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Acceleration of Breaking Buds Dormancy on Apricot Trees by Using Alternatives of Hydrogen Cyanamide (Dormex) and Assessment of Resulting Fruits Quality

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A R T I C L E I N F O

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A B S T R A C T

The purpose of this research was to determine the effectiveness of alternatives of dormex on apricot budbreak and their effect on apricot fruit quality. Our study was carried out on five-years old "Canino" apricot at Badr district, El Behira Governorate, Egypt, during the two seasons 2022 and 2023, respectively. Twenty-four uniform apricot trees were selected and sprayed to the runoff once on 20 and 25 January during 2022 and 2023, respectively, by following treatments: control, mineral oil at 2%, low pyrite urea at 2%, ammonium nitrate at 1.5%, potassium nitrate at 2%, mineral oil combined with low pyrite urea at the same concentration of 2%, mineral oil at 2 % combined with ammonium nitrate at 1.5 %, mineral oil combined with potassium nitrate at the same concentration of 2%. For each of the treatments that were used, 0.05% (v/v) of the non-ionic surfactant tween 80 was applied. In both seasons, the use alternatives dormex chemicals resulted in better budbreak than control trees especially the formulation of mineral oil at (2%) plus potassium nitrate (2%).

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Introduction

Cultivation of low chill fruit trees has been widely adopted in the last few years especially in arid regions. However, late bud opening and the need to break uniformly at the end of-dormancy have encouraged many growers to use chemicals that stimulate bud opening. Many growers lately have been using Dormex (hydrogen cyanamide) to break bud dormancy. However, there has been a reduction in using Dormex since 2008. Countries within the European Union have prohibited the use of hydrogen cyanamide due to its high toxicity (EFSA, 2010). In searching for alternatives to Dormex, one must consider efficiency, low environmental and plant toxicity, as well as low cost of use these three primary desirable qualities that were reported by (Erez, 2000) that must be available in the new bud breaking agents. Thus, the use of Dormex has been ceased because of its extreme toxicity even though its use is still going on in many countries as a mean to break bud dormancy, not only in grapevine, but also in other deciduous trees such as peach, plum, nectarine and apple trees.

This research focuses on the use of some relatively new agents especially combinations that could have synergistic effects on Canino apricot trees to break their bud dormancy especially following a relatively warm winter to be able to harvest early which increases the potential of gaining higher marketing value since this crop has the potential to marketing in Egypt and in many Arab countries in addition the export. The use of potassium, low concentration of ammonium and low pyrite urea in combination with summer-mineral oil in a synergistic formulation could raise the buds respiration and provide the growers with an application in their hands and provide an economic treatment.

Therefore, the aims of this research were to provide the apricot growers with an effective alternative to application of Dormex that is applicable on a field scale with one spray. It is also desirable to have a synergistic influence of certain combination which means lower cost with high efficacy. It is also a plus to have higher quality fruits as compared with the control.

Materials and Method

This study was completed in both of the seasons 2022 and 2023 respectively. using five years old “Canino” apricot trees cultivar (*Prunus armeniaca* L) spaced at 4×5 m and grown under drip irrigation system in a private orchard at Badr distrect, El Behira Governorate, Egypt. Trees were subjected to conventional agricultural methods throughout the season. The soil had a sandy texture and a drip irrigation system was implemented. The treatments were organized using a fully randomized block design. Each treatment was replicated three times, with one apricot tree representing each replication. A total of twenty-four trees, including the control group, were used in this study for each season. A total of twenty-four “Canino” apricot trees were randomly allocated to one of eight treatments. The treatments were administered by spraying the trees once on January 20th and January 25th in both 2022 and 2023. Twenty four apricot uniform trees were selected and sprayed by one of following treatments:

- Control (sprayed with water).
- Mineral oil at 2% (v/v) (K.Z (oil in miscible type) developed by Kafer El-Zayat pesticides & Chemicals Co.,)
- low pyrite urea at 2% (w/v)
- Ammonium nitrate at 1.5% (w/v)
- Potassium nitrate at 2% (w/v)
- Mineral oil combined with low pyrite urea at the same concentration 2%.
- Mineral oil at 2 % combined with ammonium nitrate at 1.5 %.
- Mineral oil at 2% combined with potassium nitrate at 2%.

To each of the treatments that were used, 0.05% (v/v) of the non-ionic surfactant tween 80 was applied. The trees received the usual standard horticulture practices of fertilization, irrigation and pruning. Trees had labeled ten shoots all around the canopy where five at the northern half of tree canopy and other five shoots at the southern half of canopy. Randomized complete block designs (RCBDs) were used to organize these treatments.

