Budbreak, fruit quality and maturity of 'Superior' seedless grapes as affected by Dormex® under Jordan Valley conditions

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Received 24 June 2007
Accepted 30 October 2007

Fruits, 2008, vol. 63, p. 171–178

DOI: 10.1051/fruits:2008007
www.fruits-journal.org

RESUMEN ESPAÑOL, p. 178

Budbreak, fruit quality and maturity of 'Superior' seedless grapes as affected by Dormex® under Jordan Valley conditions.

Abstract — **Introduction**. In subtropical regions, the lack of or insufficient winter chilling has been one of the most important yield-limiting factors for table grapes. Winter chilling for several weeks is required to cause the transition of both vegetative and floral buds from the dormant to the active state. Thus, the effect of time of application of Dormex® (hydrogen cyanamide) on fruit quality and ripening of 'Superior' seedless grape was evaluated under Jordan Valley conditions. **Materials and methods**. Five-year-old 'Superior' seedless vines were pruned on 20 December and sprayed to run-off with a 5% (v/v) concentration of Dormex® at pruning ($Dormex_{prun0}$), 7 d ($Dormex_{prun7}$) or 14 d ($Dormex_{prun14}$) after pruning in comparison with the pruned-only control plants. The date of vegetative budbreak and start of flowering were determined. Fruits were harvested at intervals of 7 d starting from 9 May, with four harvests. Studied data were fruit weight, total soluble solids (TSS), titratable acidity (TA) and maturity with the [TSS:TA] ratio. **Results and discussion**. All pruned and sprayed vines broke bud 23–46 d after pruning. The ($Dormex_{prun0}$) and ($Dormex_{prun7}$) treatments were the earliest. Compared with the control, Dormex®-treated vines broke bud 4–26 d earlier. All pruned and Dormex®-treated vines started flowering 55–64 d after pruning, with 4–13 d earlier than the control. Fruits of the ($Dormex_{prun0}$) treatment had significantly the highest fruit weight, TSS and the least TA, and it was the only treatment that exceeded the [18:1] (TSS:TA) level. Additionally, higher TSS and lower TA were observed for fruits of Dormex®-treated vines during all harvest dates in comparison with the control. **Conclusion**. Our study showed that, under southern Jordan Valley conditions, Dormex® should be applied as early as at pruning time to obtain early budbreak and maturity.

Jordan / Jordan River / *Vitis vinifera* / dormancy breakers / fruits / quality

Effet du Dormex® sur la levée de dormance, la qualité du fruit et la maturité de raisins aspermes 'Superior' dans les conditions de la vallée du Jourdain.

Résumé — **Introduction**. Dans les régions subtropicales, le manque ou l'insuffisance de froid hivernal a été l'un des facteurs limitants du rendement le plus important pour le raisin de table. Un froid hivernal de plusieurs semaines est nécessaire pour provoquer la transition des bourgeons végétatifs et floraux du stade dormant à un état actif. De ce fait, la période d'application du Dormex® (cyanamide d'hydrogène) a été évaluée quant à son effet sur la qualité du fruit et la maturation du raisin asperme 'Superior', dans les conditions de la vallée du Jourdan. **Matériel et méthodes**. Des vignes aspermes 'Superior' de 5 ans ont été taillées le 20 décembre et une solution à 5% de Dormex® (v/v) a été appliquée par pulvérisation soit au moment de cette taille ($Dormex_{taille0}$), soit 7 jours ($Dormex_{taille7}$) ou 14 jours ($Dormex_{taille14}$) après la taille et des vignes taillées mais non traitées ont constitué le traitement témoin. Les dates d'ouverture du bourgeon végétatif et du début de la floraison ont été déterminées. Les fruits ont été récoltés tous les 7 jours à partir du 9 mai, en quatre récoltes. Les paramètres étudiés ont été le poids du fruit, les taux de solides solubles totaux (SST), l'acidité titrable (AT), ainsi que la maturité des fruits évaluée à partir du rapport [SST:AT]. **Résultats et discussion**. Les bourgeons des plants taillés et traités par une solution de Dormex® ont éclos (23 à 46) jours après la taille. L'ouverture des bourgeons des plants ayant subi les traitements ($Dormex_{taille0}$) et ($Dormex_{taille7}$) a été la plus précoce. Les bourgeons des vignes traitées au Dormex® ont éclos (4 à 26) jours plus tôt que ceux des plants témoins. Les bourgeons floraux des plants taillés et traités ont commencé à fleurir (55 à 64) jours après la taille et (4 à 13) jours plus tôt que ceux des plants témoins. Les fruits du traitement ($Dormex_{taille0}$) ont eu un poids de fruits et un taux de SST significativement les plus élevés, une AT significativement la plus basse et ils ont été les seuls à dépasser le taux [18:1] de (SST:TA). De plus, quelle qu'ait été la date de récolte, les fruits des vignes traitées au Dormex® ont donné de plus forts taux de SST et de plus faibles AT par rapport aux fruits des plants témoins. **Conclusion**. Notre étude a montré que, dans les conditions de la basse vallée du Jourdan, le Dormex® devrait être appliqué dès la taille afin d'obtenir un démarrage des bourgeons et une maturité précoces.

