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Research Article

Bud-Break Dormancy and Improve Productivity of 'Flame Seedless' Grapevines in Response to Some Plant Extracts

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Abstract:

This research was conducted on ten-year-old 'Flame Seedless' grapevines (*Vitis vinifera* L.) grafted on 'Freedom' grape rootstocks in clay soil under a flood irrigation system at a private grape orchard, El-Baramon Experimental Farm, located at the Horticulture Research Institute, Egypt. 31°11′98″ N, 31°45′13′ E, for two seasons, 2023 and 2024. Dormex at a rate of 3% and some plant extracts at a rate of 10% (garlic, onion, licorice, and seaweed extracts) were foliar spray treatments in the fourth week of January. The results showed that spraying dormex at a rate of 3% had the earliest date of bud burst stage, date of vegetative growth stage, date of flowering stage, and harvest stage and increased bud burst percentage, bud fertility percentage, and number of clusters, followed by onion and garlic extract at a rate of 10%, followed by licorice extract at a rate of 10%, and followed by seaweed extract at a rate of 10%. Dormex at a rate of 3% and some plant extracts at a rate of 10 % improved vegetative growth, yield per vine, cluster weight, cluster length, and hundred-berry weight. Application of seaweed extract at a rate of 10 % gave the highest vegetative growth parameters.

1. Introduction

The grapevine is widely grown in subtropical regions. In these regions, the bud-break chilling requirements still need to be met, resulting in late leafing, irregular sprouting, decreased yield, uneven maturation, and delayed harvests, which result in severe economic losses. Delaying the bud break of grapes, as well as irregularities, directly leads to delaying the harvesting time. Also, shortening the Egyptian exporting window and delaying vines entering dormancy during the following year leads to several physiological defects that may affect weakness and threaten grapevine productivity (Persico et al., 2021). According to several studies (Muhtaseb and Ghnaim, 2008), hydrogen cyanamide, an effective rest-breaking treatment for grapevines, has been used successfully to supplement chilling and improve bud burst and fertility percentage, growth, and yield, and the efficient role of hydrogen cyanamide as a plant growth regulator that supplements chilling and causes earlier and more uniform bud break (Cline, 2003) improves yield (Hussein, 2009). Hydrogen cyanamide is toxic, and its use has either already been banned or is predicted to be banned in several countries (Sheshadri et al., 2011). This is especially concerning as markets are sensitive, emphasizing the importance of looking for environmentally friendly production practices for grape products. Therefore, finding a replacement for hydrogen cyanamide in *V. vinifera* CS should be a priority for the Egyptian agricultural sector (Venter et al., 2024). The hydrogen cyanamide substance is extensively used to stimulate bud break in vineyards. In searching for alternative methods,we have exposed a positive effect of plant extracts such as garlic, onion extracts, licorice (*Glycyrrhiza glabra* L.), and seaweed extract in enhancing bud break in grapevines (Or et al., 1999 and Vasconcelos et al., 2007). Plant extracts are new, natural, multi-component products that can be used as "auto chemical stress agents" to enhance the resistance of cultivated plants to biotic and abiotic stresses, increase yield and quality in healthy fruit crops (Mira et al., 2024) and reduce the use of mineral fertilizers and pesticides, while at the same time protecting the environment from pollution (Rady and Seif El-Yazal, 2013).

Garlic extract active compounds like S-methyl cysteine sulfoxide, dimethyl disulfide, and allyl sulfides stimulate bud break and influence sugar/amino acid levels (Kubota et al., 1999 and Vargas et al., 2008). Onion extract improves flowering, yield, and chemical composition of various fruits due to sulfur-containing compounds and antioxidants (Botelho et al., 2010 and Abd El-Khalek et al., 2023). Licorice extract is rich in over 100 bioactive compounds, including triterpene saponins, glycyrrhizin, amino acids, vitamins, sugars, and minerals. Mimics GA_3-like effects reduce water loss and enhance vegetative growth, flowering, and fruit quality (Shabani et al., 2009 and Nasser et al., 2014). Proven to improve growth and yield when applied with garlic extract (Qaraghouli and Jalal, 2005). Seaweed extract Contain auxins, cytokinins, betaines, gibberellins, amino acids, vitamins, and trace elements. Enhance bud-break, plant metabolism, and overall crop productivity (Arioli et al., 2015 and Amer et al., 2019). So, the goal of the present investigation is to find cheap alternatives and natural for dormex and examine the effects of using these natural extracts on the yield, fruit quality, and breaking dormancy of Flame Seedless grapevines.

