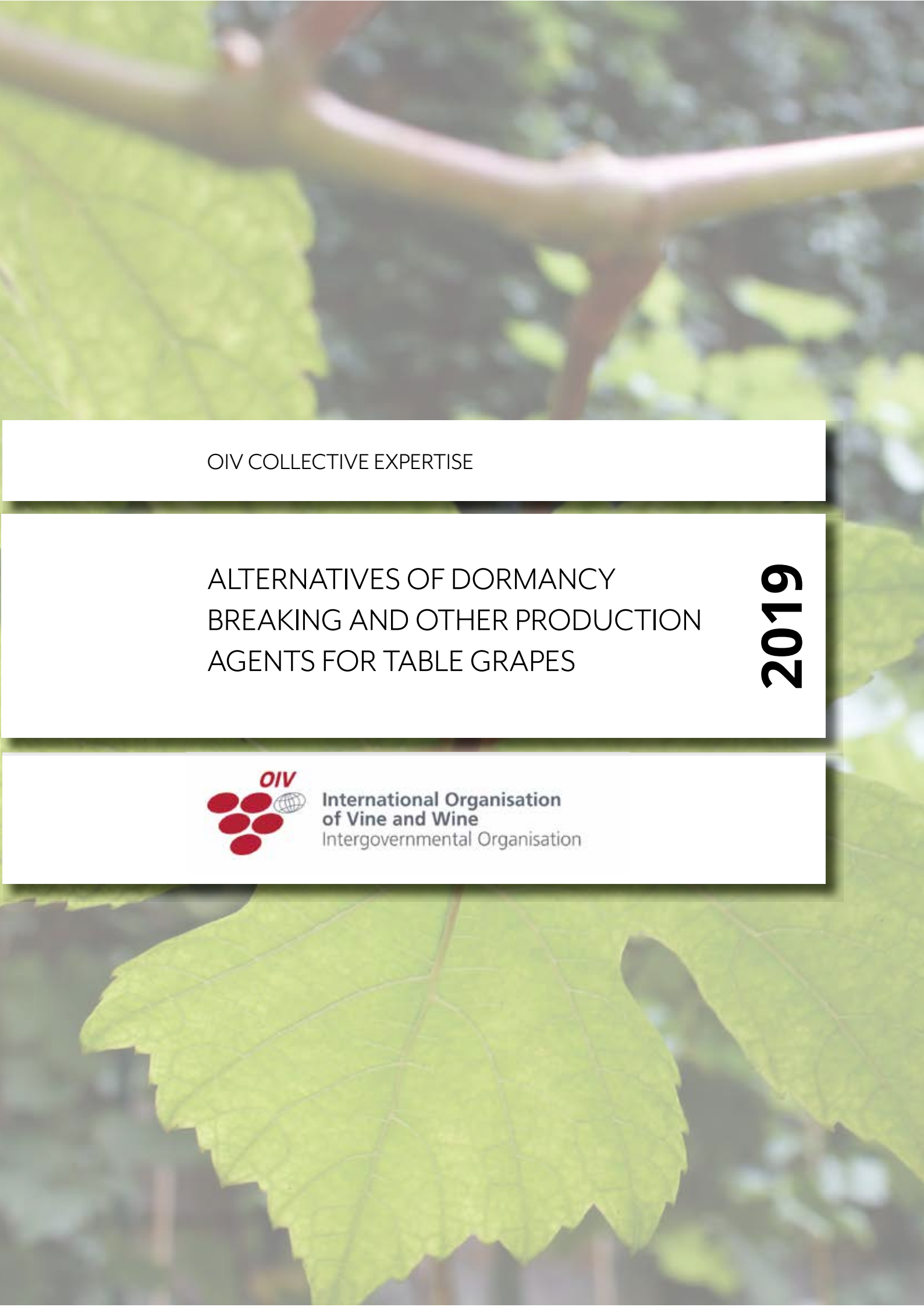

OIV COLLECTIVE EXPERTISE

ALTERNATIVES OF DORMANCY BREAKING AND OTHER PRODUCTION AGENTS FOR TABLE GRAPES

2019

International Organisation
of Vine and Wine
Intergovernmental Organisation

WARNING

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This document, drafted and developed on the initiative of the OIV, is a collective expert report.

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SCOPE

The Sub-commission Table Grapes, Raisins and unfermented vine products (SCRAISIN) has been lately concentrated around the alternatives to various inputs of the table grape production, either in the vineyard, or at the post-harvest level.

