

Torsion of canes and hydrogenated cyanamide in bud bursting and production of grapevine cv. Itália muscat in the São Francisco valley

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Abstract - The grapevine cultivated in tropical regions, such as the Sub-medium of the São Francisco Valley, exhibits a strong bud dormancy and high apical dominance, thus presenting the need for the utilization of products that promote the dormancy breaking of the buds. The aim of the present work was to evaluate the efficiency of the application of hydrogenated cyanamide and the practice of cane torsion over the breaking of bud dormancy, bud burst and yield of grapevine cv. Italia Muscat in the conditions of the Sub-medium of the São Francisco Valley. The experiment was conducted in Petrolina, PE state, during two production cycles (2015-2016). The adopted design was in randomized blocks, with treatments distributed in a 2 x 2 factorial scheme, referring to the torsion of canes (with and without) and the different doses [D1: hydrogenated cyanamide (H₂CN₂) 2.45%; D2: hydrogenated cyanamide (H₂CN₂) 2.94%], with four replicates. The use of the hydrogenated cyanamide associated to the torsion of canes influences in a distinct manner the studied variables, in the different production cycles, although increments in production and yield occur in both. Therefore, the use of 2.94% of H₂CN₂ along with the torsion of canes is a recommended practice for the increase in the bud burst rate and yield of grapevine cv. Italia Muscat, cultivated in the region of the Sub-medium of the São Francisco Valley.

Index Terms: *Vitis vinifera*, Dormex[®], dormancy breaking.

Torção de ramos e cianamida hidrogenada na brotação e produção da videira cv. Itália Muscat no Vale do São Francisco.

Resumo - A videira cultivada em regiões tropicais, como o Submédio do Vale do São Francisco, exibe forte dormência de gemas e dominância apical, havendo a necessidade da utilização de produtos que promovam a quebra de dormência das gemas. O presente trabalho teve como objetivo avaliar a eficiência da aplicação de cianamida hidrogenada e da prática de torção de ramos, sobre a quebra de dormência de gemas, a brotação e a produção da videira cv. Itália Muscat nas condições do Submédio do Vale do São Francisco. O experimento foi conduzido em Petrolina (PE), durante dois ciclos de produção (2015-2016). O delineamento utilizado foi o de blocos casualizados, com tratamentos distribuídos em esquema fatorial 2 x 2, referentes à torção de ramos (com e sem), e às diferentes dosagens [D1: cianamida hidrogenada (H₂CN₂) 2,45%; D2: Cianamida hidrogenada (H₂CN₂) 2,94%], com quatro repetições. O uso da cianamida hidrogenada, associada à torção dos ramos, influencia de forma distinta as variáveis estudadas, nos diferentes ciclos de produção, porém há incrementos na produção e na produtividade em ambos, sendo, portanto, o uso de 2,94% de H₂CN₂ mais a torção dos ramos uma prática recomendada para o aumento da brotação e da produção da videira cv. Itália Muscat cultivada na região do Submédio do Vale do São Francisco.

Termos para Indexação: *Vitis vinifera*, Dormex[®], quebra de dormência.

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Viticulture is an agricultural activity which has presented a consistent growth throughout the years. In Brazil, the grapevine-cultivated areas in 2017 was equivalent to 78.028 ha, of which 11.283 ha are located in the states of Pernambuco and Bahia, with average yield of 69.385 kg ha⁻¹ (IBGE, 2018). The Sub-medium region of the São Francisco Valley, located in the Northeast of Brazil, is characterized for presenting a hot and dry climate, with high temperatures throughout the entire year, being these factors insufficient in the induction of dormancy in the grapevine (inferior to 12 °C). However, with the technification of the grape production system, such as the use of irrigation and products with physiological effects, attached to the intrinsic characteristics of the semiarid region, it is possible to obtain fruits with higher quality (NASSUR et al., 2017).

The grapevine, when cultivated in regions of tropical climate, presents a continuous vegetative growth, with no interruption of the photosynthetic activities, what enables the production in any time of the year, and the obtaining of at least to yearly seasons (LEÃO; RODRIGUES, 2015). According to Alves et al. (2016), fruit plants of temperate climate present dormancy periods as an important physiological condition in the process of adaption to environmental conditions; therefore, bud dormancy constitutes a management difficulty in regions with subtropical or hot winter, usually resulting in the heterogeneity of bud bursting, flowering and low fruit development (KHALIL-UR-REHMAN et al., 2017). The accumulation of cold hours is the natural inducer that promotes the overcoming of the dormancy stage in the buds; however, in regions which present cold hours inferior to those required by the grapevine, the use of physiological effect products becomes necessary, aiming to interrupt the condition of vegetative dormancy (MAIA et al., 2013).