2. Materials and methods

2.1. Plant Material, Vineyard Site, and treatments

This study was conducted on 9-year-old 'Flame Seedless' grapevines grafted on freedom rootstocks in the vineyard of the EL-Baramon experimental farm Horticulture Research Institute, Agricultural Research Center, Al-Baramon, Mansoura, Dakahlia, (31°11′98″ N, 31°45′13″ E, 15 m elevation above sea level) in Egypt over two consecutive seasons (2023 and 2024). The vineyard was in clay soil without an artificial drainage system and had a groundwater table of 1.5 m. Soil samples were randomly collected from the root zone (0-90 cm) for analysis, according to the methodology adopted in the study of Wilde et al. (1985), and are displayed in Table 1.

For this experiment, 54 uniform vines with a spacing of 2 × 3 m and no indications of nutrient deficits or physiological abnormalities were selected. Using a quadrilateral cordon training technique using spur, grapevines were cultivated in a Spanish baron trellis. By mid-January in both seasons, winter pruning was completed by limiting the number of spurs on each vine to twelve 5-bud spurs and four 2-bud renewal spurs, for a total of 68 buds per vine. The same standard agricultural techniques were used for all of the chosen grapevines, just as they were for the un treated.

The vines were subjected to foliar spray treatments in the fourth week of January as follows:

1- Control (sprayed with distilled water).
2- Spraying with dormex at 3%
3- Spraying with garlic extract at 10%
4- Spraying with onion extract at 10%
5-Spraying with licorice extract at 10%
6-Spraying with Seaweed extract at 10%

The chemical components of the extracts used are shown in Table 2.

Applications were carried out using a 25-liter knapsack power sprayer (Model HT-767; Taizhou Tianyi Agricultural and Forestry Machinery Co., Zhejiang, China).

Spray all treatments with 250 g of micronized sulfur per 100 liters of water one day before treating.

Table 1. Soil analysis

Depth (cm)	0–30	30–60	60–90
Clay (%)	49.25	50.55	51.15
Silt (%)	27.69	26.72	26.11
Sand (%)	23.06	22.66	21.55
Texture	Clay	Clay	Clay
Field capacity (%)	15.3	15.7	15.8
Permanent wilting point (%)	7.4	7.6	7.7
pH (1:2.5 extract)	7.7	7.11	7.11
Organic material (%)	2.3	0.55	0.35
E.C. (dS/m) [1:5 extract]	0.61	0.61	0.61
$CaCO_3$ (%)	1.83	1.41	1.88
HCO_3^- (meq/100 g)	0.30	0.37	0.40
CO_3^{2-} (meq/100 g)	0.0	0.0	0.0
SO_4^{2-} (meq/100 g)	3.17	4.04	4.13
Cl^- (meq/100 g)	0.96	0.98	1.08
Na^+ (meq/100 g)	0.48	0.66	1.42
Ca^{2+} (meq/100 g)	0.80	0.20	1.25
Mg^{2+} (meq/100 g)	0.33	0.97	1.16
N (mg/kg)	32	24	18
P (mg/kg)	13	22	13
K (mg/kg)	271	240	230
Fe (mg/kg)	2.48	2.21	2.11
Mn (mg/kg)	4.10	3.50	3.21
Zn (mg/kg)	1.18	0.61	0.51
Cu (mg/kg)	4.24	2.10	0.75

Table 2. Chemical components of the extracts plant used.