Although some indications are mentioned in the adopted Resolutions OIV-VITI 422-2011 (Specifications for the environmental aspects of sustainability for the table and dried grape sector) and OIV-VITI 607-2018 (OIV recommendations about the use of alternatives to synthetic products for dormancy breaking agents for table grape production), this document aims to gather more specific information on the alternatives for the inputs of the production of table grapes, mainly focusing on dormancy breaking agents.

This review is based on inputs from scientific literature and technical studies founded and also, thanks to the inputs and subsequent revisions made by some OIV experts of the SCRAISIN, such the following research group:

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1. INTRODUCTION

Bud dormancy is perhaps the most climate sensitive stage in the production cycle of grapevine.

Dormancy is an adaptive mechanism that enables woody plants to survive to the freezing temperatures of winter (Rady and Seif El-Yazal, 2014).

In recent years, it was shown that respiratory stress may be at least part, important player in the cascade that lead to grape bud dormancy release. A model was suggested that claim that this may induce/change hormonal interactions that may release dormancy and initiate growth (Or, E. unpublished).

Bud dormancy is based on three successive phases as follows (Lang *et al.*, 1987; Lavee, S and May, P., 1997). Mohamed *et al.*, 2012):

1.

Paradormancy is regulated by physiological factors within the plant but outside the dormant structure;

2.

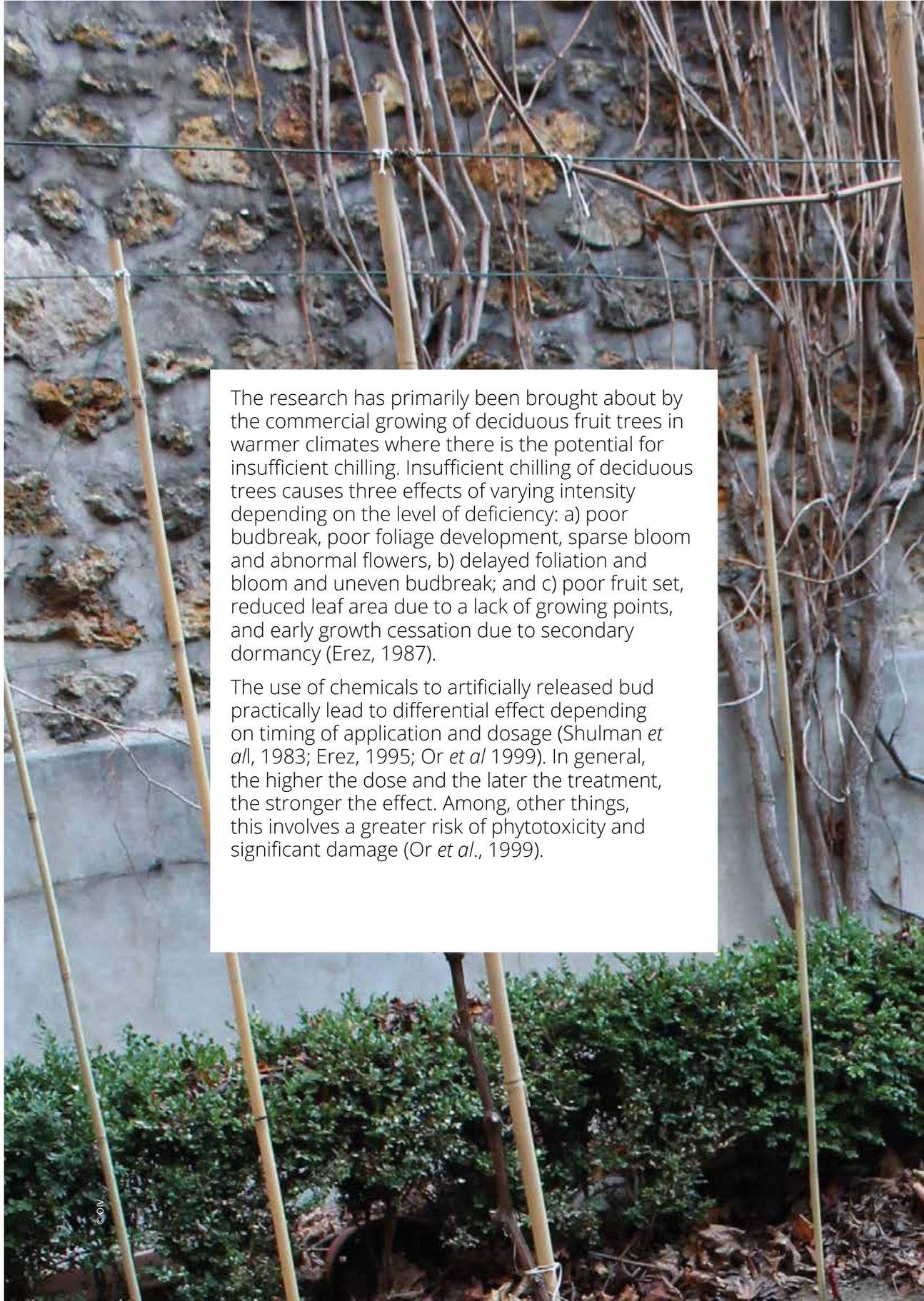
Endodormancy (coinciding with winter), which is regulated by physiological factors within the bud itself;

