Skeena Journal on Horticulture

Effect of Dormancy Disruptors in 'Golden Delicious' Apple on Development and Yield

Research Article

Volume 1 Issue 2- 2024

Author Details

Juan Manuel Soto Parra[1], Julio César Oviedo Mireles[1], Nubia Guadalupe Torres Beltrán[1], Omar Castor Ponce García[2] and Mario Alberto Cruz Osorio[3]*

[1]Faculty of Agrotechnological Sciences, Autonomous University of Chihuahua, Mexico

[2]Delicias Experimental Field Cirnoc-Inifap, Mexico

[3]Master's thesis student in Fruit Productivity Sciences Faciatec-Uach, Mexico

*Corresponding author

Julio César Oviedo Mireles, Faculty of Agrotechnological Sciences, Autonomous University of Chihuahua, Mexico

Article History

Received: November 27, 2024 Accepted: December 03, 2024 Published: December 05, 2024

Abstract

The apple tree is a temperate climate fruit tree, which needs winter cold to break its dormancy. In Mexico, 60,671 Ha are cultivated with a production of 747,176 t, Chihuahua is the main producing state with 33,936 ha and 627,603 t. The objective was to evaluate the effect of dormancy disruptors on development and yield components in 'Golden Delicious' apple trees. The treatments were applied in the 2018, 2019 and 2020 cycles, a randomized complete block design with three repetitions was used in a factorial arrangement, factor A was the years 2018, 2019 and 2020, factor B was the dormancy disruptors and factor C was the concentration used for each disruptor. Vegetative growth, nodes, buds in 1 and 2 year old shoots and sprouting percentage for 1 and 2 year old shoots were evaluated; and yield with fruit weight, equatorial and polar diameter, firmness and production. Bud sprouting in one- and two-year-old shoots was improved with hydrogenated cyanamide at a concentration of 20 mL L^{-1}, with a sprouting of 76.8% in 2018, followed by Thidiazuron at a dose of 0.4 mL L^{-1} which obtained 70.7% sprouting in 2018 and 74.3% in 2020. Thidiazuron, at the highest concentration of 0.8 gr L^{-1} obtained the best production with 68.8 t ha^{-1}, the highest firmness was obtained with the applications of BrotStart and hydrogenated cyanamide with 18.0 and 17.8 lb in2 respectively.

Keywords: Malus domestica Borkh, Cold compensators, Development, Production

Introduction

In Mexico, apple (Malus domestica Borkh) is cultivated on 60,671 ha with a production of 747,176 t, the state of Chihuahua is the main producer with 33,936 Ha and 627,603 t of production [1]. The apple tree is a deciduous fruit tree of temperate climate, which needs winter cold to break its dormancy, which is necessary to survive cold winters [2].

The apple production system is being affected by climate change-global warming, a binomial that affects the accumulation of winter cold [3] that influences the homogeneity of sprouting. Chilling deficiency results in late budding in terminal buds, poor and irregular flowering, a large number of unsprouted buds, poor fruit setting, low and poor quality production [4], as well as a higher risk of fire blight [5].

The lack of an adequate period of chilling impacts on the size, colour, firmness of the fruit and the appearance of physiological disorders. However, it not only affects the current season, but also the following one. Therefore, a strategy is needed to reduce the problems of winter chilling accumulation.

When chilling has been insufficient, chemical induction of sprouting has been used in apple production [6]. Various products have been used to break dormancy and allow plants to come out of dormancy. These include hydrogenated cyanamide (CNH) and Thidiazuron (TDZ) [4]. Pang et al. [7] suggest that the inducing effect of CNH on the budding rate may be mediated by Ca^{2+} signals, so that exogenous application of Ca2+ participated in the release of dormancy in grape buds. On the other hand, [8] with exogenous applications of H_2O_2 in grapevine buds, confirmed that increases in the level of H_2O_2 are related to the breaking of endodormancy.

Studies carried out with Erger® mixed with calcium nitrate Ca(NO3)2 in apple trees demonstrated favorable effects on axillary and terminal budding [6]. Erger® acts on the physiology of buds, providing nutrients to dormant tissues, produces a change in the balance of growth promoters/inhibitors, gives a signal for the start of metabolic activity that induces bud sprouting [9].