Different products, such as thiourea, potassium nitrate, ethephon, paclobutrazol and calcium cyanamide, have been utilized for inducing bud dormancy breaking in grapevines of tropical regions. However, the hydrogen cyanamide (H₂CN₂) has demonstrated to be the most efficient (LEÃO; RODRIGUES, 2015), promoting positive effects in the productive characteristics of the plant, especially in the flowering percentage, and, consequently, in the crop yield (WERLE et al., 2008; DÍAZ; BLANCO, 2017; BUENO et al., 2017). Conversely, the efficiency of the hydrogen cyanamide in the grapevine is dependent of factors such as variety, yield of the previous season and regional climatic conditions (EL-YAZAL; RADY, 2013), as well as usage of seedlings with elevated agronomical development, which come to favor the composition of the vineyards with high-quality plants (RIBEIRO et al., 2017).

In the Sub-medium of the São Francisco Valley, an inherent agricultural practice to grapevine management is the performing of the torsioning of productive branches (canes) after the pruning and before the application of the hydrogen cyanamide. This manually-performed practice consists in a slight torsion of the canes in all their extension, before their binding on the wire, aiming to break apical dominance and to stimulate the emergence of lateral bud bursts (GIOVANINNI, 2014). Although these are very common management practices in the grapevine cultivation in the semiarid, there is little information in scientific literature on the benefits of cane torsion in the grapevine crop, highlighting the work of Leão and Silva (2005). The benefits of the joint performing of cane torsion along with hydrogen cyanamide, although being a gap in the scientific literature, constitute a demand in the viticulture sector.

In this perspective, the present work was developed aiming to evaluate the effect of cane torsion and doses of hydrogen cyanamide on bud burst and yield of grapevine cv. Italia Muscat, in the São Francisco Valley.

The experiment was developed within the years of 2015 and 2016, during two consecutive production cycles (first and second semester), in an orchard of the Italia Muscat grape cultivar, located in the Irrigation District Senator Nilo Coelho, Petrolina – PE (state), geographic coordinates 09°17'57" of latitude South, 40°29'32" of longitude West, Sub-medium region of the São Francisco Valley.

The climate of this region is classified as BswH (Köppen), which corresponds to a semiarid region. During the execution of the experiment, the climatic data referring to pluviometric precipitation, temperature, and air relative humidity were registered in an automatic weather station (Figure 1).

The studied variety was the Italia Muscat, grafted over the 'IAC 313' rootstock, planted in December/2013 and conducted in a trellis system, in a spacing of 3.5 m between lines and 2.5 m between plants, with two lines of dripping tubes (flow rate of 2L h⁻¹) every 0.5 m. Cane and spur production prunings were performed in the two cycles, allowing six buds per cane; the remaining practices, referent to fertility management, weed, plague and disease control, were performed in accordance with the technical recommendations preconized by Leão and Rodrigues (2009).

The dates of pruning and harvest were, respectively, December 16, 2015 and April 21, 2016, for the first semester, and June 24, 2016 and October 31, 2016 for the second semester. The adopted experimental design was in randomized blocks, with treatments distributed in a 2 x 2 factorial scheme, referent to the doses of hydrogen cyanamide (D1: 2.45% H₂CN₂, and D2: 2.94% H₂CN₂) and the torsion of canes (with and without), with four replicates and five plants per parcel.

The adopted source of hydrogen cyanamide was the Dormex[®] (49% i.a.) in the doses of 5% (2.45% H₂CN₂) and 6% (2.94% H₂CN₂). The spray mix for all treatments was added with Caulim (30%), and the applications were immediately performed after the pruning, spreading the mixture through the entire cane with the aid of a roller.

The evaluated variables were: I) bud burst percentage; II) number of bunches per plant; III) average bunch mass (g); IV) production per plant (kg plant⁻¹) and; V) yield (t ha⁻¹). The variable bud burst percentage was calculated as the ratio between the number of bud sprouts and the total number of buds x 100. The remaining variables were determined at the moment of harvest, considering only the bunches with commercial quality, with firm, smooth and stainless berries, with color from green to yellow and soluble solids $\geq 15^\circ$ Brix.