3.

Ecodormancy is an inhibition imposed by environmental factors after endo-dormancy release; it ends when warm temperatures cause ecodormant buds to burst.

4.

In grapevine, decreased photoperiod (Lang, G.A., 1987); Lavee and May, 1997) and/or low temperature are the main environmental cues that induce bud dormancy, while, endodormancy is broken upon exposure to chilling (Lavee and May, 1997; Dookzlian, N.K., 1999).



The research has primarily been brought about by the commercial growing of deciduous fruit trees in warmer climates where there is the potential for insufficient chilling. Insufficient chilling of deciduous trees causes three effects of varying intensity depending on the level of deficiency: a) poor budbreak, poor foliage development, sparse bloom and abnormal flowers, b) delayed foliation and bloom and uneven budbreak; and c) poor fruit set, reduced leaf area due to a lack of growing points, and early growth cessation due to secondary dormancy (Erez, 1987).

The use of chemicals to artificially released bud practically lead to differential effect depending on timing of application and dosage (Shulman *et al*l, 1983; Erez, 1995; Or *et al* 1999). In general, the higher the dose and the later the treatment, the stronger the effect. Among, other things, this involves a greater risk of phytotoxicity and significant damage (Or *et al*., 1999).

FACTORS

CHILING FACTOR

Cultivation of table and wine grapes in subtropical and tropical climates is complicated by problems associated with delayed and uneven bud break. Rest breaking agents, mainly hydrogen cyanamide, are applied to overcome these problems. This practice increases production costs in an industry where producers are already experiencing severe cost pressure (Avenant and Avenant, 2014).

The minimum chilling required to obtain a high bud break percentage (>80%) and even bud break in grapevines, was defined as 200 hours between 0 and 10 °C, or 400 hours at 3 °C. Results reported from previous studies indicated that when chilling exceed 400 h at 3 °C, the response of grapevines to H2CN2 is greatly reduced and that there is little benefit when H2CN2 is applied to vines grown in regions accumulating sufficient chilling because the bud break of non-treated vines in these regions is sufficient (Avenant and Avenant, 2014).

Example. Coachella model (Dokoozlian, 1999)

The Coachella model of Dokoozlian (1999) for quantifying chilling status of grapevines should be evaluated further for table grape productions regions. It can be used as a decision making tool in planning of dormancy management practices. This model is obtained by calculating the ratio between exposure to chilling temperatures (hours < 7 °C) and chill negating temperatures (hours >20 °C) from the month previous to bud break. According to this model, delayed bud break and reduced total bud break is expected with a chill to chill negation ratio< 0.5, while rapid and complete bud break is expected with a chill to chill negation ratio >2 (Avenant and Avenant, 2014).

Carbohydrate reserves in plants undergo seasonal fluctuations; they accumulate late during the growing season in perennial structures and they are used later during bud growth resumption. During dormancy, part of the starch reserves is hydrolyzed into soluble sugars by starch degrading enzymes in response to chilling. Therefore, it seems likely that carbohydrate reserves are the main source of energy for the metabolic changes that occur during the dormant period and for spring budburst (Mohamed *et al*., 2012).

It was suggested that the main cause of bud dormancy release is a transient disruption of respiration by hydrogen peroxide generated by rest breaking agents-induced oxidative stress. Moreover, several reports indicate that dormancy release in buds coincides with the increase in activity of peroxide scavenging enzymes and the upregulation of other antioxidant systems (Mohamed *et al*., 2012).

