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Exogenous Dormancy-Breaking Compounds on Flowering Behavior, Yield, Fruit Quality and Some Chemical Constituents of "Anna" Apple Trees

Mohamed A. Seif El-Yazal[1*] and Samir A. Seif El-Yazal[2]

[1]Department of Agriccultural Botany, Faculty of Agriculture, Fayoum Univerity, Egypt. E-mail: mas04@fayoum.edu.eg
[2]Department of Horticulture, Faculty of Agriculture, Fayoum Univerity, Egypt. E-mail: sas00@fayoum.edu.eg

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Abstract

The role of dormex, mineral oil, potassium nitrate, calcium nitrate and thiourea in the acceleration of dormancy breaking in buds of "Anna" apple (*Malus sylvestris,* Mill) variety and their effects on metabolic changes in the contents of total chlorophyll , total carbohydrates, total protein, nitrogen, phosphorous and potassium in leaves and the contents of Total Soluble Solids (TSS), TSS/acid ratio, vitamin C, water content %, total free amino acids, total carbohydrates, total sugars and reducing sugars in fruits during bud break were assessed. The efficiency of bud break by these compounds was noticed to varying degrees. Breaking bud dormancy was correlated with the early date of bud break, the short duration of flowering, the high percentages of bud break and fruit set, and the high contents of chemical constituents. This finding was positively reflected in the tree's yield. Dormex (4%) was found to be more effective than mineral oil (5%), potassium nitrate (8%), calcium nitrate (8%) and thiourea (2%); therefore, we recommend using dormex (4%) for early bud break, short period of flowering and high percentages of bud break, fruit set, yield and fruit characters by regulating the chemical constituents of apple leaves or fruits.

Keywords: *Apple (Malus sylvestris, Mill), Dormex, Calcium nitrate, Potassium nitrate, Mineral oil, Thiourea, Bud break , Growth, yield, Chemical constituents*

1. Introduction

Most temperate zone perennials undergo an annual period of bud dormancy, which is a physiological state that reduces the ability of bud to burst in a reversible manner. Endodormancy, coinciding with winter, is an inhibition controlled from within the bud itself and released upon exposure to chilling (Petri and Leite, 2010; Seif El-Yazal *et al.*, 2012; 2013; 2014; Seif El-Yazal, 2019a, 2019b; 2019c; 2020; 2021a; 2021b). Hence, to resume growth, tree bud must receive an amount of chilling which is genetically controlled and varies among genotypes (Egea *et al.*, 2003) However, it is difficult to determine the precise amount of cold that is required to get out of lethargy (Carvajal-Millan *et al.*, 2000; Seif El-Yazal *et al.*, 2018a; 2018b; 2018c; 2018d). In temperate perennial species, a period of low temperatures (commonly referred to as winter chilling) is needed to release buds from endo-dormancy. Warm winters in many regions often limit the productivity of temperate fruit crops, including grape, apple and kiwifruit (Bound and Jones, 2004) This deficiency of cold affects a late sprouting in terminal buds, a poor and irregular flowering, large number of buds without sprouting, low fruit tie, low

* *Corresponding author: Mohamed A. Seif El-Yazal, Department of Agriccultural Botany, Faculty of Agriculture, Fayoum Univerity, Egypt. E-mail: mas04@fayoum.edu.eg*

production and poor quality, as well as an increased risk of fire blight **(**Quintana, 2006; Seif El-Yazal *et al*.,2019; Seif El-Yazal and Seif El-Yazal, 2019; 2021**)**. A management strategy to reduce problems of insufficient cooling is the application of cold compensators.

Among the compensators mentioned in the literature and that have been applied are: dormex (hydrogen cyanamide), calcium nitrate, potassium nitrate, mineral oil, thiourea, garlic extract, onion extract, aminoburts, semitrol, break trhu, Tecno Oil 100EW, revent, promalin, biozyme, thidiazuron (TDZ) and erger which widely used for stimulating bud break in various fruit species (Quintana, 2006; Botelho and Muller, 2007; Morsi and Seif El-Yazal,2008a; 2018b; Rady and Seif El-Yazal, 2013; 2014; Seif El-Yazal and Rady, 2014; Seif El-Yazal *et al*., 2018d; Seif El-Yazal *et al*., 2019**)**.

The beneficial effect of dormex, mineral oil, potassium nitrate, calcium nitrate and thiourea on bud break, growth, yield and some chemical constituents of different fruit species were studied by several workers (El-Shewy *et al*.,1999a; 1999b; 1999c; 1999d; Petri and Leite, 2010; Abd El-Rzeket *et al*., 2011; Seif El-Yazal and Rady, 2012; 2013; Seif El-Yazal *et al*., 2012; 2014; 2019; 2020; 2021; Seif El-Yazal, 2021b).