The data of each season were individually subjected to analysis of variance (ANOVA) by the F test; when significant, the means of the factors were compared by Tukey's test at 5% probability, utilizing the Assisat statistical software, version 7.7 (SILVA; AZEVEDO, 2016).

According with the synthesis of the analysis of variance for the results obtained in the first semester of production, it is verified that there was a significant interaction between the torsion of the canes and the doses of hydrogen cyanamide only for the variables production and yield, and the torsion of the canes affected in an isolated manner the variables bud burst rate and number of bunches (Table 1). The second semester of production presented a significant interaction for the variables bud bursting rate, number of bunches and bunch mass. In contrast, the interaction for the variables production and yield was not significant, presenting an additive effect for each of the studied factors (Table 1).

In the first semester, the bud burst percentage in the plants in which the torsion of canes was performed was superior to that of the plants without the torsion (Table 1), with a better bud fertility, increasing in 12.56% the bud burst rate.

The increase in the bud burst rate obtained in this work, in the first semester, might be justified, beyond the torsion of the canes, by the performing of prunings in all treatments, possessing, as one of its objectives, to promote alterations in the hormonal balance. According to Taiz et al. (2017), after the removal of the branch apexes, site of the auxin synthesis, its levels are considerably reduced, favoring the increase in the levels of cytokinin, which, associated to the torsion of the canes, induces the breaking of apical dormancy and the development of the lateral buds, through consequent actuation of the cytokinin in the processes of cell division and elongation.

Leão and Silva (2005) evaluated the application effect of the hydrogen cyanamide added to a spreader-sticker, associated to the torsion of canes in grapevine

cv. Italia cultivated in the São Francisco Valley, and observed that in the first production cycle, performed within the months of September 2001 and January 2002, the treatment with 2.94% H₂CN₂ promoted an average bud burst of 75.5%, a superior valor to the bud burst rate found in this work; however, the authors did not observe a significant difference between this dose and the remaining treatments with H₂CN₂, not even when co-associated the dose of 2.45% with the torsion of canes. Conversely, under application of 2% Dormex[®] in the crop of grapevine cv. 'Niagara Rosada', in the conditions of the western region of Paraná state, Werle et al. (2008) obtained a significant difference in the bud burst rate, presenting an average of 93.6%, demonstrating superiority when compared with the witness (64.6%).

Mohamed and Gouda (2017), studying the bud dormancy breaking and the fructification of grapevine cv. "Superior", in hot climate, during two production cycles (2015 and 2016) evaluated the pulverization of 5% H₂CN₂ (Dormex[®]), and obtained bud burst rates of 63.30% and 67.66%, in the respective cycles. Although the values are similar to those found in this work, it is worth mentioning that in the first production semester the use of the dose of 2.94% H₂CN₂ provided a bud burst rate of 70.26%, therefore, it was possible to obtain a superior result by utilizing a 41.20% inferior dose. Furthermore, in general, the bud bursting percentages cited in this work reflect the induced answers by the mode of action of the H₂CN₂ in different grapevine cultivars and in regions with distinct climatic conditions.

In the second evaluation semester, the bud burst variable presented significant difference within the treatments with and without torsion of canes. As for the doses of hydrogen cyanamide, the treatment associating the dose of 2.94% H₂CN₂ + torsion was 13.5% superior to the result of the lowest dose + torsion (Figure 2A). Camille et al. (2010), working with the grapevine cv. Superior Seedless in the wine region of the São Francisco Valley, under application of bioregulators, utilized as witness the dose of 5% Dormex[®] and verified a bud burst rate of 66.5% for the second semester of production. Feitosa et al. (2018) evaluated the bud burst rate of the grapevine cv. Sugrathirteen treated 5% Dormex[®] in the years of 2014 and 2015, and obtained responses of 73.08% and 65.53% respectively. For the grapevine cv. Early sweet, treated with 3% Dormex[®] Shi et al. (2018) observed a progression in the bud burst rate of the plants with values superior to 85%, 28 days after the application.

However, observing Figure 2A, it is suggested that the use of cane torsion associated to a dose of 6% Dormex[®] (2.94% H₂CN₂) constitutes a more effective practice, able to provide a higher bud bursting rate in the semiarid-cultivated grapevine.