RESPIRATORY STRESS

The transition to bud burst can be accelerated by numerous sub-lethal stresses, including transient inhibition of respiration, heat shock or hypoxia (Or *et al*., 2009; Meitha *et al*., 2015). Respiratory stress is involved in the mechanism underlying the dormancy breaking effect of hydrogen cyanamide (H_2CN_2) and sodium azide in grapevine buds; indeed, reductions in oxygen levels (hypoxia) and inhibitors of respiration promote bud-break in grapevines (Rubio *et al*., 2014).

Sodium azide is a well-known inhibitor of mitochondrial respiration, stimulating bud-dormancy release in grapevines in a way similar to hydrogen cyanamide: this latter well-known dormancy release agent inhibited the O2 uptake in isolated grape bud mitochondria similarly to NaN3. Both stimuli also upregulated the transcription of 1,3-β-d-glucanase, a key enzyme in dormancy release. It suggests that as a consequence of O2 deprivation, increases in glycolysis and in ethanolic fermentation could be responsible for activation of downstream stages in the dormancy release mechanisms (Pérez *et al*., 2009).

In grapevines, respiratory stress is involved in the release mechanism of buds from endodormancy. Hypoxia induces budburst (Rubio *et al*., 2014), and H2CN2, a well-known dormancy-breaking compound, increases starch hydrolysis.

HOT WATER TREATMENT

Near-lethal heat stress brought about by soaking in hot water was found effective in releasing buds of woody plants from dormancy. Mohamed *et al*., (2012) have shown (in laboratory conditions) that treated cuttings reached 50% budbreak or more after 18 days of forcing (up to 94% after 30 days), while buds on control cuttings didn't reach this level even after one month of forcing.

DORMANCY BREAKING AGENTS AND ALTERNATIVES

VEGETAL EXTRACTS

Nowadays, chemical rest breakages as Dormex® and thioura are recommended for bud break induction and yield promotion in grapevines. Due to the great toxicity and expensive costs for these compounds, there is a necessity for searching of new natural agents for dormancy break that are easily available, effective, low toxic and used in low concentrations such as turmeric, cinnamon, ginger, colocynth, nigella, olive, clove, red chilies, coffee and garlic for their higher own content of volatile compounds, plant pigments, tannins, phenol compounds, plant pigments, antioxidants, vitamins and different nutrients (Ahmed *et al*., 2014).

Salicylic acid has an announced role in reducing the activity of catalase and increasing the release of H_2O_2. It is a new plant hormone and has been shown to interfere with the biosynthesis and / or action of ethylene, ABA, and cytokinins. Also, it is responsible for inhibiting abiotic stress (Ahmed *et al*., 2014).

Ahmed *et al*., (2014) have shown that using chemical rest breakages (such as H_2O_2, salicylic acid, thiourea or Dormex®) was significantly superior than using the ten plant extracts in breaking dormancy and enhancing percentages of bud break and fruiting buds.

The active substances occurred in turmeric, cinnamon, ginger, colocynth, nigella, olive, clove, garlic, red chilies and coffee that are responsible for breaking bud dormancy in grapevines are sulfur containing compounds (allyl group and mono- di' tri and tetra sulfides), volatiles, tannins, phenols antioxidants, vitamins, amino acids and plant pigments; cysteine acts as a precursor for the synthesis of all other organic compounds containing reduced Sulphur as well as for other biosynthesis pathways such as the formation of ethylene. Also, the great biosynthesis of GA3 and IAA during dormancy period surely reflected on terminating bud dormancy. The beneficial effects of salicylic acid on enhancing H_2O_2 and natural hormones and reducing ethylene biosynthesis could explain this effect (Ahmed *et al*., 2014).