The main desirable characteristics of chemical substances are their effectiveness, low cost and minimum toxicity for plants and the environment [10]. Therefore, it is of utmost importance to identify and compare new, more effective compounds to break dormancy and that can replace toxic products such as CNH considered as the most potent chemical compound in bud sprouting. It is hypothesized that dormancy disruptors contribute to the development of the 'Golden Delicious' apple tree, its effect can potentiate the development of the 'Golden Delicious' apple tree.

Materials and Methods

The experiment was carried out in the Campo 22 orchard, coordinates 28° 27' 12.1" N 106° 53' 27.7" on 28-year-old 'Golden Delicious' apple trees. Treatment applications were carried out on March 14, 2018, March 5, 2019, and March 6, 2020, using a Swissmex brand manual sprayer model 501058 with a volume capacity of 15 liters and a pressure of 14.5 to 87 lb in-2. Spraying was carried out to cover all of the buds of the selected trees. A randomized complete block design with three replications was used in a nested factorial arrangement, where factor A was the years 2018, 2019 and 2020 with three levels, while factor B was the dormancy disruptors with five concentrations, nested within the factors (BrotStart, CNH, Erger® + Ca $(NO3)_2$, H_2O_2 + SA and TDZ) and factor C was the concentration used for each disruptor (Table 1).

Table 1: Cold compensators, application levels and concentration

Levels	Dormancy disruptors*				
	Brot Start	CNH	Erger® + $Ca(NO_3)_2$	H2O2 + SA	TDZ
0	0	0	0 + 0	0 + 0	0
1	1	1	0.75 + 0.75	2 + 0.005	0.04
5	5	5	3.75 + 3.75	10 + 0.025	0.2
10	10	10	7.5 + 7.5	20 + 0.050	0.4
20	20	20	15 + 15	40 + 0.100	0.8

*Application concentrations L/Kg per 1000 L of water. Applications were made in 2018, 2019 and 2020.

To estimate the development parameters of each tree (replication), 6 shoots were selected and from them the growths of the year, shoots of two and three years on the same branch and randomly in which the growth was measured in cm with an elastic tape graduation 1 to 150 cm, of each growth of each year the number of nodes was measured and with this the density of nodes was derived and for the current growth by dividing the length of the shoot by the number of nodes. In the same way the length of one-year shoots was evaluated and the number of sprouted and non-sprouted buds was counted and with this the percentage of sprouting in one-year branches was obtained. This same scheme was used to estimate the number of sprouted and non-sprouted buds in two-year branches and with this the percentage of sprouting in two-year branches was obtained.

The weight of the fruit was determined using an analytical balance. The equatorial diameter and polar diameter were measured, using a vernier. From these values, the L/D ratios were generated. Fruit firmness was determined with a penetrometer model Effe-Gi 327, 0 – 28 lb in-2. Yield in tons ha-1 was estimated based on the production of 20kg boxes per selected tree. This estimate was corroborated and adjusted with the orchard manager. Statistical analysis was performed according to the proposed factorial experiment. For the separation of factor means, the Tukey test α 0.05 (year and disruptor) was used, while for the applied concentration, orthogonal polynomials up to 4 polynomial degrees (linear, quadratic, cubic and quartic) were used. Likewise, the interactions year by concentration, disruptor by concentration and year by disruptor by concentration were obtained.

Results and Discussion

Apple trees, in order to maximize their photosynthetic efficiency, must maintain a ratio of vegetal shoot/ fruiting shoot to maintain a good yield year after year. Table 2 presents the results of the performance parameters and Table 2 shows the results of the development in 'Golden Delicious' apple trees treated with individual commercial cold compensators of the cycles studied 2018, 2019 and 2020.