Garlic extract		Onion extract		Licorice extract		Seaweed extract	
Compounds	**mg/100g**	**Compounds**	**mg/100g**	**Compounds**	**mg/100g**	**Compounds**	**mg/100g**
Diallyl sulfide	33.67	**1-Propenyl propyl**	7.26	Total phenol	405	Organic matter	530
Diallyl disulfide	10.31	**Methyl propyl trisulfide**	5.2	Mg	174.7	N	13
Allyl methyl sulfide	8.96	**Menthone**	0.34	Total flavonoids	114.9	P	0.4
3-vinyl-1,2-dithiole-5-cyclohexene	28.19	**Methyl propyl trisulfide**	0.47	Ca	104.6	K	110
Vinyl-1,2-thia-4- cyclohexene	10.26	**Dimethyl tetrasulfide**	0.15	Tannins	47.5	Ca	0.7
Methyl sulfide	8.6	**Dipropyl trisulfide**	17.1	Saponins	27.9	Mg	0.4
		Eugenol	3.07	Carotenoids	11.8	S	3
		2-Methyl-3,4-dithiaheptane	6.48	Vitamin C	1.2	Zn (ppm)	55
		Dipropyl tetrasulfide	0.55	K	341.5	Fe (ppm)	125
		Dipropyl disulfide	30.92	Na	122.8	Mn (ppm)	8
		Allyl propyl sulfide	0.42	Zn	0.4		
		Dimethy trisulfide	0.3	Mn	0.4		
				Fe	1.2		
				Cu	0.18		

The tested vines of both cultivars were sprayed with plant extract at 10%, hydrogen cyanamide (H_2CN_2 - dormex) at 3%, and control (spray with water). Treatments were rearranged in randomized complete block designs each one replicated with three vines for both cultivars

The recorded measurements during the two experimental seasons.

2.2. Date of phonological stages

During the growing season, the beginning of the phenological stages of the grapevine was recorded of the three tested genotypes

1. Date of bud burst stage (days).
2. Date of vegetative growth stage (days).
3. Date of flowering stage (days).
4. Date of Harvest stage (days).

2.3. Bud behavior parameters

The numbers of total buds were recorded during pruning time (mid-January), while the number of dormant buds and the number of bursted buds were recorded after bud break (the week of March), as follows:

3.3.1. Bud burst (%): The percentage of bud burst was computed by dividing the number of burst buds by the total number of buds remaining per vine and multiplying by 100.

3.3.2. Dormant bud (%): dormant bud percentage is calculated by dividing the number of dormant buds per vine by the total number of buds per vine (×100).

3.3.3. Bud fertility (%): The number of clusters per vine divided by the total number of buds per vine × 100).

3.3.4. The number of fruitful buds: the number of fruitful buds per vine (buds which gave at least one cluster).

2.4. Vegetative growth

At the stage of pea-size berries or approximately during the second week of May (≈10–13 days after fruit set), the number of leaves per shoot was counting, four non-fruiting shoots off the renewal spurs were randomly marked; two shoots at each side of the vine to measure shoot length (cm), using a 1000 cm wind-up measuring tape (Fisher Scientific, Waltham, MA, USA), and calculate the average shoot length (Elaidy et al., 2025). The mature leaves (i.e., the 6th and 7th from the shoot tip) on each selected shoot were collected to measure leaf area (cm^2) using a LI-3100 leaf area meter (LI-COR, Inc., Lincoln, NE, USA).

2.5. Yield

All clusters were harvested when SSC reached 16–17° Brix. The soluble solids content was determined using a hand-held refractometer 0-32%, Model N-1E (Atago Co., Ltd., Tokyo, Japan). Twenty-five clusters of each vine in a replicate were weighed using a standard field digital scale [200 kg capacity] (VEVOR Equipment and Tools, Rancho Cucamonga, CA, USA). Subsequently, the average yield per vine (calculated as the product of cluster weight multiplied by the number of clusters per vine) was determined in kilograms per vine. Additionally, average cluster weight (grams) and average weight of 100 berries (grams) were calculated.

2.6. Statistical analysis

Data were first examined using the Shapiro-Wilk and Levene testing for numerical normality and homogeneity of variance, respectively. Prior to conductinganalysis of variance (ANOVA), percentage data were first converted to the values of the Arcsine square root. The outcomes were then shown as back-transformed means. The CoStat software packaging, version 6.311 (CoHort software, Monterey, CA, USA), was used for carrying out the ANOVA. Tukey's honestly significant difference (HSD) test was used to conduct mean comparisons at probability (p) < 0.05 (Snedecor and Cochran, 1990).