In Egypt, because winter is short and does not provide the chilling requirement for buds of apple tree, any delay in bud break in ''Anna'' apple trees until late winter exposes them to damage by high temperatures and/or delays in entering dormancy in the following year. This can lead to physiological defects that may result in weakness and death of buds, and consequently threaten the productivity of ''Anna'' apple in Egypt. Therefore, the aim of this study was to investigate the potential effects of some foliar-applied dormancy-breaking chemicals (i.e., dormex, mineral oil, potassium nitrate, calcium nitrate and thiourea) on the duration to full bud break, fruit yield, as well as metabolic changes in the contents of leaves and fruites of ''Anna'' apple trees during bud break under winter conditions in Egypt.

2. Materials and Methods

Twelve-year-old trees of ''Anna'' apple variety (*Malus sylvestris*, Mill.) grafted on Malling-Merton 106 (MM 106) rootstock and grown on loamy sand soil were randomly selected for a preliminary study in 2015 and for the main research study in the 2016/2017 and 2017/2018 seasons. All trees were grown in the Horticultural Station in Aboksah village, Abshawai District, Fayoum, Egypt in attempt to reach break dormancy at the appropriate time. The selected trees (n=6 for each treatment) were labeled in November 2016 for the preliminary study. Another 36 trees were labeled and received foliar treatments during December 2016, and were then sampled from (May15 for chemical constituents and July 30 for mineral elements in leaves and at harvesting, for fruits) for the first main study season. The experiment was repeated exactly for the second season (2017/2018) with another 36 trees. Trees of each experiment were arranged in a complete, randomized design. Each tree was designed as one replicate, and each treatment included six trees. Foliar spray applications (36 tree^{-1}) were conducted as follows: Treatment 1 (control trees) did not receive any of the dormancy-breaking agents, but only of tap water; Treatment 2 consisted of a foliar spray with run-off of 4% (v/v) hydrogen cyanamide [Dormex™; molecular weight 42.04 g mol^{-1}, density1.065 g 1-1]; Treatment 3 consisted of a foliar application of 5% (v/v) mineral oil (regular winter oil having a UR of 75%); Treatment 4 consisted of a foliar application of 8% (w/v) potassium nitrate (KNO_3; containing13%N and 44%K); Treatment 5 consisted of a foliar application of 8% (w/v), calcium nitrate **(**$Ca(NO_3)_2$; containing 15.5% nitrogen and 19%Ca); Treatment 6 consisted of a foliar application of 2% (w/v) thiourea (molecular weight 76.12, assay 99-101%, sulfated ash 0.1%). All spray treatments were applied on December 10. Triton Bat 0.1% (v/v) was added as a wetting agent to the spray solutions. The selected concentrations of the DBAs were found to be most significant for later bud growth in ''Anna'' apple trees (data not shown). Therefore, these treatment levels were used for this study.

The physical and chemical characters of the orchard soil was determined according to Wilde *et al.* (1985) and the results are shown in Table 1.

In all experiments, Phosphorous as calcium super phosphate (15.5% P_2O_5) at the rate of 200 kg/fed., was added in the orchard in the second week of February. Nitrogen as ammonium nitrate (33.5% N) at the rate of 250 kg /fed. was added in two doses for the orchard (first dose 150 kg/fed. in the second week of February and second dose 100 kg./fed. before top flowering (first week of April)) and potassium sulphate (48% K_2O) at the rate of 50 kg/fed., was given in two equal doses in alternative with nitrogen fertilizer. The first dose of fertilizer was added in (March) and the second dose given after 30 days from the first one. The other cultural practices were followed as normal. The control trees were sprayed with tap water, however, dormex, calcium nitrate, potassium nitrate, mineral oil and thiourea were sprayed before the end of dormancy (nearly December 30), with a volume of 4 L/tree for each one. Triton B as a wetting agent at 0.1% was added to the spraying solutions.