Table 2 shows the results of vegetative growth, statistically the years 2018 and 2020 were significant in relation to the general average and compared to the year 2019, where there was greater growth with an average of 16.3 and 14.7 cm respectively. Standing out in 2018 with the application of TDZ where there was an average of 19.8 cm of shoot growth, followed by CNH with 17.6 cm and H2O2 with 17.4 cm. In 2020, the application of TDZ gave the best response with an average shoot growth of 20.0 cm, followed by CNH with 15.9 cm and Erger®-Ca with 14.9 cm. Regarding the percentage of sprouting in relation to the percentage of the year considered, in 2018 with the application of CNH, 75.5% was obtained in one-year shoots and 65.6% in two-year shoots, with H_2O_2 it was 71.0% in one-year shoots and 63.8 in two-year shoots, while in Erger®-Ca there was 57.7% sprouting in two-year buds.

For the year 2020, TDZ had 74.5% sprouting in one-year branches and 67.9% for two-year branches, while H2O2 had 69.4% sprouting in two-year branches. Although the degree of response varies, our results agree with those obtained by Llamas-Llamas et al. [11], where TDZ and CNH caused significant increases in the sprouting of lateral and apical buds in crowned saplings of 'Golden Delicious' apple trees. Under conditions in which catalase activity is inhibited by CNH application, the excess of H2O2 through the ascorbate-glutathione cycle [12] causes detoxification and subsequent activation of the pentose phosphate pathway PPP [13], thus increasing NADPH concentration and could be crucial steps in breaking endodormancy (ED) caused by CNH, which could not be completely produced by exogenous applications of H_2O_2. However, the mechanism by which CNH exerts its effect of breaking dormancy through other metabolic pathways not signaled by H_2O_2 cannot be ruled out [8].

In our results obtained in the 2018 cycle in one-year branches, as the TDZ concentration increased, the greatest sprouting was obtained up to 70.7% with 0.4 mL L^{-1} while with 0.8 mL L^{-1} it tended to decrease to 66.4%, while for the year 2020 with a concentration of 0.4 mL L^{-1} there was 74.3% and with 0.8 mL L^{-1} 76.7% sprouting. These results are similar to those obtained by Llamas-Llamas et al. [11] in 'Golden

Delicious' apple trees, reported that as the TDZ concentration increased, sprouting was noticeably greater, reaching 68.1% with 0.5 mL L^{-1} and 69.2% sprouting with 0.7 mL L^{-1}.

For yield, the results shown in Table 3 reflect that in the 2020 cycle, the fruit weight was greater than in the 2018 and 2019 cycles, with an average of 129.1$_g$, being highly significant as well as the polar diameter with 59.0 mm, which together with the equatorial diameter of 65.9 mm, could have influenced to obtain a greater weight of the apple fruit. However, production in 2020 was 28.3 t ha^{-1}, similar to that in the 2018 cycle with a yield of 29.4 t ha^{-1}, while in 2019 the highest yield of the three cycles studied was 51.8 t ha^{-1}, reflecting a marked alternation. Our results coincide with those reported by. Hawerroth et al. [9] In apple trees of the 'Maxigala' and 'Fuji Suprema' varieties, fruit set was reduced with the application of bud-breaking products, especially in the treatments that resulted in greater and more intense flowering. They concluded that there is a relationship between bud-breaking intensity and fruit set that can be drastically reduced due to the nutritional competition established between vegetative and reproductive sinks. On the other hand, the reduction of the flowering period provided by dormancy disruptors can lead to a shorter pollination period that can negatively influence fruit set [6]. Nunes et al. [14] report that the increase in fruit production may be due to a greater development of the leaf area and a greater photosynthetic capacity in plants treated with bud-breaking agents. It can be stated that for average fruit weight, the Erger® treatments associated with Ca (NO3)2 were similar to the standard treatment of CNH mixed with mineral oil [6].

