

Department of Viticulture and Enology, University of California, Davis, CA, USA
Kearney Agricultural Center, Parlier, CA, USA

The effect of cyanamide on budbreak and vine development of Thompson Seedless grapevines in the San Joaquin Valley of California

by

L. E. WILLIAMS

Der Einfluß von Cyanamid auf den Knospenaustrieb und die weitere Entwicklung der Rebsorte Thompson Seedless im San Joaquin Valley (California)

Zusammenfassung: In 2jährigen Untersuchungen wurden dormante Tragruten von Freilandreben der Sorte Thompson Seedless mit Cyanamid (H_2CN) behandelt, um dessen Einfluß auf den Knospenaustrieb und die anschließende Entwicklung der Reben zu ermitteln. Hierzu wurde unmittelbar nach dem Rebschnitt eine 2,5%ige (v/v) Cyanamidlösung aufgesprüht. Reben, die jeweils am 17. Januar 1984 und 1985 geschnitten und mit Cyanamid behandelt worden waren, trieben im 1. Versuchsjahr 3 d, im 2. Jahr 7 d früher als die nur geschnittenen Kontrollreben aus. Wurden dieselben Behandlungen am 1. März durchgeführt, so war der Austrieb gegenüber den Kontrollen verzögert. Bestanden zwischen dem frühesten und dem spätesten Austriebstermin — als Folge der Cyanamidbehandlung — Differenzen von 9 d (1984) bzw. 15 d (1985), so hatten sich diese Unterschiede bei der Blüte (50 % der Blüten aufgeblüht) auf 3 d bzw. 6 d reduziert. Die Anzahl der Grad · Tage ($> 10^\circ C$) zwischen Austrieb und Blüte betrug im Durchschnitt der Behandlungen $365^\circ C \cdot d$ (1984) und $372^\circ C \cdot d$ (1985). In beiden Jahren bewirkten die Behandlungen keine signifikanten Unterschiede der Reifeparameter wie Beerengewicht oder Mostgewicht. Die Ergebnisse zeigen, daß Cyanamid benutzt werden kann, um den Austriebstermin zu verschieben, wodurch wiederum der Blühtermin beeinflusst wird. Im San Joaquin Valley entscheiden jedoch offenbar andere Faktoren als diese beiden phänologischen Abläufe über die Beerenreife der Sorte Thompson Seedless.

Key words: growth regulator, bud burst, flower biology, berry, maturation, raisin, USA.

Introduction

Studies have demonstrated that budbreak of grapevines can be manipulated by the use of several different chemicals or growth regulators (KUROI *et al.* 1963; WEAVER *et al.* 1974; SHULMAN *et al.* 1983; LIN *et al.* 1983; LIN and WANG 1985). While the mode of action of these compounds on the physiological processes associated with bud dormancy is unclear (SHULMAN *et al.* 1983; NIR *et al.* 1984), their use has been shown to be beneficial in areas where the release from bud dormancy is a problem (KUROI *et al.* 1963; LIN and WANG 1985). An additional benefit derived from the manipulation of the time of budbreak is the possibility to further the understanding of the effects the environment has on the phenology of the grapevine. Previous studies only have been able to compare the phenology of single grape cultivars among locations or years (CHRISTENSEN 1969; MCINTYRE *et al.* 1982; WILLIAMS *et al.* 1985). Altering the date of budbreak at one location with a single cultivar would enable one to keep soil and biological factors constant, thus allowing a correlation to be made between the vine's phenology and its atmospheric physical environment.

The purpose of this study was to determine the effect of cyanamide on releasing from dormancy buds on Thompson Seedless grapevines used for raisin production in the San Joaquin Valley of California and subsequent vine development. In addition, I was interested in determining the effect of temperature on the timing of various phenological events due to differences in the timing of budbreak.