Jordanie / Jourdain / *Vitis vinifera* / substance levant la dormance / fruits / qualité

1. Introduction

Table grape (*Vitis vinifera* L.), a temperate climate plant, adapted to warm summers and cold winters, is one of the famous fruit trees in Jordan that occupies about 14000 ha, producing 65 000 t·year^{-1} [1]. Due to the origin of grapes being in the Caspian Sea region, winter dormancy is a genetic necessity and a rest period is essential in the growth cycle of the grapevine. In the traditional grapevine cultivation regions, the cold autumns and winters are sufficient to satisfy its chilling requirement to cause the transition of both vegetative and floral buds from the dormant to the active state. However, in subtropical regions, the lack of or insufficient winter chilling has been one of the most important yield-limiting factors for table grapes. Therefore a considerable number of buds fail to grow despite the severe winter pruning which partially breaks dormancy [2–4]. In these areas, chemical plant-growth regulators are used worldwide to stimulate budbreak [2, 3]. The use of hydrogen cyanamide (H_2CN_2) as a budbreak agent started about two decades ago with the discovery of its dramatic effects on budbreak of different fruit trees [4–11]. In grapevines, variable results have been obtained with H_2CN_2 depending on the plant variety, timing of treatment, application rate, stage of bud development, method of application, latitude and weather conditions, and, even on the same variety, it may have no effect on bud development or promote, delay budbreak or kill buds, depending on the concentration and time of application [12–14].

Grapevines treated with H_2CN_2 have been reported to exhibit early and more uniform budbreak, flowering, ripening, and advancing maturity and had higher fresh weight of the fruit than the control [15–20]. However, Poni *et al.* [21] obtained an advanced budbreak and higher yield with the earliest H_2CN_2 spray, but it did not affect time of fruit maturity and the final berry size. The timing of application of H_2CN_2 remains a problem; early application will result in frequently uneven budbreak, while late applications can lead to bud damage [22]. In addition, climatic conditions, such as sudden temperature changes after application of rest-breaking chemicals, can negatively influence the budbreak process [3].

Our work was carried out to study the effect of the application time of DORMEX® (H_2CN_2) on fruit quality and ripening of 'Superior' seedless grape under Jordan Valley conditions.

Table I.
Some soil characteristics at two soil depths of the area where the study regarding the effect of Dormex® application on the budbreak of grapes under southern Jordan Valley conditions took place (2004 season; soil texture: sandy loam).

Soil depth (cm)	pH	Electrical conductivity (dS·m^{-1})	$CaCO_3$ (%)
0–30	7.8	7.8	18.0
30–60	7.9	7.0	17.4

2. Materials and methods

Our study was carried out during the 2004 season in a private farm located in Southern Jordan Valley, at the southern end of the Dead Sea, 387 m below sea level. The climate is hot and dry in summer, and warm with low rainfall in winter; it receives about 75 mm of rainfall per year. Soil characteristics of the area of the study were measured (*table I*).