Table 2: Development in 'Golden Delicious' apple trees treated with cold compensators, 2018 – 2020

	Vegetative growth cm	Nodes cm^{-1}	Buds cm^{-1} Shoots 1 year	%Sproubting shoots 1 year	Buds cm^{-1} shoots 2 years	%Sproubting shoots 1 year
Year	0.0107^W	0.1021	0.0134	0.0949	0.0184	0.0187
2018	16.3 a^Z	1.8 a	2.1 a	65.0 a	2.6 a	56.7 b
2019	11.7 b	2.0 a	2.0 a	63.8 a	2.2 ab	61.0 ab
2020	14.7 a	1.8 a	1.7 b	70.1 a	1.9 b	68.9 a
DMSX	2.8	0.3	0.3	7.9	0.5	8.7
Compensator	0.0002	0.0119	<.0001	0.5293	0.001	0.4752
BroStart	11.2 b	1.7 b	1.7 b	64.6 a	2.1 b	60.0 a
CNH	14.7 ab	2.0 ab	2.2 a	66.7 a	2.4 ab	62.7 a
Erger®-Ca	13.9 b	1.8 ab	1.8 b	64.1 a	2.0 b	62.0 a
H_2O_2-SA	13.4 b	1.8 ab	1.8 b	68.0 a	2.0 b	63.8 a
TDZ	18.2 a	2.0 a	2.2 a	68.0 a	2.7 a	62.6 a
DMSX	3.6	0.3	0.3	8.7	0.5	6.2
Year*Com.	0.3285	0.0039	0.0123	0.0087	0.0212	<.0001
Concentration	0.5548	0.6026	0.3443	0.051	0.2955	0.0224
0	14.7 a	1.9 a	2.0 a	68.7 a	2.3 a	63.0 ab
1	14.5 a	1.9 a	1.9 a	66.9 a	2.2 a	60.6 b
5	14.5 a	1.8 a	1.9 a	64.6 a	2.3 a	60.5 b
10	13.4 a	1.8 a	1.9 a	64.2 a	2.2 a	61.7 ab
20	14.2 a	1.8 a	1.9 a	67.0 a	2.1 a	65.2 a
LSDX	2.3	0.2	0.2	4.6	0.3	4.5
Year*Conc.	0.1997	0.4162	0.3814	0.586	0.2189	0.4752
Com.*Conc.	0.4258	0.2893	0.3987	0.138	0.7611	0.381
Y*Com.*Conc.	0.6701	0.5462	0.5435	0.0578	0.1398	0.1452
µ	14.3	1.9	1.9	66.3	2.2	62.2
C.V.	27.58	16.47	18.36	11.97	22.4	12.31
R2	0.7077	0.6798	0.7065	0.7151	0.7282	0.739

^{W}Probability Pr≥0.05 not significant, 0.05 ≤ Pr ≤ 0.01 significant, Pr<0.01 highly significant, XLeast Significant Difference, YTreatment means with different letters are statistically different (Tukey α 0.05), ZOrthogonal polynomials based on the means Y. µ overall mean, C.V. coefficient of variation. BroStart, (total nitrogen 8%, calcium 11.0%, total oxidizable organic carbon 0.5%; CNH, Hydrogenated cyanamide (Dormex 49%); Erger®-Ca, Erger® (nitrogen 15%, calcium 4.7%, density 1.4 g cm3) plus calcium nitrate (15.5% nitrogen, 26.3% CaO, (Ca 19.0%)), H2O2, hydrogen peroxide (50% H2O2) plus salicylic acid (SA), TDZ, Thidiazuron (Revent, N-Phenyl-N'-1,2,3-thiadazol-5-yl-urea 42.4%). Application concentrations L/Kg per 1000 L-1 water: BroStart 0, 1, 5, 10 and 20; CNH 0, 1, 5, 10 and 20; Erger®-Ca(NO3)2 0(0), 0.75 (0.75), 3.75 (3.75), 7.5 (7.5), 15.0 (15.0); H2O2-(AS) 0 (0), 2 (0.005), 10 (0.025) 20 (0.050) 40 (0.100); Thidiazuron 0, 0.040, 0.200, 0.400, 0.800. Applications 2018, March 14; 2019, March 05; 2020, March 06.