The following parameters were determined to evaluate the tested treatments:

- *Buds manner:* Start of bud burst was recorded for each treatment. The numbers of total buds and opened buds were counted and the percentage of opened and closed buds were calculated.
- *Chemical characteristics:* A Carl-Zeiss hand refractometer was used to measure the percentage of total soluble solids (TSS) in fruit juice (AOAC, 1994).

According to (AOAC, 1994), total titratable acidity (%) is expressed as g of malic acid per 100 milliliters of juice. Soluble solids content (SSC) / acid ratio: This ratio was determined using the titratable acidity and TSS data for fruit juice.

Identification of total carotenoids by using the technique described by Ranganna (1995). Five grammes of fresh apricot fruit, or a known weight of the sample, were weighed and then coarsely pulverised in acetone using a mortar and pestle until the residue was colourless. A conical flask was used to collect the acetone extract. The carotenoid pigments were separated using a separating funnel. After moving the carotenoid extract into a separating funnel, petroleum was added along with 10% $Na2SO4$. To separate the carotenoid layer, swirl the funnel. Volumetric flasks held the collected separated carotenoids. Until no colour was left in the extract, the procedure was repeated. The absorbance was measured spectrophotometrically at 452 nm. Total carotenoids were estimated using following formula:

$$\frac{\text{TC (mg/100g F.W basis} = 3.87 \times \text{A (452 nm)} \times \text{VM} \times \text{DF} \times 100}{VS(\text{g}) \times 1000}$$

TC : Total carotenoids
A : absorbance
VM : Volume make up
DF : Dilution factor
VS : weight of sample

Determination of vitamin C content was determined using the spectrophotometer (APEL, PD-303S Japan). Desai and Desai (2019) state that, in technique, upon the addition of bromine water, ascorbic acid undergoes oxidation and transforms into dehydroascorbic acid. A coupling reaction takes place when 2, 4 dinitrophenyl hydrazine is subjected to heating at a temperature of 37°C for a duration of three hours. Following the addition of 85% H_2SO_4 to the solution, a colored complex formed after three hours. The absorbance at 491 nm was then measured.

Statistical Analysis

It was done according to Gomez and Gomez, 1984, using CoStat (Version 6.303, CoHort, USA, 1998–2004).

Results

The data in (Table 1) and (Figure 1 and 2) showed that variations in opened buds in the southern and northern directions of the tree due to applied treatments. The data indicated that the greatest open buds in the southern half of the tree were obtained with the use of mineral oil plus potassium nitrate ranging from 88 to 95 % followed by the same components (mineral oil at 2% plus ammonium nitrate at 1.5%) which resulted in the percentage of open buds between 60 and 70 % in two seasons. That was the case at the northern direction of the tree. Since the greatest percentage of opened buds was obtained also by application of mineral oil 2% plus potassium nitrate at 2 % followed by mineral oil at 2 % plus ammonium nitrate at 1.5 %. The greater magnitude was found with the buds at the southern half of the tree when compared with the northern half. The second magnitude of increase in opened buds was obtained by mineral oil at 2 % plus low pyrite urea at 2 %. Meanwhile, that was the case with the southern half but with lower magnitude ranging between 27 % to 38 %. Mineral oil at 2 % alone resulted in 10 to 16 % and 6 to 7 % in the southern and northern parts of the tree respectively.

The data in (Table 2) show the changes in total soluble solids (TSS) in response to the various studied applications as an alternative to Dormex. The data provided evidence that the tree that had a progress in the development also reflected greater advancement in the development of the TSS.

Table 1. Percentage of opened (southern and northern) buds of "Canino" apricot as affected by pre-harvest applying during the two seasons 2022 and 2023.

Treatments	percentage of the southern opened buds		percentage of the northern opened buds	
	2022	2023	2022	2023
Control	3.14^{g*}	9.48^{g}	0.80^{g}	1.43^{h}
Mineral oil 2%	10.67^{f}	16.38^{f}	6.57^{f}	7.17^{g}
low pyrite urea 2%	25.50^{e}	20.05^{ef}	7.66^{f}	12.03^{f}
Ammonium nitrate 1.5 %	30.64^{e}	23.75^{e}	12.80^{e}	15.11^{e}
potassium nitrate 2%	40.28^{d}	28.60^{d}	18.12^{d}	20.87^{d}
Mineral oil 2% + low pyrite urea 2%	55.00^{c}	44.34^{c}	27.56^{c}	38.20^{c}
Mineral oil 2% + ammonium nitrate 1.5 %	70.57^{b}	61.99^{b}	48.72^{b}	54.57^{b}
Mineral oil 2% + potassium nitrate 2%	94.69^{a}	88.44^{a}	76.33^{a}	67.27^{a}
LSD $_{at\ 5\%}$	7.09	3.92	2.48	2.87

* Values in each column that were followed by similar letters did not differ substantially at 5%, the Least Significant Difference was used to compare the means.