Table 1: Chemical and Physical Analysis of the Soil

Physical Characteristics										
Depth	Particle Size Distribution				Texture	Bulk Density (g/cm^3)	Organic Matter (%)	Soil Moisture Constant %		
	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)				FC	WP	AW
0-30	50.13	29.50	9.02	11.35	Loamy	1.43	0.71	19.2	7.12	11.22
30-60	50.95	26.17	8.35	14.53	Sand	1.46	0.76	19.1	7.94	12.33

Chemical Characteristics								
	Soluble Cations (meq /L)				pH	ECe	Soluble Anions (meq/l)		
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}		(dS/m)	Cl^{-}	HCO_3^-	SO_4^-
0-30	15.33	17.25	13.10	1.54	7.34	3.50	6.15	3.01	25.69
30-60	12.15	14.20	7.12	089	7.56	3.10	4.20	3.12	21.58

2. Data Recorded

2.1. Morphological Characteristics and Yield Measurements

In both studied seasons, bud counts were made for each tree (n=6) in all treatments. The dates on which floral and vegetative buds started to open were recorded. The numbers of vegetative and floral buds were counted when all the buds had opened, and the percentages of each were estimated. Dormant buds were also counted and expressed as a percentage of the total number of buds. The dates on which flowering reached 25, 50, 75 and 100 % of the total final number of flowers were estimated in each treatment. Flowers in which the calyx began to extend were tagged, in order to measure the percentage of fruit set. At harvest, all the apple fruits were harvested from each tree, the yield of fruits in kg/ tree as well as the number of mature fruits/ tree were recorded when fruits reached the commercial colour to be picked.

In order to determine fruit quality, 20 fruits were taken at random from each tree as a sample. Samples were transferred immediately to the laboratory. Each fruit was weighed to get the average fruit weight. Average fruit size was determined by emerging the fruit in a jar containing water and receiving the excess water in a graduated cylinder.

3. Chemical Analysis

Fresh and dried leaves as well as fruits (May15 for chemical constituents and July 30, for mineral elements in leaves and at harvesting, for fruits) were taken to determine the following constituents: total chlorophyll was extracted from fresh leaves by acetone (80%) and its concentration was determined as mg/100g fresh weight according to Welburn and Lichtenthaler (1984), total carbohydrates mg/g dry weight were determined colorimetrically by using phenol-sulphuric acid reagent according to the method described by Herbert *et al.* (1971). Total free amino acids in fresh fruits were determined as mg/g fresh weight colorimetrically using ninhydrin reagent according to the method described by Jayarman (1981). (Total and reducing sugars were determined as mg/g fresh weight using phosphomolybdic acid reagent., total phenols in fresh fruits were determined as mg/g fresh weight using Folin-Denis reagent. Water content in fruits was determined, total soluble solids (TSS) in fruits were estimated using handle Refractometer model PZONr. 19877, total acidity was estimated in fruits as malic acids using sodium hydroxide for a known normality and phenolphthaline as an indicator. Total soluble solids/acid ratio were calculated and vitamin C content in fruits, Nitrogen %, crude protein percentage and phosphorus % in dry leaves were determined according to AOAC, 1995). Potassium was determined by Flame Photometer, Parkin–Elmer model 52 according to the method described by Page *et al*. (1982).

4. Statistical Analysis

The experiment was in a complete randomized block design with 6 treatments and 3 replicates for each treatment. One tree was used as a replicate. Results were statistically analyzed using the LSD at probability level of 5% for comparisons according to **(**Gomez and Gomez, 1984**)**.

5. Results

5.1. Date of Flower Bud Break

Foliar application with hydrogen cyanamide (Dormex), mineral oil, potassium nitrate, calcium nitrate and thiourea for ‘‘Anna’’ apple trees hastened the floral bud break when compared with the control in which trees were sprayed with tap water (Table 2). These compounds were found to shorten the period to the first floral bud break. The earliness periods were about 37 and 39 days for dormex at 4%, 20 and 21 days for mineral oil at 5%, 23 and 23 days for potassium nitrate at 8%, 15 and 16 days for calcium nitrate at 8% and 18 and 19 days for thiourea at 2%, when compared with the control in both seasons respectively. The duration to full flowering (50 % bud break) was shortened by 27 and 30 days for dormex at 4%, 7 and 7 days for mineral oil at 6%, 4 and 8 days for potassium nitrate at 8%, 8 and 9 days for calcium nitrate at 8% and 7 and 10 days for thiourea at 2% over the control in both seasons, respectively.