The number of bunches obtained in the first semester was a reflection of the bud burst rate occurred in function of the torsion of canes, with a significant increase of 6.55 bunches plant⁻¹ (Table 1). In the second semester, the number of bunches was influenced by the studied factors, once that the practice of cane torsion promoted positive increments, mainly associated to the dose of 2.94% H₂CN₂ (Figure 1B).

For the bunch mass variable, it is observed that there was no influence of the variation sources in the first semester (Table 1). Conversely, in the second semester, there was significant difference when compared the treatments with and without the torsion practice along with the application of the dose of 2.45% H₂CN₂, also verifying a significant difference between the dosages in the absence of cane torsion (Figure 3).

As it might be seen in Figure 2, for the variables: bud burst rate, number of bunches and bunch mass, the significant interaction within the factors observed in the second semester is probably related to the high temperatures of the region of the São Francisco Valley (Figure 1), associated to the mechanical damage of the torsion, conditions which are capable of promoting the oxidative stress of cells, resulting in the production of reactive oxygen species in the buds, such as the H₂O₂, directly contributing to the significant effect of the interaction between the factors (torsion + H₂CN₂).

In the first production semester, the unfolding of the interaction between hydrogen cyanamide doses and the torsion of canes (Figure 3A and 3B) demonstrates that for both variables, production and yield, the studied factors presented equal significance. Independently of the evaluated dose, the treatment with torsion of canes presented increase in the responses, compared to the treatment without torsion, that is, for the dose of 2.45% H₂CN₂ the torsion provided increase of 6.2 kg plant⁻¹ and 8.93 t ha⁻¹ whereas for the dose of 2.94% the increases were of 2.4 kg plant⁻¹, equivalent to 3.45 t ha⁻¹.

When evaluating the doses within each level of torsion (Figure 3), it might be realized that without the use of torsion, the dose of 2.94% H₂CN₂ presented a 12.2% superior result, whereas with the performing of torsion the hydrogen cyanamide doses were indifferent, being dispensable, therefore, the use of the higher dose. Leão and Silva (2005) obtained increases of 3.2 kg plante-1 for the treatment with torsion of canes and use of the dose of 2.45% H₂CN₂, although without significant difference.

As demonstrated in Table 1, in the second semester there was no significant difference, proceeding to the separate evaluation of the factors, where the production variable presented an increase of 7.57 kg plant⁻¹ in the treatments without (21.65 kg plant⁻¹) and with torsion (29.22 kg plant⁻¹) (Table 1). In function of the production values, the yield variable, for this factor, also presented averages which statistically differed within the levels

without (31.17 t ha⁻¹) and with torsion (42.08 t ha⁻¹), obtaining a gain of 10.91 t ha⁻¹ (Table 1).

For the production per plant, the treatment with the application of the dose of 2.94% H₂CN₂ presented a significantly superior average (27.02 kg plant⁻¹) to the treatment with the dose of 2.45% (23.85 kg plant⁻¹) (Table 1). As a consequence, a similar behavior to that of the production variable was observed for yield, with average of 34.34 t ha⁻¹ in the dose of 2.45% H₂CN₂ and 38.91 t ha⁻¹ in the dose of 2.94% (Table 1).

These results might be explained due to the fact that the H₂CN₂ is a rapidly absorbed and metabolized substance in the plants, and its mode of action is related to the decrease in the activity of the enzymes involved in the metabolic pathway of reactive oxygen species, such as the catalase, which degrades the hydrogen peroxide (H₂O₂) into one oxygen molecule (O₂) and one water molecule (H₂O), resulting in the increase of the H₂O₂ concentration in the buds (GOLDBACK et al., 1988).

As a result of the H₂O₂ increase, the plant starts a detoxication process through a sequence of metabolic reactions, related to the pentose phosphate pathway, promoting an increase of NADH, accelerating the metabolism and causing the breaking of bud dormancy (NIR et al., 1986), what probably occurred in the present work, since besides the bud burst rate, also the number of bunches and the bunch mass were significantly influenced by the application of H₂CN₂ in the second semester, reflecting in an increase in the production per plant and in the yield.