Table 2. TSS, acidity and TSS/acidity of "Canino" apricot as affected by pre-harvest applying during the two seasons 2022 and 2023.

Treatments	TSS (%)		Acidity (%)		TSS/Acidity (ratio)	
	2022	2023	2022	2023	2022	2023
Control	11.39^{f*}	11.85^{ff}	1.56^{a}	1.62^{a}	7.29^{f}	7.32^{g}
Mineral oil 2%	11.71^{ef}	12.24^{ef}	1.49^{ab}	1.54^{a}	7.86^{ef}	7.95^{g}
low pyrite urea 2%	12.12^{de}	12.64^{de}	1.40^{b}	1.42^{b}	8.68^{e}	8.91^{f}
Ammonium nitrate 1.5 %	12.43^{cd}	12.93^{cd}	1.28^{c}	1.33^{bc}	9.69^{d}	9.76^{e}
potassium nitrate 2%	12.73^{bcd}	13.23^{bc}	1.21^{cd}	1.25^{cd}	10.55^{cd}	10.55^{d}
Mineral oil 2% + low pyrite urea 2%	13.13^{abc}	13.75^{ab}	1.16^{de}	1.20^{de}	11.29^{c}	11.48^{c}
Mineral oil 2% + ammonium nitrate 1.5 %	13.37^{ab}	13.92^{a}	1.07^{e}	1.10^{e}	12.50^{b}	12.69^{b}
Mineral oil 2% + potassium nitrate 2%	13.72^{a}	14.27^{a}	0.97^{f}	0.97^{f}	14.21^{a}	14.71^{a}
LSD $_{at\ 5\%}$	0.71	0.58	0.10	0.10	0.89	0.68

* Values in each column that were followed by similar letters did not differ substantially at 5%, the Least Significant Difference was used to compare the means.

For example, the trees that had received mineral oil at (2%) plus potassium nitrate at (2%) achieved progress in their TSS that was significantly higher compared to the control or mineral oil 2% alone, as well as potassium nitrate at 2% alone. In parallel progress there was a significant increase in the TSS with the application of mineral oil at (2 %) plus ammonium nitrate at (1.5 %) as compared with the control or with the individual treatment of ammonium nitrate alone or with mineral oil at 2 % alone. Therefore, the progress in opening the flower buds led to a significant increase in TSS in the trees, as shown in (Table 2). Hence, there was an increase in the TSS values reflecting the progress that occurred in breaking their bud dormancy. With regard to the response of fruit acidity to used treatments, the data in (Table 2) showed that mineral oil at (2 %) resulted in the highest juice acidity that was similar to that of the control in both seasons followed by the sole addition of urea (low pyrite) then ammonium nitrate as an individual treatment in a same pattern in both seasons. Meanwhile, applying potassium nitrate individually resulted in a juice acidity that was similar to that of ammonium nitrate in both seasons. Meanwhile, the combination treatments whether the mineral oil was mixed with the low pyrite urea or with ammonium nitrate had similarly juice acidity without any significant difference in both seasons. Meanwhile, the lowest juice acidity was obtained with the combination of mineral oil plus potassium nitrate at (2 %) and even significantly lower than the control.

With regard to the ratio between TSS and acidity in response to different treatments, the data in (Table 2) revealed that the highest value was found with the combination of mineral oil plus potassium nitrate related to the control and all other treatments followed by mineral oil plus ammonium nitrate. In the combination treatments, the combination of mineral oil plus low pyrite urea was effective but in a lower magnitude than others. It is noticeable that the use of individual application had significantly lower efficacy than the control and the combination treatments maintained a constant pattern across the two seasons. The only sole application that did not vary from the control in TSS/ acidity was the addition of mineral oil at (2%).

Changes in the percentage of total sugars in "Canino" apricot fruit during the two seasons 2022 and 2023 at the harvest time presented in table 93). The data indicated that the highest content of total sugar was obtained with the application of mineral oil at (2 %) plus ammonium nitrate at (1.5 %) followed by the application of mineral oil at (2 %) plus potassium nitrate at (2 %) when comparing with the control group during both seasons. While there was no notable distinction between the two formulations. Moreover, many other treatments did not significantly vary from the control such as potassium nitrate alone, ammonium nitrate alone and low pyrite urea especially in the first season, as well as mineral oil alone. Thus, the delay in buds opening was reflected on the content of total sugars at the harvest time.