Five-year-old 'Superior' seedless vines grafted on P1103 rootstock were used with 2 m × 3 m spacing and trained by a Y-trellis system. The vines received standard cultural practices as practiced by Jordan valley grape-growers in respect to cane pruning, drip irrigation, fertilization, pest management and weeding. Cane pruning of 'Superior' seedless grapevines grown on southern Jordan Valley vineyards is normally done between 15 and 20 December. Four treatments were randomly assigned to a group of 36 vines with three vines per replicate and two buffering vines between treatments and replicates. All selected vines were pruned on the same day (20 December), then Dormex® (40% aqueous hydrogen cyanamide)

Table II.
Important climatic parameters which prevailed during our study regarding the effect of Dormex® application on the budbreak of grapes under southern Jordan Valley conditions (2004 season).

Month	Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Minimum	Maximum		
December	10.4	20.6	69.6	17.4
January	11.2	21.7	60.3	33.5
February	12.3	22.6	58.4	6.2
March	15.1	26.3	57.9	24.1
April	19.1	31.9	44.6	0.0
May	21.4	35.2	48.6	0.0

at 5% (v/v) in distilled water was sprayed to run-off at pruning, and at (7 and 14) d after pruning, in comparison with pruned-only control. Spraying was done in the morning, using a small hand-sprayer, when the temperature was superior or equal to 14–15 °C.

The budbreak was determined as the date when buds on marked fruiting canes had reached the “green tip” stage. The start of flowering was determined as the time when flower caps started to fall. Bunches and shoots were hand-thinned similarly for all treated and control vines to ensure uniformity. Vines were harvested at the commercially acceptable stage of fruit maturity (total soluble solids ≥ 15%) at intervals of 7 d starting from 9 May, with a total of four harvests. Two bunches per vine were randomly sampled at each harvest date, and washed. One hundred berry fruits were randomly collected and weighed for average fruit weight and fruit quality assessments. Juice was extracted with a fruit juicer and filtered to exclude precipitates. Total soluble solids (TSS) expressed as °Brix were measured by Fisher® refractometer (Fisher Scientific Co.). For titratable acidity measurement, 10 mL of filtrate was dispensed and supplied for titration by 0.1 N NaOH until pH 8.1. The amount of NaOH in mL was recorded to calculate titratable acidity, which is expressed as tartaric acid percentage [23]. Maturity was defined as sugar content exceeding 15% TSS, and a [TSS: titratable acidity] ratio exceeding [18:1] [18].

The experimental design was four treatments with three triple-vine replications. Treatments were randomly assigned in a Randomized Complete Block Design (RCBD). Collected data were statistically analyzed using MSTAT software [24]. Significance was calculated at $P \leq 0.05$, and least significant difference (LSD) was used for comparison of mean values.

3. Results

3.1. Environmental conditions

During our experimental season (2004), the minimum monthly temperature ranged from 10.4 °C in December to 21.4 °C in May, which is insufficient for winter chilling to overcome dormancy, while the maximum monthly temperature ranged from 20.6 °C in December to as high as 35.2 °C in May, which will affect fruit maturity. The relative humidity during the study ranged from 69.6% in December to 48.6% in May. Very low rainfall was recorded, with a total of 81.2 mm (*table II*).

3.2. Budbreak

All Dormex®-sprayed vines broke buds (23 to 46) d after pruning; among these, the Dormex applied at pruning ($\text{Dormex}_{\text{prun0}}$) treatment and the Dormex applied 7 d after

Table III.
Days from pruning (20 December 2004) to budbreak and to start of flowering of table grapes c.v. "Superior" seedless, under the conditions of the southern Jordan Valley, in relation to the time of Dormex® application (2004 season).