Materials and methods

17-year-old own-rooted *Vitis vinifera* L. vines (cv. Thompson Seedless) grown at the University of California, Kearney Agricultural Center, near Fresno, California, were used in this study. Vines were trained to a single wire at 1.4 m with cultural practices typical of those used for raisin production. The experimental design was a randomized complete block with 8 single vine replicates in 1984 and 16 replicates in 1985. Vines used in 1984 also were used in 1985. There were four treatments consisting of two pruning dates with vines either sprayed with a 5% (v/v) solution of SKW 83010 (SKW Trostberg AG), containing cyanamide (H_2CN_2) as the active ingredient, or left unsprayed after pruning. Triton X-100 (0.05% v/v) was used as a surfactant. The spray volume of the SKW 83010 solution was 250 l/ha, which under our experimental conditions completely covered the dormant canes to the point of runoff. Budbreak was determined by counting the appearance of green shoot tissue at each node on 2 canes per replicate vine. Counts were made every two days for a period of approximately 3 weeks. The date of 50% budbreak represents the day when 50% of all buds that actually developed, as determined by shoot counts later in the season, had burst. Percent bloom was found by estimating bloom on 10 marked clusters on each replicate vine every day for a 6 d period in 1984. Percent bloom in 1985 was found by estimating bloom on each vine every day for a 10 d period. Fruit maturation was measured on 100 berry samples from each single-vine replicate. Samples were weighed and soluble solids concentration determined with a digital refractometer (American Optical, Model 10450). Vineyard temperature was monitored with a thermistor, housed in a shelter 0.2 m above the vine canopy, and connected to a Campbell Scientific CR-21 datalogger. The datalogger calculated degree days ($^{\circ}\text{C} \cdot \text{d}$) by subtracting 10°C (the minimum temperature threshold) from temperature readings taken each minute, dividing this number by 1440 and then summing all 1440 values at the end of the 24 h period. Daily degree days were accumulated by the datalogger throughout the experiment. Analyses of variance were conducted on fruit maturation characteristics and percent total bud burst data. Comparisons among treatment means were made using least significant difference.

Results

The effects of two pruning dates and application of cyanamide on budbreak and bloom is found in Table 1. The variation in date of budbreak from year to year was evident as there was a 7 d difference in budbreak for the control vines pruned January 17 both years. An application of cyanamide at time of pruning hastened budbreak by 3 d in 1984 and 7 d in 1985 when compared to the control vines. When vines were pruned and sprayed with cyanamide on March 1, budbreak of the treated vines was delayed when compared with the control vines pruned on that date. The difference in time between the earliest and latest dates of budbreak varied between years. While there

Table 1

The effect of an application of cyanamide and pruning date on budbreak, bloom and degree days between budbreak and bloom for Thompson Seedless grapevines grown in the San Joaquin Valley of California ¹⁾

Einfluß von Cyanamidbehandlung und Termin des Rebschnittes auf Austrieb, Blüte und Grad·Tage zwischen Austrieb und Blüte (Thompson Seedless, San Joaquin Valley, California)

Year	Pruning date	Cyanamide treatment at pruning	Date of 50 % budbreak	Date of 50 % bloom	°C·d between budbreak and bloom
1984	Jan. 17	Yes	Mar. 5	May 8	373
		No	Mar. 8	May 10	364
	Mar. 1	Yes	Mar. 14	May 11	357
		No	Mar. 9	May 10	369
1985 ²⁾	Jan. 17	Yes	Mar. 8	May 7	375
		No	Mar. 15	May 10	372
	Mar. 1	Yes	Mar. 23	May 13	369
		No	Mar. 17	May 11	373

¹⁾ The application concentration of SKW 83010 was 5.0 % (2.5 % active ingredient).

²⁾ The 16 cyanamide treated vines this year represented 8 vines that had been sprayed in 1984 and an additional 8 vines sprayed with cyanamide for the first time in 1985. Data for each set of 8 vines were combined as there were no differences between the two sets.

was a difference of 7 calendar days between date of 50 % budbreak in 1984 and 1985 when vines were pruned on January 17, date of 50 % bloom occurred on May 10 both years. The difference in days among treatments to 50 % budbreak was greater than the difference in time among treatments to 50 % bloom. For example, the 15 d difference between date of budbreak for the vines sprayed with cyanamide and pruned on January 17 and March 1 in 1985 was reduced to 6 d between date of 50 % bloom for these two treatments. There was an average of 369 °C · d between 50 % budbreak and 50 % bloom both years the study was conducted. The amount of degree days accumulated between these two phenological events was slightly less for vines pruned on March 1 than for vines pruned on January 17.

Even though dates of budbreak and bloom differed among the various treatments, these differences were not detected at fruit harvest (Table 2). There was no significant effect of cyanamide application on berry weight or soluble solids concentration either year. Linear regression analysis indicated that crop load accounted for the majority of the variation ($r^2 = 0.86$) in soluble solids concentration both years.

There were significant differences between cyanamide treated vines and controls with respect to the percent number of buds that burst (Table 3). Despite an increase in the number of buds that burst per vine, there was no significant increase in the number of clusters per vines in 1984 (unpublished data).