It is worth noting that the yield obtained in the first season in function of the interaction within the factors, with emphasis on the dose of 2.45% + torsion of canes (45.57 t ha⁻¹), was of 32.78 t ha⁻¹, therefore superior to the average of Brazil in the year of 2016, which totalized 12.79 t ha⁻¹ (IBGE, 2018). In the second semester, the additive effect of each of the factors provided the highest values for the treatments with the torsion practice (42.08 t ha⁻¹) and for the dose of 2.94% H₂CN₂ (38.91 t ha⁻¹), a difference of 29.29 t ha⁻¹ and 26.12 t ha⁻¹ respectively, when compared with the average Brazilian yield.

In this manner, by observing the responses to the factors in this work, the importance of the use of H₂CN₂ + torsion of canes is highlighted, defining these as an effective strategy in the productive of the grapevine cv. Italia Muscat, to be performed right after the production pruning, aiming to optimize the production and the yield.

The use of the hydrogen cyanamide associated to the torsion of canes influences in a distinct manner the studied variables in the different production cycles, demonstrating a higher effectivity in the bud burst rate, number of bunches and bunch mass, when evaluated in the first semester. In the second semester, the factors exercised additive influence and were responsible for promoting increases in the variables production and yield.

For the increase of bud burst rate and production of the grapevine cv. Italia Muscat cultivated in the region of the Sub-medium of the São Francisco Valley, the use of the

concentration of 2.94% H_2CN_2 along with the torsion of the canes is recommended.

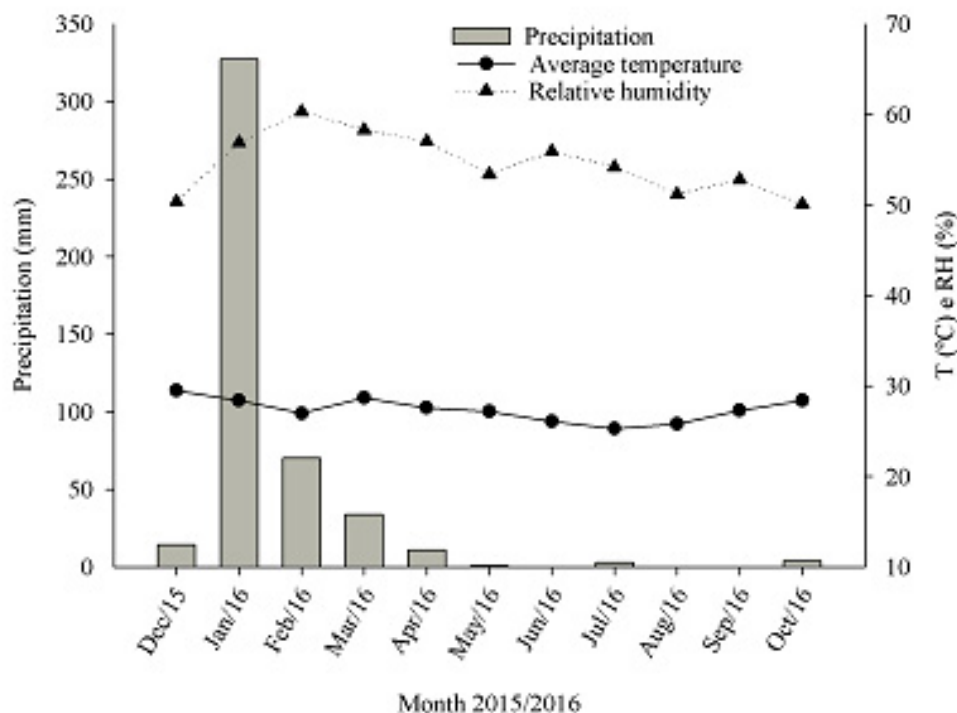


Figure 1. Average temperature, average air relative humidity and precipitation during the execution period of the experiments. Petrolina-PE.