Citation: Juan MSP, Julio COM, Nubia G, Omar CPG, Mario ACO. Effect of Dormancy Disruptors in 'Golden Delicious' Apple on Development and Yield. *S J horti*. 2024;1(2):1–5. DOI: 10.51626/sjh.2024.01.00006

Table 3: Performance parameters behavior in 'Golden Delicious' apple trees treated with cold compensators, 2018-2020

	Fruit weight g	Ecuatorial diameter fruit mm	Polar diameter fruit mm	L/D	Firmness lb in²	Production t ha⁻¹
Year	0.0037W	0.0141	0.0043	0.3311	0.0005	0.0024
2018	113.9 bZ	63.5 b	56.7 b	0.891 a	18.2a	29.4b
2019	116.0 b	63.0 b	56.6 b	0.899 a	17.5 b	51.8 a
2020	129.6 a	65.9 a	59.0 a	0.896 a	16.8 c	28.3 b
DMSX	7.8	2	1.3	0.017	0.4	10.7
Compensator	0.0319	<.0001	<.0001	0.1128	0.0015	<.0001
BroStart	116.7 ab	62.6 c	56.1 b	0.895 a	18.0 a	42.4 a
CNH	113.2 b	62.0 c	55.5 b	0.896 a	17.8 ab	29.5 b
Erger®-Ca	121.8 ab	67.0 a	60.3 a	0.901 a	17.2 b	32.9 b
H2O2-SA	117.4 ab	63.6 bc	56.5 b	0.888 a	17.2 b	34.0 b
TDZ	126.9 a	65.6ab	58.9 a	0.898 a	17.2 b	43.7 a
LSDX	12.4	2.2	2.3	0.013	0.7	7.6
Year*Com.	0.0344	<.0001	<.0001	0.0021	0.0641	0.0001
Concentration	0.331	0.3453	0.4552	0.0401	0.0852	0.0017
0	116.3 a	64.7 a	57.9 a	0.895 ab	17.7 a	36.2 ab
1	120.5 a	64.3 a	57.6 a	0.897 ab	17.3 a	42.2 a
5	120.7 a	63.6 a	57.4 a	0.903 a	17.6 a	38.0 ab
10	117.5 a	64.1 a	56.9 a	0.887 b	17.4 a	34.1 b
20	121.0 a	64.2 a	57.4 a	0.895 ab	17.4 a	32.1 b
DMSX	7.9	1.5	1.6	0.014	0.4	7.1
Year*Conc.	0.151	0.0227	0.2398	0.1306	0.2037	0.2496
Com.*Conc.	0.1905	<.0001	0.0003	0.8972	0.0079	0.0705
Y*Com.*Conc.	0.2307	<.0001	<.0001	0.075	0.0028	0.7493
μ	119.2	64.1	57.5	0.895	17.5	36.5
C.V.	11.32	3.99	4.72	2.68	4.41	33.28
R2	0.7117	0.8364	0.8154	0.5651	0.7667	0.7724

[W]Probability Pr≥0.05 not significant, 0.05 ≤Pr≤0.01 significant, Pr<0.01 highly significant, X Least Significant Difference, YTreatment means with different letters are statistically different (Tukey α 0.05), ZOrthogonal polynomials based on the meansY. μ overall mean, C.V. coefficient of variation. BroStart, (total nitrogen 8%, calcium 11.0%, total oxidizable organic carbon 0.5%; CNH, Hydrogenated cyanamide (Dormex 49%); Erger®-Ca, Erger® (nitrogen 15%, calcium 4.7%, density 1.4 g cm3) plus calcium nitrate (15.5% nitrogen, 26.3% CaO, (Ca 19.0%)), H2O2, hydrogen peroxide (50% H2O2) plus salicylic acid (SA), TDZ, Thidiazuron (Revent, N-Phenyl-N'-1,2,3-thiadazol-5-yl-urea 42.4%). Application concentrations L/Kg per 1000 L-1 water: BroStart 0, 1, 5, 10 and 20; CNH 0, 1, 5, 10 and 20; Erger®-Ca(NO3)2 0(0), 0.75 (0.75), 3.75 (3.75), 7.5 (7.5), 15.0 (15.0); H2O2-(AS) 0 (0), 2 (0.005), 10 (0.025) 20 (0.050) 40 (0.100); Thidiazuron 0, 0.040, 0.200, 0.400, 0.800. Applications 2018, March 14; 2019, March 05; 2020, March 06.