Treatments	Days to budbreak[1]	Days to start of flowering
Pruning without Dormex® (control)	49 a	68 a
Dormex® application at pruning	23 b	55 b
Dormex® applied 7 days after pruning	34 b	60 ab
Dormex® applied 14 days after pruning	45 a	64 ab

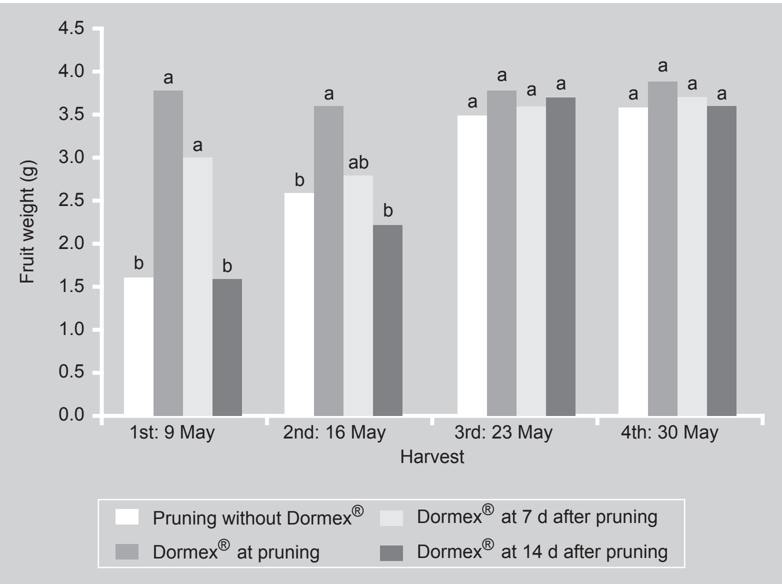
[1] Mean separation at the 5% level (LSD); values with different letters are significantly different.

pruning ($Dormex_{prun7}$) treatment were significantly the earliest (*table III*). Compared with the control, Dormex®-treated vines broke buds (4 to 26) d earlier. However, the efficacy of Dormex® in promoting budbreak decreased with time (*table III*).

Due to early budbreak, considerable differences occurred in flowering time; all Dormex®-treated vines start flowering (55 to 64) d after pruning, (4 to 13) d earlier than the pruned-only control, and even the latest Dormex® application was effective in advancing flowering.

The interval from budbreak to the start of flowering decreased by 32 d for the ($Dormex_{prun0}$) treatment, 26 d for the ($Dormex_{prun7}$) treatment, 11 d for the Dormex applied 14 d after pruning ($Dormex_{prun14}$) treatment, and 19 d for the control (no application of Dormex). This could be directly related to the time of budbreak, *i.e.*, later budbreak in warmer conditions means shorter time to flowering since the initial development of cyanamide-treated vines was slow compared with untreated vines [18]. These results are in agreement with the work of several authors [13, 15–21, 25–30]. However, the amount of budbreak would be closely related to the quantity of chilling received at the application time and the concentration of H_2CN_2 [13].

Figure 1.
Effect of application time of Dormex® on fruit weight of grapes c.v. 'Superior' seedless under southern Jordan Valley conditions at four harvest dates. Means with the same letter are not significantly different at $P \leq 5\%$.



3.3. Fruit quality and maturity

The ($Dormex_{prun0}$) treatment significantly led to the largest fruit weight with no significant difference with the ($Dormex_{prun7}$) treatment, especially at the first two harvests; after that, at the last two harvests, no significant differences were observed among treated fruits – including the control ones – (*figure 1*). This agrees with the results of Bikash Das *et al.* [15], who found that H_2CN_2-treated plants had higher fruit fresh weight than the control.

According to McColl [18], fruit maturity is determined when its TSS exceeds 15 °Brix. In this respect, the ($Dormex_{prun0}$) treatment significantly was the only treatment which gave fruits exceeding this level, and it was more efficient in advancing maturity than the other treatments; nevertheless, at the last two harvests, the (Dormex$_{prun7}$) treatment could allow the maturity of fruits reaching this threshold of 15%. Additionally, higher TSS was recorded for all fruits of Dormex®-treated vines during all harvesting dates in comparison with the control (*figure 2*). This could be related to the reduction in fruit numbers on these vines, as these two parameters were highly negatively correlated [14]. However, delaying Dormex® treatment more than 2 weeks after pruning had little or no effect on fruit TSS content (*figure 2*). Earlier flowering resulted in earlier fruit maturity, although the (Dormex$_{prun7}$), (Dormex$_{prun14}$) and control treatments were not quite mature during all harvests except for the (Dormex$_{prun14}$) treatment, at the last two harvests (*figure 2*). These results are in agreement with those of several authors who noticed that fruits of H_2CN_2-treated vines reached maturity earlier than those of untreated vines pruned on the same day [13, 15–20]. However, other authors noticed no significant differences between vines pruned and treated with H_2CN_2 and pruned-only controls in fruit maturity parameters such as berry weight and TSS [20, 21, 25].