Table 3. Total sugar, vitamin C and total carotenoid of "Canino" apricot as affected by pre-harvest applying during the two seasons 2022 and 2023.

Treatments	Total sugar (%)		Vitamin C (mg/100g)		Total carotenoid (mg/100g)	
	2022	2023	2022	2023	2022	2023
Control	7.51^{f*}	7.93^{g}	11.35^{h}	11.83^{h}	1.31^{f}	1.36^{g}
Mineral oil 2%	7.87^{ef}	8.29^{fg}	11.95^{g}	12.43^{g}	1.58^{f}	1.70^{fg}
low pyrite urea 2%	8.14^{de}	8.55^{ef}	12.68^{f}	13.19^{f}	1.89^{e}	2.02^{ef}
Ammonium nitrate 1.5 %	8.49^{cd}	8.95^{de}	13.35^{e}	13.95^{e}	2.23^{d}	2.33^{de}
potassium nitrate 2%	8.74^{c}	9.23^{cd}	13.97^{d}	14.54^{d}	2.53^{c}	2.67^{cd}
Mineral oil 2% + low pyrite urea 2%	9.18^{b}	9.61^{bc}	14.70^{c}	15.22^{c}	2.74^{bc}	2.85^{bc}
Mineral oil 2% + ammonium nitrate 1.5 %	9.82^{a}	10.32^{a}	15.22^{b}	15.81^{b}	3.17^{a}	3.36^{a}
Mineral oil 2% + potassium nitrate 2%	9.49^{ab}	10.02^{ab}	15.82^{a}	16.41^{a}	2.98^{ab}	3.14^{ab}
$LSD_{at\ 5\%}$	0.40	0.49	0.36	0.46	0.28	0.38

* Values in each column that were followed by similar letters did not differ substantially at 5%, the Least Significant Difference was used to compare the means.

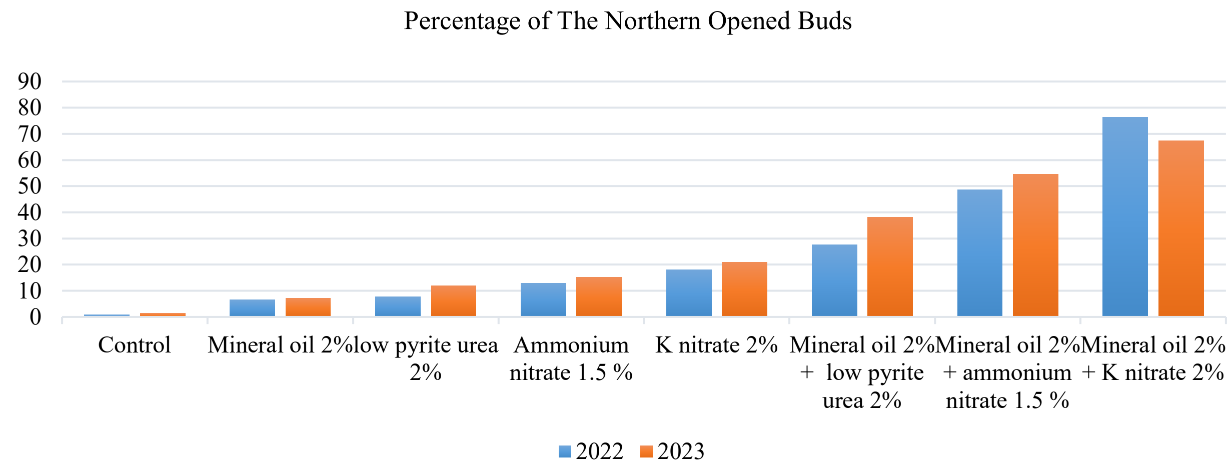

Figure 1. Effect of treatments on percentage of the northern opened buds in both seasons 2022 and 2023