Table 1. Synthesis of the analysis of variance for bud burst rate (%), number of bunches per plant, average bunch mass (g), production per plant ($kg\ plant^{-1}$) and yield ($t\ ha^{-1}$) of grapevine cv. Itália Muscat in function of the torsion of canes and hydrogenated cyanamide.

| Sources of variation | Average squares | | | | |
|----------------------|-----------------------|-----------------------|----------------------|----------------------|-----------------------|
| | Bud burst | Number of bunches | Average bunch mass | Production | Yield |
| First semester | | | | | |
| Torsion (T) | 342.6250** | 171.6123** | 0.0001 ^{ns} | 73.9621** | 153.3612** |
| Without | 64.43 b | 33.62 b | 0.80 a | 27.00 b | 38.88 b |
| With | 73.69 a | 40.67 a | 0.80 a | 31.30 a | 45.07 a |
| H_2CN_2 | 23.0496 ^{ns} | 0.4956 ^{ns} | 0.0001 ^{ns} | 5.7655 ^{ns} | 11.9476 ^{ns} |
| 2.45 % | 67.86 a | 36.72 a | 0.80 a | 28.55 a | 41.11 a |
| 2.94 % | 70.26 a | 37.07 a | 0.80 a | 29.75 a | 42.84 a |
| T x H_2CN_2 | 44.1543 ^{ns} | 51.8434 ^{ns} | 0.0001 ^{ns} | 29.9438* | 29.9422* |
| CV (%) | 5.77 | 9.89 | 0.6 | 5.3 | 5.3 |
| Second semester | | | | | |
| Torsion (T) | 857.9011* | 306.2565** | 0.0024** | 229.5255** | 475.9376** |
| Without | 56.14 b | 28.22 b | 0.76 b | 21.65 b | 31.17 b |
| With | 70.78 a | 36.97 a | 0.79 a | 29.22 a | 42.08 a |
| H_2CN_2 | 217.4112* | 31.3622** | 0.0047** | 40.3232** | 83.6110** |
| 2.45 % | 59.77 b | 31.20 b | 0.76 b | 23.85 b | 34.34 b |
| 2.94 % | 67.15 a | 34.00 a | 0.79 a | 27.02 a | 38.91 a |
| T x H_2CN_2 | 148.9623** | 13.6912** | 0.0040* | 1.3232 ^{ns} | 2.7401 ^{ns} |
| CV (%) | 1.53 | 3.27 | 1.7 | 3.28 | 3.28 |

Means followed by the same lowercase letter on the column do not differ within each other by the F test at 5% probability. **: significant ($p < 0,01$); *: significant ($p < 0,05$); ns: not significant; CV%: coefficient of variation.