Low fruit titratable acidity (TA) percentage was observed for fruits of Dormex®-treated vines during all harvest dates (*figure 3*). The (Dormex$_{prun0}$) treatment significantly gave fruits with the least TA during all harvesting dates, which means that they were more mature than those of other treatments. In addition, the control treatment gave fruits with the significantly highest TA during the first two harvests; however, no significant differences were observed during the last harvests among fruits treated with Dormex® (*figure 3*).

According to McColl [18], maturity is determined when [TSS:TA] exceeds [18:1]. Therefore, fruits of the (Dormex$_{prun0}$) treatment significantly were the only ones that exceeded this level (*figure 4*). While no significant differences of this ratio were observed during all harvests among the fruits of the other treatments, at the 4th harvest date, the differences among them became less but still under the [18:1] ratio, which may, eventually, reach the minimum maturity standard under the influence of climatic conditions. Fruits of Dormex®-treated vines had a higher [TSS:TA] ratio than those of pruned-only control vines; however, little differences were observed between the control and the (Dormex$_{prun14}$) treatment during all harvests. This agrees with Lombard *et al.* [3], who found that H_2CN_2 treatment will advance harvest. On the contrary,

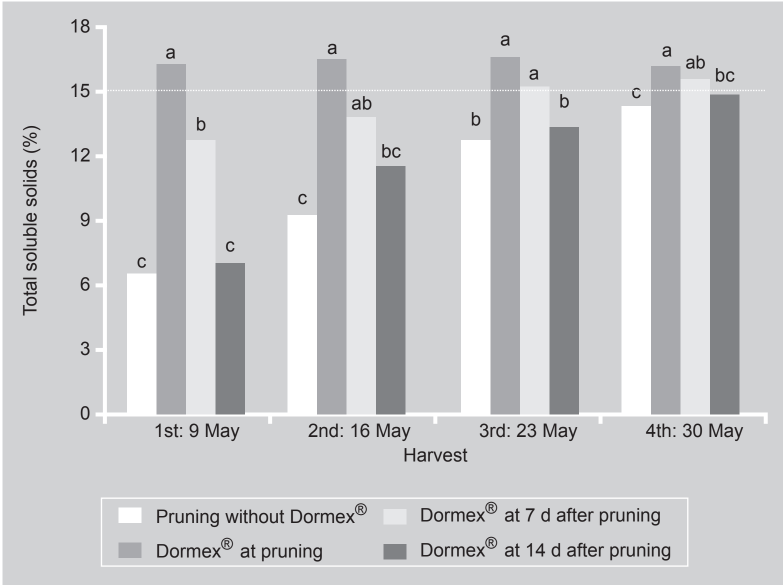


Figure 2.
Effect of application time of Dormex® on fruit total soluble solids of grapes c.v. 'Superior' seedless under southern Jordan Valley conditions at four harvest dates. Means with the same letter are not significantly different at $P \leq 5\%$.