In the analysis of the three years by compensator, TDZ was significant with a mean for fruit weight of 126.9 g, favorably influenced by the polar diameter with 58.9 mm, which was highly significant. At the same time, having a higher fruit weight is reflected in the production of 43.7 t ha^{-1}, being highly significant, as was BroStart with 42.4 t ha^{-1}. The Erger®-Ca compensator was highly significant in terms of the fruit's equatorial diameter and polar diameter with a mean of 67.0 mm and 60.3 mm respectively. Firmness was favorably influenced and highly significant by the BrotStart compensators with 18.0 lb in2 and CNH with 17.8 lb in 2. The mean equatorial diameter of the fruit and polar diameter were smaller than those of the other compensators, with smaller and firmer fruits. Our results are similar to those obtained in Kiwi by Marsh and Stowell [15-16] who report a significantly higher firmness compared to the control with a high concentration of 2.0% CNH.

The factors year by compensator and levels, there was a positive interaction in terms of yield in 2019, with the application of TDZ standing out being highly significant, the higher the concentration the higher the production, with the application of 0.2 and 0.4 gr L^{-1} the average was a production of 62.5 t with both concentrations, and with 0.8 gr L^{-1} the average was 68.8 t. In the same year 2019, applications of the BrotStar compensator with 1.0 mL L^{-1}, an average of 81.25 t ha^{-1} was obtained, and at higher concentrations of 5.0, 10.0 and 20.0 mL L^{-1} the yields decreased to 77.1, 60.41 and 54.2 t ha^{-1}, a decrease that was repeated in the years 2018 and 2020 [17-20].

Conclusions

The results show that vegetative growth can be significantly improved with the sprouting disruptors in order of importance, Thidiazuron, hydrogenated cyanamide, hydrogen peroxide and Erger®-Ca. Bud sprouting can be improved in one and two year old shoots, hydrogenated cyanamide was the best with the highest applied concentration of 20 mL L^{-1}, a sprouting of 76.8% was obtained in 2018, followed by Thidiazuron with very similar percentages, finding that the optimal concentration of Thidiazuron was 0.4 mL L^{-1} to reach 70.7% sprouting in 2018 and 74.3% in 2020. With the application of Erger®-calcium in the 2018 cycle, with the highest concentration used of 15 mL L^{-1}/15 gr L^{-1}, they show 68.1% sprouting. The interaction year* compensator* concentration, in the variables of production and fruit quality, Thidiazuron was the best, the highest concentration of 0.8 gr L^{-1} had the best production with 68.8 t ha^{-1}, in 2019, the application of BrotStart at a concentration of 1.0 mL L^{-1} obtained the highest production of 81.25 t ha^{-1}, and its behavior was that, at higher concentrations, yields decreased in that year and the other two years studied. The greatest firmness was had with the applications of BrotStart and hydrogenated cyanamide, obtaining 18.0 and 17.8 lb in^2 respectively.