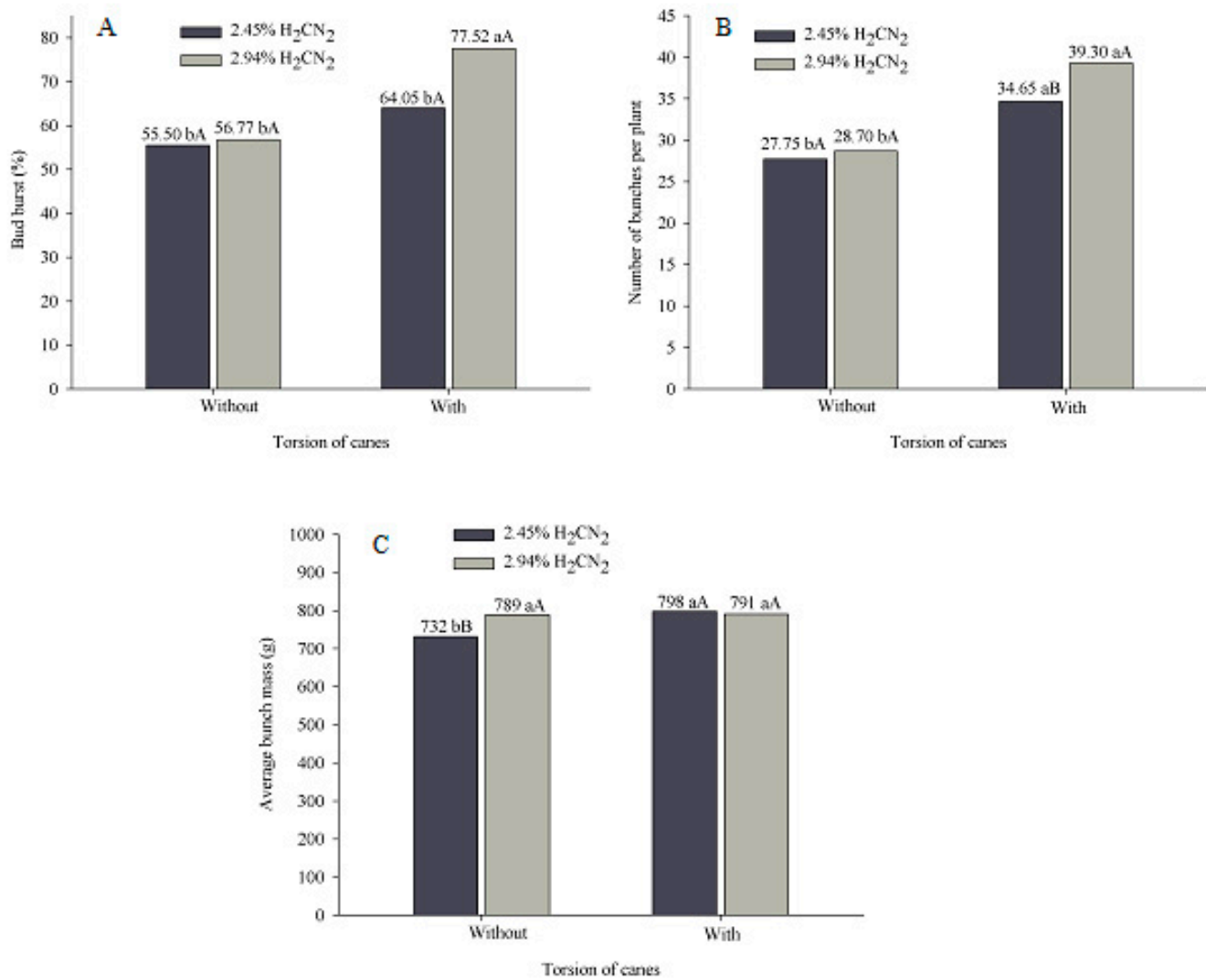


Figure 2. Bud burst rate (A), number of bunches per plant (B) and bunch mass (C) of grapevine cv. Italia Muscat in function of the torsion of canes and hydrogenated cyanamide in the second production semester. On the slashes the lowercase letters compare the torsion of canes, and uppercase letters compare the doses of hydrogenated cyanamide. Slashes with the same letters do not differ within each other by Tukey's test at 5% probability.

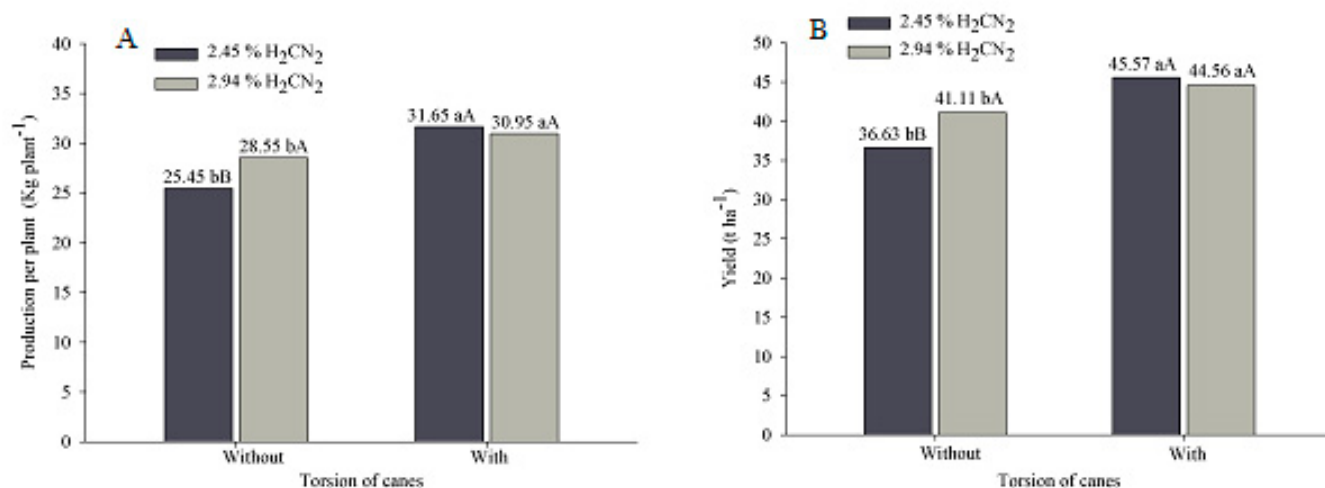


Figure 3. Production per plant (A) and yield (B) of grapevine cv. Italia Muscat in function of the torsion of canes and hydrogenated cyanamide in the first production semester.

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