Discussion

An application of a cyanamide solution to dormant canes of field-grown Thompson Seedless grapevines was effective in altering the date of budbreak. The application of

Table 2

The effect of date of budbreak on fruit maturation characteristics of Thompson Seedless grapevines. Budbreak was modified by cyanamide and date of pruning treatments ¹⁾

Einfluß des Austriebstermins auf Merkmale der Beerenreife bei der Sorte Thompson Seedless. Der Austrieb wurde durch Cyanamid und den Zeitpunkt des Rebschnittes modifiziert

Year	Pruning date	Cyanamide treatment at pruning	100 berry wt. ²⁾ (g)	Soluble solids ²⁾ (°Brix)	Vine cluster wt. ²⁾ (kg)
1984	Jan. 17	Yes	173	21.3	17.4
		No	163	20.1	25.5
	Mar. 1	Yes	163	20.3	21.3
		No	156	20.6	21.3
1985	Jan. 17	Yes	168	20.1	25.0
		No	167	19.3	26.5
	Mar. 1	Yes	162	20.0	23.7
		No	157	19.5	25.7

- ¹⁾ Berry sampling and vine harvests took place on August 27 and 21 in 1984 and 1985, respectively.
²⁾ There were no significant differences in berry weight or soluble solids among treatments either year. Cluster weight for the January 17, Yes treatment, was significantly ($P < 0.05$) lower than the other three treatments in 1984.

Table 3

The effects of date and rate of application of a 2.5 % cyanamide solution on the percent number of buds on Thompson Seedless fruiting canes that burst in 1984 ¹⁾

Einfluß des Zeitpunktes und der Behandlung mit 2,5 %iger Cyanamidlösung auf den Prozentsatz ausgetriebener Knospen an den Tragruten der Sorte Thompson Seedless (1984)

Cyanamide treatment	Date of application		Mean effect of rate
	Jan. 17	Mar. 1	
Yes	80.4	85.3	82.8
No	76.0	73.7	74.8
Mean effect of date	78.2	79.5	
LSD _{0.01}	Date = NS ²⁾		Rate = 6.9

- ¹⁾ The number of nodes on two canes per replicate vine was determined prior to budbreak and the total that burst was determined later during the growing season.
²⁾ LSD was not significant at the 5 % level.

cyanamide during January enhanced budbreak from 3 to 7 d over the control vines (Table 1). Cyanamide previously has been shown to enhance budbreak on several different varieties when compared with control vines that also were pruned the same date (SHULMAN *et al.* 1983; LIN *et al.* 1983; WICKS *et al.* 1985). Pruning with an application of cyanamide shortly before natural budbreak would occur resulted in a delay of bud-

break by approximately 1 week when compared with control vines pruned in January. JENSEN and BETTIGA (1985) found similar results, with the same *V. vinifera* cultivar used in this study.

The use of chemicals to release grapevine buds from dormancy generally has been associated with grape production in warm regions (SHULMAN *et al.* 1983). It is thought that there is insufficient winter chilling in those regions to break dormancy, with the result that many buds fail to grow (ANTCLIFF and MAY 1961). Poor budbreak due to a lack of winter chilling in the San Joaquin Valley is not a problem (JENSEN and BETTIGA 1985). The main purpose of this study was to assess the effect of date of budbreak on subsequent vine development in the raisin production area of California. It was hoped that an earlier budbreak would result in earlier bloom and subsequent fruit maturation. This would be beneficial for the production of natural raisins since an earlier harvest date would help avoid inclement weather in the fall that can destroy or significantly reduce the quality of the crop once the grapes are laid to dry. Advancing or delaying budbreak resulted in similar changes at bloom time, but the differences in days among treatments were smaller at 50 % bloom than at 50 % budbreak (Table 1). There was no significant treatment effect on berry maturation either year (Table 2). WICKS *et al.* (1985) reported similar results on Thompson Seedless vines grown in the Coachella Valley of California. It appeared that crop load may have been a more important determinant of fruit maturation than any other single factor in this study. Crop load long has been shown to affect berry maturation (WINKLER 1953 and 1954).

The average degree day accumulation per calendar day at budbreak, bloom and harvest was 3.9, 9.4 and 15.1 °C · d respectively, both years. This would explain the decrease in calendar days among treatments with regards to phenological events of the vines occurring later in the growing season. Thus, while there was no significant difference in soluble solids concentration among treatments, vines with earlier budbreak generally had higher °Brix readings at harvest with the exception of the March 1, Yes treatment in 1985. The accumulation of 50 °C · d (approximate time between earliest and latest date of budbreak in this study) at harvest time would occur in approximately 3 d. Soluble solids accumulation for the vineyard used in this study averaged 0.6 °Brix/50 °C · d (unpublished data). The variation in data from treatment to treatment probably masked the differences that actually may have been present at harvest among treatments.