3. Results and Discussion

3.1. Dates of phonological stages

Table 3 indicates that the dormex and some plant extracts differ in the date of the bud burst stage, vegetative growth stage, flowering stage, and harvest stage compared to the control in both seasons of Flame Seedless grapevines. Dormex, at a rate of 3%, had the earliest (date of bud burst stage, date of vegetative growth stage, date of flowering stage, and harvest stage), followed by onion and garlic extract at a rate of 10%, followed by licorice extract at a rate of 10% followed by seaweed extract at a rate of 10%. According to El-Yazal et al. (2021), dormex and certain plant extracts sprayed on apple trees cause the bud break to begin earlier than on the control. According to Khalil-Ur-Rehman et al. (2020), garlic extract and hydrogen cyanamide have been successfully utilized to accelerate bud breaking and encourage early ripening in deciduous fruit trees (Leonel et al., 2016 and Elaidy et al., 2024). Other dormancy-breaking substances can be used with hydrogen cyanamide. After treating "Early Maycrest" peach plants with hydrogen cyanamide, Campoy et al. (2011) noted that the plants bloomed and were harvested earlier than expected.

3.2. Bud behavior parameters

Table 4 indicates the effect of dormex and some plant extracts on bud burst%, bud fertility%, coefficient of fruitful buds, and number of clusters of Flame Seedless grapevines. Dormex at 3% increased bud burst%, bud fertility%, and number of clusters, followed by onion extract at 10%, followed by licorice extract at 10%. On the other hand, vines treated with onion extract at a rate of 10% produced the maximum coefficient of fruitful buds. Control (sprayed with distilled water) gave the lowest bud burst%, bud fertility%, coefficient of fruitful buds, and number of clusters in comparison to other treatments.

Extracting plants and H_2CN_2 enhanced the breaking of dormancy and sprouting of intact dormant grapevine buds. The process of breaking the bud dormancy is triggered in nature by low temperatures (Shulman et al., 1983). The chemical mechanism by which hydrogen cyanamide acts on grapevine compound buds has been the subject of a substantial amount of research up to this point (Petri et al., 2014). H_2CN_2 suppresses catalase (CAT), which causes the buds to become hypoxic. This leads to fermentative metabolism, which raises reactive oxygen species (ROS) and nitric oxide (Beauvieux et al., 2018). Transcription factors that upregulate growth and differentiation-related genes are triggered by the ensuing ROS and NO species signaling (Liang et al., 2019).

Onion and garlic extract increased the studied vine's availability of certain nutrients, particularly sulfur, which is why these favorable results were obtained (Rady and Seif El-Yazal, 2013). According to Kubota et al. (1999), exposure to diallyl di- and tri-sulfide volatiles was the most efficient way to encourage bud break in this regard, regardless of exposure duration or concentration.

Table 3. Effect of dormex and some plant extracts on dates of phonological stages of 'Flame Seedless' grapevines

	Treatments	Date of the end bud burst stage		Date of the end bud vegetative growth stage		Date of the end bud flowering stage		Date of Harvest stage	
		2023	2024	2023	2024	2023	2024	2023	2024
T1	**Control (sprayed with distilled water)**	29th Mar.	31th Mar.	25th April.	27th April.	10th May.	12th May.	15th July	20th July
T2	**Spraying with dormex at 3%**	15th Mar.	17th Mar.	10th April.	12th April.	1th May.	2th May.	5th July	12th July
T3	**Spraying with onion extract at 10%**	24th Mar.	26th Mar.	15th April.	17th April.	4th May.	5th May.	10th July	15th July
T4	**Spraying with licorice extract at 10%**	26th Mar.	28th Mar.	16th April.	18th April.	8th May.	10th May.	15th July	20th July
T5	**Spraying with garlic extract at 10%**	24th Mar.	26th Mar.	15th April.	17th April.	4th May.	5th May.	10th July	15th July
T6	**Spraying with Seaweed extract at 10%**	28th Mar.	30th Mar.	23th April.	24th April.	8th May.	10th May.	15th July	20th July

Table 4. Effect of dormex and some plant extracts on bud burst, bud fertility, coefficient fruitful buds and number of clusters of 'Flame Seedless' grapevines