Therefore, these studies show some beneficial effects of plant extracts on terminating bud dormancy and enhancing fruiting of Superior grapevines, using these plant extracts as a partial replacement of chemical rest breakages.

a) Garlic extracts

Garlic extracts are not only used for fungi and pathogen control such as anthracnose (Elsinoe ampelina; Botelho *et al*., 2009). Foliar applications of onion and garlic bio-extracts usually content volatile compounds from S-methyl cysteine sulfoxide, which could promote an increment of bud break from all cultivars. The compounds from garlic that stimulated bud break in grapevines include Sulfur in their molecules (Vargas-Arispuro *et al*. 2008); therefore it is assumed that Sulfur could play a key role in breaking bud dormancy of grape cultivars.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Kubota and Miyamuki (1992) verified that garlic paste applied to cane cut surfaces of 'Muscat of Alexandria' grapevines, immediately after pruning, was more efficient than calcium cyanamide ($CaCN_2$), a substance typically used for vines in Japan. Satisfactory results were also obtained with 20% garlic oil in 'Pione' and 'Thompson Seedless' grapevines (Kubota *et al*., 2000). Botelho *et al*. (2007), observed 37% and 75% sprouted buds in cuttings of grapevines cv. Cabernet Sauvignon sprayed with garlic extract 3%, submitted to 0 and 168 chilling hours (=7,0 °C), respectively, but this treatment were less effective than hydrogen cyanamide (Botelho *et al*., 2010).

On the other hand, it could be mixed with hydrogen cyanamide or hydrogen peroxide with success in regarding with the number of shoots per plant or sprouting percentage (Saavedra del Aguila *et al*., 2015).

In apple trees, results shown that all garlic treatments reached on 50% bud break through foliar application when they were compared to the control. These earliness reached about 30 days over the control for garlic extract applied between 5 and 20% (Rady and Seif El-Yazal, 2014).

b) Dormant Oil

Spraying of dormant trees with Winter Oil or Summer Oil at the traditional concentrations of 2% (i.e. 20L/1000L).

c) Naphthaleneacetic Acid and Vegetable Oil

Grapevine (cv. 'Edelweiss') dormant canes were treated with naphthaleneacetic acid (NAA) between forcing solutions at 500- 1500 mg/L with vegetable oil 10% v/v, and the non-treated control. Results showed a month, bud position, and treatment interaction. NAA at 1000 ppm significantly delayed bud break 7 days and 5 days using NAA at 1500 ppm. Shoot length was not affected (Qrunfleh and Read, 2013).

FERTILIZERS AND CHEMICAL PRODUCTS

a) Nitrogen fertilizer and CaO

Very common in table grapes production under applications of 100-150 kg/ha (= 5-7 L/ha; employing 100L/ha of water) 4 weeks before budbreak desired date.

b) Surfactants

Bud break rate increase and seems to be highly sensitive to surfactants addition until 2% of product, when it was used with H2CN2 (Dookozlian et al., 1998). Therefore, the addition of surfactants can significantly reduce the amount of active ingredient (H2CN2 solutions) necessary for maximum efficacy on grapevines. Hydroxypolyoxyethylene-polyoxypropylene-ethylalkylamine, Alkyl-polyoxyethylene-ether or paraffin petroleum oil are some of the chemical surfactants commonly used nowadays.

CROP PRODUCTION – USE OF HORMONES

a) Abcisic acid (ABA)

ABA levels increase in the autumn and act as a signal of shorter day-length inducing of the endodormancy. Previous studies proposed a central role for abscisic acid in the repression of bud meristem activity, and suggested its removal as a critical step in the hydrogen cyanamide (HC) induced cascade. Zheng et al., (2015) demonstrated that ABA indeed inhibits dormancy release in grape (Vitis vinifera) buds and attenuates the advancing effect of HC. However, HC-dependent recovery was detected, and was affected by dormancy status. It seems clear that the relationship between exogenous and endogenous ABA, and also, the HC activity can modulate the reponse to endodormancy and full budbreak capacity.

b) CCC chlorocholine chloride

c) Alghe (natural substances containing hormones)

d) Ethylene and cytokinins.

Paiva and Robitaille, 1978, cited by Lavee and May (1997) said that “in grapevine, however, ethylene was found to be ineffective in releasing buds from dormancy”. Lavee and May (1997) said that the growth substances are not the primary factors controlling the time of dormancy and post dormancy.

AGRONOMIC PRACTICES

Reduction of the dormancy period and the advance of bud break it’s possible with a severe water stress during berry development: in Malbec with irrigation of 35% ETc and 70% ETc from the phenological phase of pea-size in comparison with 100% ETc the chilling accumulation has been 120 chill units for the 35% ETc, 220 for the 70% and 320 for the well-watered vines (Shelli *et al*., 2018).

Covering with plastic film the vineyard at the end of the chill unit accumulation can shorter the ecodormancy by increasing the air temperature inside the cover vineyard, advancing bud breaking up to 40-50 days (Novello *et al*., 2000; Novello and de Palma, 2008).

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