.24 b
10	16.4 b	0.66 b	24.9 b	379.6 b	24.9 b	1.01 c	0.75 c
20	16.9 a	0.65 b	26.0 a	380.4 a	23.4 c	0.22 d	0.67 d

[z]Applied to the vines as no girdling, 5%, 10% and 20% an external diameter of the trunk after 30 days of full bloom.
[y]L*: lightness (0~90), a*: +90 red~-90 green, b*: +90 yellow ~ -90 blue.
[x]Mean separation within columns by Duncan's multiple range test at 5% level.

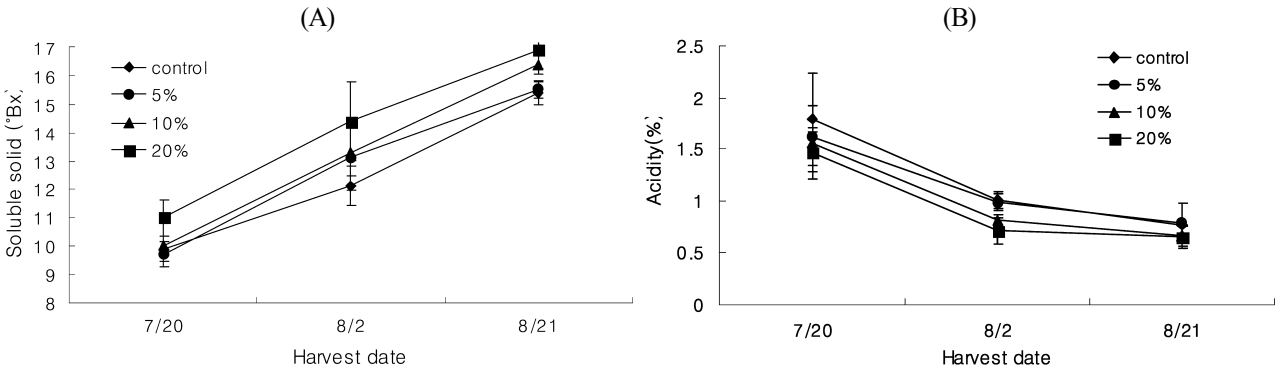

Fig. 1. Seasonal changes in soluble solids (A) and tartaric acid (B) content of 'Shigyoku' grapes as affected by girdling treatment. Vertical bars represent standard error.

Table 4. Tree characteristics of 'Shigyoku' grapes as affected by girdling treatment

Girdling treatment[z] (%)	Weakness rate of tree vigor[y] (%)	Berry cracking cluster rate (%)	Branch ripening rate at first harvest (%)
0	0	2.3 a x	72.3 a
5	0	2.4 a	72.4 a
10	0	1.4 b	70.9 b
20	13.3	1.3 b	68.6 c

[z]Applied to the vines as no girdling, 5%, 10% and 20% an external diameter of the trunk after 30 days of full bloom.
[y]Reducing the average length of the growth per shoot.
[x]Mean separation within columns by Duncan's multiple range test at 5% level.

color development; hence, maturation dates must be carefully evaluated to ensure berry quality.

A 20% girdling treatment might result in a 13.3% loss of vigor in the following year. Those trees, which were treated with broader girdling, would heal more slowly, thereby inflicting a greater weakening effect that reduces the average length of the growth per shoot; it is thus recommended that 20% girdling not be applied to weak vines. A loss of vigor was caused by a delayed healing process, due to broader girdling being performed among weaker trees. The berry cracking percentage decreased significantly in the 10% girdling treatment, demonstrating that girdling is an effective way of reducing berry cracking. Shoot maturity in the majority of vines, a measure of their strength, decreased by 68.6% in vines treated with 20% girdling compared to 72.3% in the vines not girdled; again, this is a result of decreased vigor of vines stemming directly from the use of girdling (Table 4).

In summary, girdling has been found to accelerate color development and berry enlargement and to diminish cracking, but it also results in lower-quality grapes during early harvests. This problem could be mitigated by adhering to full maturity dates before harvesting. Also, girdling hastened to decrease the titratable acidity. Poorly care-for girdling in contrast, may be very crippling to tree; hence, these treatments should be applied only to healthy and vigorous vines; proper attention during cultivation – particularly in irrigation and in thinning – will make girdling less detrimental.

Literature Cited

Choi, S.Y., J.S. Kim, J,T. Yoon, J.Y. Oh, and D.W. Choi. 1993. Effects of girdling on the maturity and quality of grape 'Campbell Early'. RDA. J. Agri. Sci. 35(1): 565-569.

Fishler, M. E., E. Goldschmidt, and S.P. Monselise. 1983. Leaf area and fruit size on girlded grapefruit branches. J. Amer. Soc. Hort. Sci. 108(2): 218-221.

Fujishima, H., M. Shiraishi, S. Shimomura, and Y. Horie. 2005. Effects of gridling on berry quality of 'Pione' grapevine.

Hort. Res. (Japan) 4(3): 313-318.

Fuleki, T. and F.J. Francis. 1968. Quantitative methods for anthocyanin. 1. Extraction and determination of total anthocyanin in cranberries. J. Food. Sci. 33: 72-77.

Jacob, H.E. 1928. Some responses of the seedless varieties of *Vitis vinifera* to girdling. Proc. Amer. Hort. Sci. 25: 223-229.

Jensen, F., D. Luvisi, F. Swanson, G. Leavitt, F.G. Mitchell, and G. Mayer. 1976. Effects of complete and incomplete girdles on 'Thompson seedless' and 'Ribier' table grapes. Amer. J. Enol. Viticult. 27(4): 65-67.

Kim, W.S. and S.J. Chung. 2000. Effect of GA_3, ethephon, girdling and wiring treatment on the berry enlargement and maturity of 'Himrod' grape. J. Kor. Soc. Hort. Sci. 41(1): 75-77.

Oiue, Y. 1977. Research of grapes. Hirotomosha, Tokyo, pp. 551-557

Weaver, R. J. 1952. Thinning and girdling of 'Red Malaga' grape in relation to size of berry, color and percentage of total soluble solids of fruit. Amer. Soc. Hort. Sci. 60: 132-139.

Winkler, A.J., J.A. Cook, W.M. Kliewer, and L.A. Lider. 1974. General viticulture. Univ. California Press., Barkely and Los Angeles. pp. 345-354.

Yamamoto, K., K. Takahashi, and K. Takata. 1992. Techniques of improving grape quality by girdling. Shimane Pref. Agr. Exp. Sta. 83: 38-42.

Yamane, T. and K. Shibayama. 2007. Effects of treatment date, width of girdling, and berry number of girdled shoot on the coloration of grape berries. Hort. Res. (Japan) 6(2): 233-239.

Yamane, T. and K. Shibayama. 2006. Effects of trunk girdling and crop load levels on fruit quality and root elongation in 'Aki Queen' grapevines. J. Japan. Soc. Hort. Sci. 75(6): 439-444.

(Received 18 August 2009 ; Accepted 30 March 2010)