	Treatments	Bud burst (%)		Bud fertility (%)		Coefficient fruitful buds		Number of clusters	
		2023	2024	2023	2024	2023	2024	2023	2024
T1	**Control (sprayed with distilled water)**	74.90 d	74.90 d	52.90 d	49.97 e	0.65 ab	0.64 b	34 e	36 c
T2	**Spraying with dormex at 3%**	93.13 a	95.57 a	66.10 a	66.50 a	0.70 ab	0.68 ab	45 a	45 a
T3	**Spraying with onion extract at 10%**	88.2 ab	90.60 ab	65.60 ab	63.20 ab	0.70 ab	0.72 a	43 ab	45 ab
T4	**Spraying with licorice extract at 10%**	82.35 bc	84.31 bc	60.78 bc	58.80 bc	0.71 a	0.72 a	40 bc	41 b
T5	**Spraying with garlic extract at 10%**	79.41 cd	82.35 c	57.83 cd	56.80 cd	0.71 a	0.70 ab	39 cd	39 b
T6	**Spraying with Seaweed extract at 10%**	80.00 cd	79.40 cd	54.40 cd	51.40 de	0.64 b	0.68 ab	35 de	37 c

Means in each column followed by the same letter (s) are not significantly different at 5 % level according to Tukey's HSD Test.

The bioactive components of licorice extract, including phenols, flavonoids, saponins, and effectiveness in encouraging budbreak. According to Koyuncu et al. (2013). These phytochemicals are thought to be essential for overcoming dormancy, perhaps via mechanisms similar to those activated by hydrogen cyanamide, as proposed by Pérez and Lira (2005). Seaweeds are employed as biofertilizers to compensate for soil nutrient deficiencies. Seaweed extract includes regulators, plant growth hormones, carbohydrates, auxins, gibberellins, and vitamins, which can help to improve crop productivity and maintain fertility. These results are in line with those of El-Sawy (2009) on "Superior Seedless" grapevines and Hussein et al. (2021) on tomato plant.

3.3. Vegetative growth

The data provided in Table 5 suggested that treating the vines with dormex and some plant extracts significantly optimized the leaf area, number of leaves/shoot, shoot length total, and chlorophyll content in leaves compared with the control. The maximum values in the leaf area (149 and 152 cm^2), number of leaves/shoot (23.3 and 23.8), and shoot length (167 and 170 cm) were recorded by spraying with seaweed extract at 10%, followed by dormex at 3%, followed by garlic extract at 10% in both seasons, respectively. Non-significant differences between the used 10% seaweed extract and 3% dormex on the number of leaves/shoot and total chlorophyll content in leaves in both seasons were clear. Control (sprayed with distilled water) gave the lowest leaf area, number of leaves/shoot, shoot length total, and chlorophyll content in leaves in comparison to other treatments. Seaweed extract is rich in cytokinins, IAA, GA_3, amino acids, polysaccharides (like laminarin), and nutrients. These stimulate polyamine synthesis, promoting cell division and elongation, leading to increased shoot length and leaf area (Colavita et al., 2011). Onion extract enhances H_2O_2 levels by inhibiting catalase and boosting respiration (Foyer and Halliwell, 1976). Triggers proline accumulation, which supports bud break by acting as a nutrient source during stress recovery. Licorice extract contains GA_3-like compounds (e.g., glycyrrhizin, saponins) that break down complex molecules, aiding in protein synthesis and enhancing vegetative growth and flowering (Shabani et al., 2009). Dormex (H_2CN_2) is a highly effective chemical treatment that ensures uniform and early bud break, improving bud burst %, shoot growth, leaf area, and wood development. Its efficacy is concentration-dependent, as supported by multiple studies.

Table 5. Effect of dormex and some plant extracts on the leaf area, number of leaves/shoot, shoot length of 'Flame Seedless' grapevines

	Treatments	Leaf area (cm^2)		Number of leaves/shoot		Shoot length (cm)	
		2023	2024	2023	2024	2023	2024
T1	**Control (sprayed with distilled water)**	117 e	119 e	18.6 d	19.0 d	133 e	136 c
T2	**Spraying with dormex at 3%**	139 b	141 b	22.6 a	23.1 ab	161 b	166 a
T3	**Spraying with onion extract at 10%**	127 cd	129 cd	20.5 c	21.4 bc	147 c	153 b
T4	**Spraying with licorice extract at 10%**	121 de	124 e	20.0 c	21.2 c	140 d	151 b
T5	**Spraying with garlic extract at 10%**	133 bc	136 bc	21.4 b	22.3 abc	156 b	159 ab
T6	**Spraying with Seaweed extract at 10%**	149 a	152 a	23.3 a	23.8 a	167 a	170 a

Means in each column followed by the same letter (s) are not significantly different at 5 % level according to Tukey's HSD Test.