The accumulation of degree days between budbreak and bloom was fairly uniform among treatments and between years (Table 1). An average of 369 °C · d (greater than 10 °C) between budbreak and bloom reported in this study is less than the average of 410 °C · d between these two phenological events as reported by CHRISTENSEN (1969). Differences in results between the studies may be due to the difference in methods used to calculate degree days and definitions of budbreak and bloom and how each were determined. CHRISTENSEN (1969) used March 17 as the date of budbreak all 4 years the study was conducted and defined bloom when approximately 70 % of the calyptres had fallen off. MCINTYRE *et al.* (1982) found there were 287 °C · d between budbreak and bloom for an 'average' vine in their study. While Thompson Seedless was close to being an 'average' vine in that work, a comparison between the results in this paper and their's is difficult since the method of calculation of degree days was not given. An additional explanation for differences among studies may be due to soil or biological factors associated with location of the respective investigation sites.

While the usefulness of cyanamide in releasing buds from dormancy is apparent in the warmer grape growing regions of the world, it also may be used as a management tool where budbreak is not a problem. Delaying budbreak with an application of cyanamide close to natural budbreak may provide a means of frost protection, by

avoidance. The application of higher concentrations of cyanamide also has been suggested as a means of frost protection since this too delayed budbreak (BRACHO *et al.* 1985). In addition, the production of table grapes requires that cultural practices used to increase berry size need to be performed within a narrow time frame at specific stages of vine development or the practice is not as effective (CHRISTODOULOU *et al.* 1968; WEAVER and McCUNE 1959; WEAVER and POOL 1971; KASIMATIS *et al.* 1971). Cyanamide could be used to alter the time of phenological events from one field to another early in the season providing the vineyard manager time to effectively perform all practices when labor and machinery are limited. Lastly, the use of cyanamide did not increase crop load (Table 2), even though there were significant differences between treatments in the number of shoots that developed per vine (Table 3).

Results from this study suggest it is doubtful that cyanamide could be used to economically enhance fruit maturity of vines grown in the San Joaquin Valley of California. While the phenological events of the Thompson Seedless grapevine are closely associated with time, as measured by degree days greater than 10 °C, the accumulation of degree days prior to natural budbreak does not appear to be sufficient to enhance berry maturity until shortly before the normal harvest time in this region. The use of cyanamide to regulate growth early in the season, however, has been demonstrated for Thompson Seedless vines at this location.

Summary

Cyanamide (H_2CN_2) was applied to dormant canes on Thompson Seedless grapevines grown in the field to determine its effect on budbreak and subsequent vine development. A 2.5 % (v/v) solution of cyanamide was sprayed on vines just subsequent to pruning in a 2 year study. Vines pruned and treated with cyanamide on January 17 had budbreak 3 and 7 d earlier than the pruned only controls in 1984 and 1985, respectively. The same treatment imposed on March 1 delayed budbreak when compared with the control vines. There were differences of 3 and 6 d between the dates of 50 % bloom for the treatments with the earliest and latest dates of budbreak in both years. The number of degree days > 10 °C between budbreak and bloom averaged 365 and 372 °C · d for all treatments in 1984 and 1985, respectively. There were no significant differences in fruit maturation characteristics such as berry weight and soluble solids concentration among treatments in both years. Results indicate that cyanamide can be used to alter the date of budbreak which subsequently affects bloom date of Thompson Seedless grapevines. However, factors other than those two phenological events become more important in determining fruit maturation of this variety when grown in the San Joaquin Valley of California.

Acknowledgements

The author acknowledges the technical assistance of R. J. SMITH, P. J. BISCAY, and D. C. HARRELL. Support for this project was funded in part by a grant from the California Raisin Advisory Board.