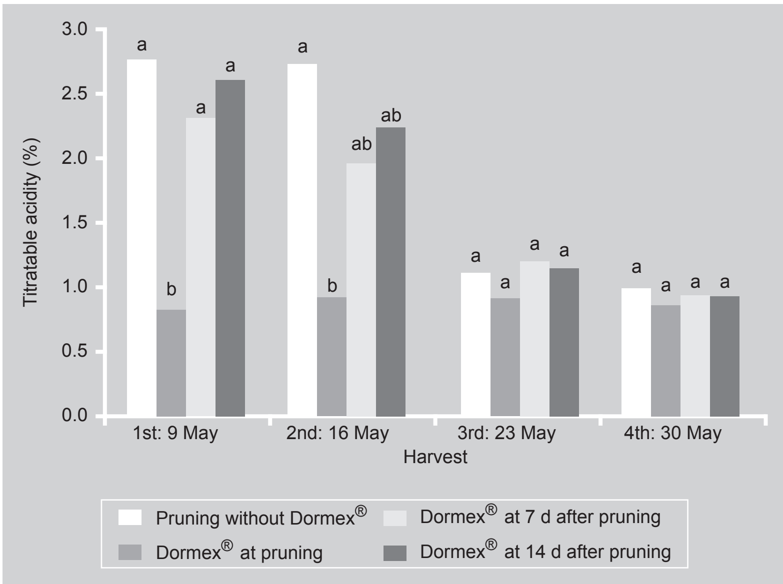


Figure 3.
Effect of application time of Dormex® on fruit titratable acidity (as tartaric acid) of grapes c.v. 'Superior' seedless under the conditions of the southern Jordan Valley at four harvest dates. Means with the same letter are not significantly different at $P \leq 5\%$.

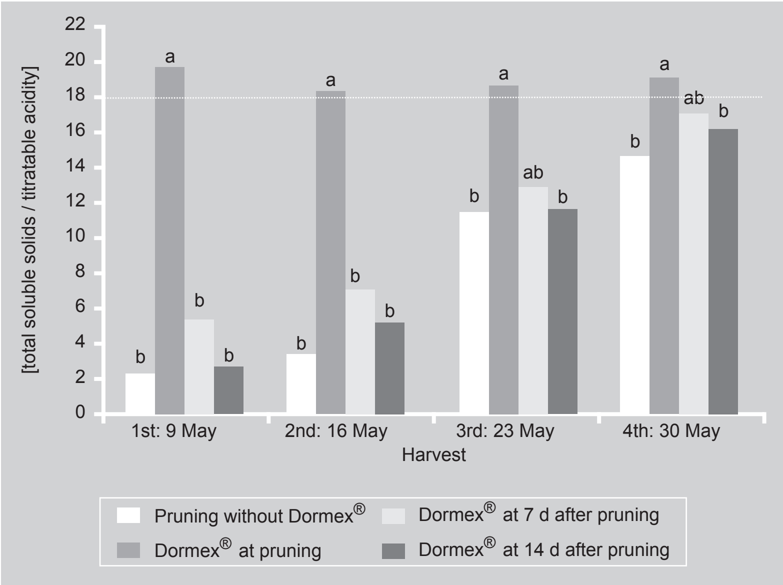


Figure 4.
Effect of application time of Dormex® on fruit [TSS/TA] ratio of grapes c.v. 'Superior' seedless under the conditions of the southern Jordan valley at four harvest dates. Means with the same letter are not significantly different at $P \leq 5\%$.

Bikash Das *et al.* [15] found that ripening time and TSS content did not vary among the control and H_2CN_2-treated plants.

4. Discussion

Early and even budbreak of table grapes is desirable to obtain early-maturing fruit and to improve the ease of cultural operations. Treatments with H_2CN_2 enhanced the effect of pruning on the breaking of dormancy and sprouting of intact dormant grapevine buds. The process of breaking the bud dormancy is triggered in nature by low temperature. Growth inhibitors were reported to be involved with the development of bud dormancy, but no clear and meaningful correlation between the level of growth regulators and bud dormancy has been found [4].

Timing of H_2CN_2 application is an important factor in determining the date of budbreak and/or the length of the flowering period. North [28] suggested that, although the time of application of H_2CN_2 affected the rest-breaking response, the best response was associated with high temperature conditions during and a few days after treatment. Our study supports the claim that late applications delay budbreak, whereas early applications can advance budbreak and flowering [25]. Our work has demonstrated that Dormex® advanced budbreak and fruit maturity of 'Superior' seedless grapes, and early applications were the most effective at advancing maturity. In our experiment, the earliest vine treatment attained the largest fruit size and these fruits ripened first; with each successive treatment, a further delay in fruit maturity occurred.