Table (6). Effect of dormex and some plant extracts on b cluster weight, yield/vine, cluster length, and average 100 berry weight of 'Flame Seedless' grapevines

	Treatments	Cluster weight (g)		Yield/vine (kg)		Cluster length (cm)		Average 100 berry weight	
		2023	2024	2023	2024	2023	2024	2023	2024
T1	**Control (sprayed with distilled water)**	485.6 c	489.6 d	19.5 b	19.6 c	22.0 b	23.0 b	205.0 c	211.0 c
T2	**Spraying with dormex at 3%**	519.3 bc	524.3 bc	23.4 a	23.4 a	25.3 a	26.3 a	225.3 b	231.3 b
T3	**Spraying with onion extract at 10%**	516.0 bc	521.0 bcd	22.2 ab	23.4 a	26.0 a	27.0 a	224.0 b	229.6 b
T4	**Spraying with licorice extract at 10%**	492.0 c	499.6 cd	19.7 b	20.6 b	25.3 a	25.6 ab	216.6 bc	222.6 bc
T5	**Spraying with garlic extract at 10%**	535.3 ab	540.3 ab	20.7 ab	21.3 b	27.0 a	27.3 a	232.3 ab	239.0 ab
T6	**Spraying with Seaweed extract at 10%**	563.3 a	568.3 a	19.7 b	20.6 b	27.6 a	28.0 a	244.6 a	251.7 a

Means in each column followed by the same letter (s) are not significantly different at 5 % level according to Tukey's HSD Test.

3.4. Yield and Physical properties of cluster

Table 6 indicates the effect of dormex and some plant extracts on cluster weight, yield/vine, cluster length, and 100 berry weights of Flame Seedless grapevines. Vine treated with seaweed extract at a rate of 10% produced maximum values of cluster weight (563.3 and 568.3 g), cluster length (27.6 and 28 cm), and 100 berry weight (244.6 and 251.66 g). On the other hand, Dormex at 3 gave maximum values in yield/vine (23.37 and 23.42 Kg), followed by onion extract at 10%, followed by licorice extract at 10%. Besides, the statistical analysis declared no significant differences in the cluster length between treatments in the two seasons except control. Sprayed with distilled water gave the lowest cluster weight, yield/vine, cluster length, and width in comparison to other treatments.

Dormex (hydrogen cyanamide) stimulates early and uniform bud break, increasing leaf area and overall photosynthetic capacity (Abo-Elwafa et al., 2016). Reflect on enhanced yield, cluster number, weight, and quality traits across several cultivars (Abdalla, 2007 and El-Halaby, 2006). Garlic Extract Proven effective in breaking bud dormancy and improving yield and fruit quality in both grapes and peaches .3% garlic extract notably increased cluster number and weight in multiple grape cultivars (Khan et al., 2012). Seaweed extract improves vine vigor, yield, and fruit quality in various table grape cultivars (Arioli et al., 2015). Licorice extract rich in vitamins, macronutrients, and mevalonic acid, mimicking GA_3 effects. Enhances water and nutrient uptake, boosting fruit yield and quality (Alsalhy and Aljabary, 2020).

4. Conclusion

Dormex spraying at a rate of 3% had the earliest dates of bud burst, vegetative growth, flowering, and harvest stages. It also increased the number of clusters, bud burst percentage, and bud fertility percentage. Onion and garlic extracts came in second and third at 10%, respectively, followed by licorice extract and seaweed extract at 10%. Dormex 3% and certain plant extract 10% enhanced vegetative growth, yield per vine, cluster weight, cluster length, and hundred-berry weight. Applying seaweed extract at a rate of 10% improved vegetative development characteristics.

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