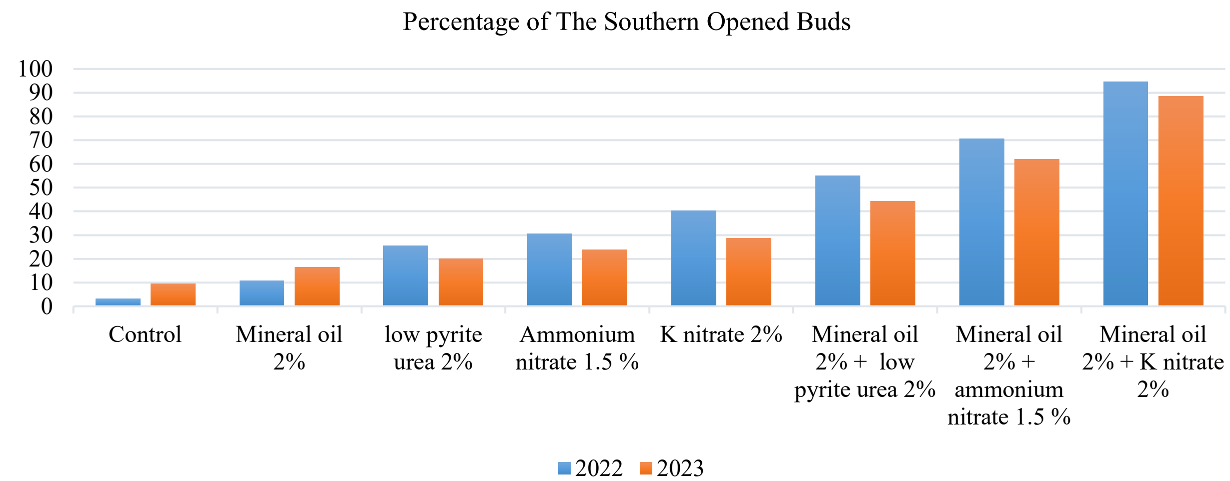

Figure 2. Effect of treatments on percentage of the southern opened buds in both seasons 2022 and 2023

The response of vitamin C in apricot fruits at harvest time to various early applications to break bud dormancy (one application in January in 20 or 25 in the two seasons respectively), was published in (Table 3). The statistics indicated that mineral oil plus potassium nitrate resulted in the greatest content of vitamin C in the fruit at harvest followed by mineral oil combined with ammonium nitrate. Such variations were consistent during the two seasons. The third magnitude of vitamin C content was achieved with the application of mineral oil but combined with low pyrite urea as compared with the control, the same pattern was true in two seasons. In addition, when either potassium nitrate or ammonium was applied alone, there was a significant reduction in vitamin C content as compared with the combination treatments during both seasons. Thus, it was better to apply the used concentration of the mineral oil than to use the individual treatment in terms of gaining higher content of vitamin C in the fruit at the harvest time.

The content of carotenes in the fruit at the harvest time in response to earlier treatments that were used to break bud dormancy was presented in (Table 3). The data suggested that total carotenes in the fruit was also influenced by early treatments last January in two seasons. Again, the greatest magnitude of the increase was achieved with the combination of mineral oil plus ammonium nitrate related to the control. And many other individual treatments in both seasons. Such treatment was followed by mineral oil plus potassium nitrate that was similar to mineral oil plus urea at low pyrite. Moreover, all used treatments individually did not result in greater carotene content except with potassium nitrate or ammonium nitrate as compared with mineral oil or low pyrite urea individually and separately in both seasons.

Discussion

It was logical to find a greater bud break in the southern half of the tree as compared with the northern half. The exposure of buds to the sun is for a longer duration and the exposure to a higher temperature which means the tissue temperature which means a rising bud temperature. Such an increase is synergistic with the rise of respiration gained with the application of summer oil at 2%. The combination of the summer oil plus potassium nitrate and tween 80 means more penetration of the sprayed formulation across the buds cuticle since the summer mineral oil has a hydrophobic (lipophilic) nature. No wonder to find that the highest effectiveness was found with the combinations of either summer mineral oil plus either potassium nitrate or ammonium nitrate followed by the combination of the summer oil plus low pyrite urea at 2% (w/v) (Erez, 2020; Singh, 2020; Çalışkan & Kılıç, 2022; Luna et al., 1993; Uber et al*.,* 2020).

Conclusion

The results provided evidence about the possibility of controlling bud break of apricot trees especially some formulations such as summer mineral oil at (2%) plus either potassium nitrate at (2%) or ammonium nitrate at (1.5%) in the presence of the surfactant tween 80.

With regard to bud break, the results indicated the highest bud break with the application of mineral oil at 2% (v/v) plus potassium nitrate at 2% (w/v). The greatest advancement in the rate of fruit growth was achieved with the application of mineral oil plus potassium nitrate as revealed by the TSS percentage, the TSS to acidity ratio, the sugar or even the carotenoid content.

The use of the formulation containing mineral oil plus potassium nitrate plus the surfactant tween 80 appeared as a suitable alternative to Dormex whether economically, environmentally or with any health concerns.

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