As fruit from earlier opening flowers have faster initial growth rates than the fruit from later flowers, it is valid to assume that advancement in flowering should result in larger fruit [25]. According to Nee [12], the best time to overcome the bud rest period safely and effectively with H_2CN_2 is during the post-rest phase. During this period, the time and extent of budbreak was greater and the amount of H_2CN_2 phytotoxicity was less severe than at the later stages of development. Additionally, H_2CN_2 may cause moderate to severe floral and fruitlet abscission; consequently, yields will be reduced compared with untreated control vines [14]. This could explain the higher fruit size obtained in H_2CN_2-treated vines compared with untreated ones.

The efficacy of H_2CN_2 at breaking bud dormancy is dependent on the growth status of the buds. This may provide an explanation for the variable results reported by other authors on the effects of hydrogen cyanamide in overcoming rest in other fruit crops [13]. The annual variation in the accumulation of chilling units will create a problem, as grape-growers are disposed to apply rest-breaking treatments on the same dates each year [22]. As a result, when rest-breaking treatments are applied on the same date every year, the vines would not be at the same stage of dormancy, which may influence their efficacy [15].

5. Conclusion

Table grapes grown in the subtropical regions are facing important yield-limiting factors due to the lack of winter chilling. Chemical plant-growth regulators are used to stimulate budbreak, especially in the warm, desert or tropical regions. However, the application time of Dormex® treatment remains a problem. Therefore, our study showed that, to obtain early budbreak and maturity under the conditions of the southern Jordan Valley, Dormex® should be applied as early as pruning time.

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Efecto del Dormex® sobre el cese de la latencia, la calidad del fruto y de madurez de uvas sin semillas 'Superior' en las condiciones del valle del río Jordán.

Resumen — **Introducción**. En las regiones subtropicales, la falta o la insuficiencia de frío hibernal fue uno de los factores limitadores del rendimiento más importante para la uva de mesa. Se necesita un frío hibernal de varias semanas para provocar la transición de las yemas vegetales y florales de su estado latente a un estado activo. Por todo ello, se evaluó el periodo de aplicación del Dormex® (cianamida de hidrógeno) en cuanto a su efecto sobre la calidad del fruto y la maduración de la uva sin semillas 'Superior', en las condiciones del valle del Jordán. **Material y métodos**. Se talaron viñas sin semillas 'Superior' de 5 años de edad el 20 de diciembre y se aplicó una solución de un 5% de Dormex® (v/v) mediante pulverización bien en el momento de dicha tala ($Dormex_{tala0}$), bien 7 días ($Dormex_{tala7}$) o 14 días ($Dormex_{tala14}$) tras la tala; y, las viñas taladas pero no tratadas constituyeron el tratamiento testigo. Se determinaron tanto las fechas de apertura de la yema vegetal como el principio de la floración. Se cosecharon los frutos cada 7 días a partir del 9 de mayo, en cuatro cosechas. Los parámetros estudiados fueron el peso del fruto, el índice de sólidos solubles totales (SST), la acidez valorable (AT), así como la madurez de los frutos evaluada a partir de la relación [SST:AT]. **Resultados y discusión**. Las yemas de las plantas taladas y tratadas mediante una solución de Dormex® brotaron (23 a 46) días después de la tala. La apertura de las yemas de las plantas sometidas a los tratamientos ($Dormex_{tala0}$) y ($Dormex_{tala7}$) fue la más precoz. Las yemas de las viñas tratadas con Dormex® brotaron (4 a 26) días antes que aquellos de las plantas testigo. Las yemas florales de las plantas taladas y tratadas comenzaron a florecer (55 a 64) días después de la tala y (4 a 13) días antes que los de las plantas testigo. Los frutos del tratamiento ($Dormex_{tala0}$) tuvieron un peso de frutos y un índice de SST significativamente los más elevados, una AT significativamente la más baja y fueron los únicos a sobrepasar el índice [18:1] de (SST:AT). Asimismo, independientemente de la fecha de cosecha, los frutos de las viñas tratadas con Dormex® dieron índices de SST más fuertes e índices de AT más flojos en relación con los frutos de las plantas testigo. **Conclusión.** Nuestro estudio mostró que, en las condiciones del bajo valle del Jordán, el Dormex® debería aplicarse en el momento de la tala con el fin de obtener un arranque de las yemas así como una madurez precoces.

Jordania / Río Jordán / *Vitis vinifera* / interruptores de latencia / frutas / calidad