Literature cited

1. ANTCLIFF, A. S.; MAY, P.; 1961: Dormancy and bud burst in Sultana vines. *Vitis* **3**, 1—14.
2. BRACHO, E.; JOHNSON, J. O.; WICKS, A. S.; LIDER, L. A.; WEAVER, R. J.; 1985: Using hydrogen cyanamide to promote uniform budbreak in Cabernet Sauvignon in California: Preliminary results. Proc. of Bud Dormancy in Grapevines: Potential and Practical Uses of Hydrogen Cyanamide on Grapevines. Univ. of California, Davis, 20 August 1984, 11—14.
3. CHRISTENSEN, P.; 1969: Seasonal changes and distribution of nutritional elements in Thompson Seedless grapevines. *Amer. J. Enol. Viticult.* **20**, 176—190.
4. CHRISTODOULOU, A.; WEAVER, R. J.; POOL, R. M.; 1968: Relation of gibberellin treatment to fruit-set, berry development, cluster compactness in *Vitis vinifera* grapes. *Proc. Amer. Soc. Hort. Sci.* **92**, 301—310.
5. JENSEN, F.; BETTIGA, L.; 1985: The effect of hydrogen cyanamide on budbreak of Thompson Seedless, Emperor, and French Colombard. Proc. of Bud Dormancy in Grapevines: Potential and Practical Uses of Hydrogen Cyanamide on Grapevines. Univ. of California, Davis, 20 August 1984, 16—25.
6. KASIMATIS, A. N.; WEAVER, R. J.; POOL, R. M.; HALSEY, D. D.; 1971: Response of 'Perlette' grape berries to gibberellic acid application applied during bloom and at fruit set. *Amer. J. Enol. Viticult.* **22**, 19—23.
7. KUROI, I.; SHIRAIISHI, Y.; IMANO, S.; 1963: Studies on breaking the dormancy of grape vines. I. Effects of lime nitrogen treatment for shortening the rest period of glasshouse-grown grape vine. *J. Jap. Soc. Hort. Sci.* **32**, 175—180.
8. LIN, C. H.; LIN, H. S.; LIN, J. H.; LIAW, W. J.; CHANG, L. R.; 1983: The application of cyanamide on termination of dormancy in Kyoho grapevine bud. (I) *In vitro* cutting test. *Proc. Natl. Sci. Council. Monthly, ROC* **11**, 291—300.
9. — — ; WANG, T. Y.; 1985: Enhancement of bud sprouting in grape single bud cuttings by cyanamide. *Amer. J. Enol. Viticult.* **36**, 15—17.
10. LIN, H. S.; CHANG, L. R.; LIN, J. H.; LIAW, W. J.; LIN, C. H.; 1983: The application of cyanamide on termination of dormancy in grapevine bud. (II) Field test. *Proc. Natl. Sci. Council. Monthly ROC* **7**, 237—242.
11. MCINTYRE, G. N.; LIDER, L. A.; FERRARI, N. L.; 1982: The chronological classification of grapevine phenology. *Amer. J. Enol. Viticult.* **33**, 80—85.
12. NIR, G.; SHULMAN, Y.; LAVEE, S.; 1984: Catalase involvement in grapevine buds' dormancy [Abstr.]. *Plant Physiol., Suppl.* **75**, 104.
13. SHULMAN, Y.; NIR, G.; FANBERSTEIN, L.; LAVEE, S.; 1983: The effect of cyanamide on the release from dormancy of grapevine buds. *Sci. Hort.* **19**, 97—104.
14. WEAVER, R. J.; MANIVEL, L.; JENSEN, F. L.; 1974: The effects of growth regulators, temperature and drying on *Vitis vinifera* buds. *Vitis* **13**, 23—29.
15. — — ; McCUNE, S. B.; 1959: Response of certain varieties of *Vitis vinifera* to gibberellin. *Hilgardia* **28**, 297—321.
16. — — ; POOL, R. M.; 1971: Berry response of 'Thompson Seedless' and 'Perlette' grapes to application of gibberellic acid. *J. Amer. Soc. Hort. Sci.* **96**, 162—166.
17. WICKS, A. S.; JOHNSON, J. O.; JENSEN, F.; BRACHO, E.; NEJA, R.; LIDER, L. A.; WEAVER, R. J.; 1985: Induction of early and more uniform budbreak in *Vitis vinifera* L. cvs. Perlette, Flame Seedless and Thompson Seedless grapes with hydrogen cyanamide. Proc. of Bud Dormancy in Grapevines: Potential and Practical Uses of Hydrogen Cyanamide on Grapevines. Univ. of California, Davis, 20 August 1984, 48—55.
18. WILLIAMS, D. W.; ANDRIS, H. L.; BEEDE, R. H.; LUYISI, D. A.; NORTON, M. V. K.; WILLIAMS, L. E.; 1985: Validation of a model for the growth and development of the Thompson Seedless grapevine. II. Phenology. *Amer. J. Enol. Viticult.* **36**, 283—289.
19. WINKLER, A. J.; 1953: Producing table grapes of better quality. *Blue Anchor* **30**, 28—31.
20. — — ; 1954: Effects of overcropping. *Amer. J. Enol.* **5**, 4—12.

Eingegangen am 20. 8. 1986

Dr. L. E. WILLIAMS
Kearney Agricultural Center
9240 S. Riverbend Avenue
Parlier, CA 93648
USA