References

1. SIAP (2020) Servicio de Información Agroalimentaria y Pesquera, SIAP 2020. fecha de consulta 08/10/2023.
2. Mohamed ASY, Samir ASY, Mostafa MR (2014) Exogenous Dormancy-Breaking Substances Positively Change Endogenous Phytohormones and Amino Acids during Dormancy Release in 'Anna' Apple Trees. Plant Growth Regulation 72(3): 211-220.
3. Ramírez LMR, José ARC, Guillermo MG, Juan LJC, Rafael APQ, et al. (2011) Perspectives on the Apple Production System in Chihuahua Facing Climate Change. Revista Mexicana de Ciencias Agrícolas 2(spe2): 265-279.
4. Juan MSP, María AFC, Esteban SC, Ramona PL, Francisco JPR (2019) Compensadores de Frío En Manzano 'Golden Glory': Desarrollo y Producción. Revista Mexicana de Ciencias Agrícolas 11(1): 69-82.
5. Quintana LE (2006) Aplicación de promotores de brotación en base a la actividad metabólica de las yemas en manzano Golden Delicious. Tesis de Maestría de la Facultad de Ciencias Agrotecnologicas Universidad Autónoma Chihuahua pp.103.
6. Petri JL, Leite GB, Couto M, Gabardo GC, Haverroth FJ (2014) Chemical Induction of Budbreak: New Generation Products to Replace Hydrogen Cyanamide. Acta Horticulturae 1042: 159-166.
7. Xuequn P, Tamar H, Omer C, Tsvicka K, Alexandra KK, et al. (2007) Involvement of Calcium Signalling in Dormancy Release of Grape Buds. Journal of Experimental Botany 58(12): 3249-3262.
8. Francisco JP, Ricardo V, Sebastián R (2008) H_2O_2 Is Involved in the Dormancy-Breaking Effect of Hydrogen Cyanamide in Grapevine Buds. Plant Growth Regulation 55(2): 149-55.
9. Hawerroth FJ, JL Petri, Berenhauser G, Herter FG (2010) Brotação de gemas em macieiras 'ImperialG e 'Fuji Suprema' pelo uso de Erger® e nitrato de cálcio. Rev Bras Frutic Jaboticabal 32(2): 343-350.
10. Erez A (2000) Bud Dormancy; Phenomenon, Problems and Solutions in the Tropics and Subtropics. In: Erez A Ed, Temperate Fruit Crops in Warm Climates, Springer.
11. Llamas LJ, Carbajal ME, A Orozco AA, Rascón CA, Romo C, et al. (2002) Metabolic and bursting responses of apple buds to budbreaking promoters. Rev Fitotec Me 25(4): 411-417.
12. Foyer CH, Halliwell B (1976) The Presence of Glutathione and Glutathione Reductase in Chloroplasts: A Proposed Role in Ascorbic Acid Metabolism. Planta 133: 21-25.
13. Salvemini F, Franze A, Lervolino A, Filosa S, Salzano S, et al. (1999) Enhanced Glutathione Levels and Oxidoresistance Mediated by Increased Glucose-6-Phosphate Dehydrogenase Expression The Journal of Biological Chemistry 274(5): 2750-2757.
14. José LDSN, Gilmar RBM, Ivar AS (2001) Cianamida hidrogenada, thidiazuron e óleo mineral na quebra de dormência e na produção do pessegueiro cv Chiripá. Revista Bras de Frutic 23: 493-496.
15. Marsh KB, Stowell BM (1993) Effect of fertigation and hydrogen cyanamide on fruit production, nutrient uptake, and fruit quality in kiwifruit. New Zealand journal of crop and horticultural science 21(3): 247-252.
16. Arlie AP, David GH, ED T (2000) Effect of Hydrogen Cyanamide (Dormext) on Replacing Lack of Chilling in Kiwifruit (Actinidia Deliciosa). Small Fruits Review 8851: 79-82.
17. vila AJJ, Rodríguez J, Santamaría C (2007) Efecto de La Cianamida de Hidrógeno En La Estimulación de Brotes de Nogal Pecanero [Carya Illinoinensis (Wangenh.) K. Koch] En La Comarca Lagunera. Revista Chapingo Serie Zonas Áridas 4(1): 29-34.
18. Caldwell J (1989) Kiwi fruit performance in South Carolina and effect of winter chilling. Proc Ala Fruit and Vegetable Growers Assoc 10: 127-129.
19. Pérez FJ, Burgos B (2004) Alterations in the Pattern of Peroxidase Isoenzymes and Transient Increases in Its Activity and in H 2 O 2 Levels Take Place during the Dormancy Cycle of Grapevine Buds: The Effect of Hydrogen Cyanamide. Plant Growth Regulation 43: 213-220.
20. Wang SY, Hong J, Miklos F (1991) Changes in Metabolic Enzyme Activities during Thidiazuron-Induced Lateral Budbreak of Apple. Hort Science 26(2): 171-73.

Citation: Juan MSP, Julio COM, Nubia G, Omar CPG, Mario ACO. Effect of Dormancy Disruptors in 'Golden Delicious' Apple on Development and Yield. *S J horti*. 2024;1(2):1–5. DOI: 10.51626/sjh.2024.01.00006