Table 2: Effect of Spraying With Dormex, Mineral Oil, Potassium Nitrate, Calcium Nitrate and Thiourea Treatments on Time of Flower Bud Opening in “Anna” Apple Trees

Treatments	Date of Flower Bud Opening											
	Beginning		25%		50%		75%		End		Flowering Period (No. of Days)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control	26/2	28/2	28/2	28/2	5/3	7/3	16/3	17/3	29/3	28/3	31	28
Dormex 4%	20/1	20/1	29/1	31/1	6/2	5/2	17/2	16/2	19/2	18/2	30	29
Mineral oil 5%	6/2	7/2	16/2	18/2	26/2	28/2	28/2	1/3	13/3	14/3	35	35
Potassium Nitrate 8%	3/2	5/2	15/2	19/2	27/2	27/2	10/3	6/3	14/3	15/3	39	38
Calcium Nitrate 8%	11/2	12/2	15/2	16/2	25/2	26/2	4/3	6/3	16/3	17/3	33	33
Thiourea 2%	8/2	9/2	20/2	19/2	26/2	25/2	4/3	5/3	15/3	16/3	35	35

5.2. Percentage of Bud Break

Data presented in Table 3 clearly show that all treatments gave a high percentage of flower bud break compared with the control. The maximum increases were recorded with dormex 4% which recorded 97.56 and 98.20% in both seasons as compared with the control, respectively.

5.3. Yields and its Components

Data in Table 3 indicated that all the tested substances increased apple yield and its components (fruit-setting, fruit weight, fruit size and fruit number) as compared to the control trees. Such trend was true during the two studied seasons. The maximum increases were recorded with dormex at 4% which recorded 14.69 and 15.20 for fruit-setting, 119.25 and 120.55g for fruit weight, 122.15 and 119.90 CC^3 for fruit size, 171.35 and 175 fruits for fruit number and 19.85 and 18 kg for apple yield/tree in both seasons, respectively as compared to the control trees.

5.4. Chemical Constituents of Leaves

5.4.1. Total Chlorophyll, Total Carbohydrates and Total Protein

Data presented in Table 4 clearly showed that, during the two successive seasons of the study, all treatments increased the concentrations of leaf constituents (total chlorophyll, total carbohydrates, total protein) as compared to the control. The best results were observed when apple trees were sprayed with dormex at 4% which recorded 1.96 and 1.95 mg/gFW for total chlorophyll, 87.09 and 88.19 mg/gdw for total carbohydrates and 12.00 and 12.12% for total protein in both seasons as compared to the control plants, respectively.

Table 3: Effect of Dormex, Mineral Oil, Potassium Nitrate, Calcium Nitrate and Thiourea Treatments on the Percentage of Bud Break, Fruit Setting, Fruit Weight (g), Fruit Size (CC³), Total Number of Fruits/Tree and Yield/ Tree in "Anna" Apple Trees

Treatments	Date of Flower Bud Opening											
	Bud Break (%)		Fruit Set (%)		Fruit Weight (g)		Fruit Size CC³		Total Numbers of Fruits/Tree		Yield per Tree/kg	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control	90.99	88.33	9.1	9.6	83.22	82.99	93.00	93.64	112.00	110.38	9.31	9.66
Dormex 4%	97.56	98.20	14.69	15.20	119.25	120.55	122.15	119.90	171.35	175.00	19.85	18.00
Mineral Oil 5%	97.38	95.71	16.23	16.50	116.22	113.44	116.60	117.00	168.00	166.93	16.65	16.09
Potassium Nitrate 8%	97.58	92.16	17.55	19.50	118.16	117.20	115.00	114.11	155.00	154.81	18.33	18.00
Calcium Nitrate 8%	97.39	90.86	13.66	14.33	112.50	111.90	116.20	113.60	150.21	151.55	16.11	16.25
Thiourea 2%	96.87	93.16	12.00	13.15	108.29	105.90	107.10	108.70	126.99	130.17	11.33	12.56
LSD at 5%	2.22	2.31	1.36	1.30	1.13	1.14	1.26	1.33	2.72	2.71	1.02	1.03

5.4.2. Nitrogen, Phosphorus and Potassium Concentrations in Leaves

Data presented in Table 4 revealed that, leaves of apple trees contained higher concentrations of nitrogen, phosphorus and potassium under foliar spray with any of the treatments than the control. The maximum increases were obtained when dormex at 4% were used which recorded 1.92 and 1.93% for nitrogen, 0.25 and 0.25% for phosphorous and 1.52 and 1.53% for potassium in both seasons respectively as compared to the control trees.

Table 4: Effect of Dormex, Mineral Oil, Potassium Nitrate, Calcium Nitrate and Thiourea Treatments on Chemical Contents of Leaves in "Anna" Variety

Treatments	Total Chlorophyll (mg/gfw)		Total Carbohydrate (mg/gdw)		Total Protein (%)		N (%)		P (%)		K (%)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control	1.88	1.78	76.21	75.163	10.56	10.56	1.69	1.69	0.20	0.20	1.52	1.51
Dormex 4%	1.96	1.95	87.09	88.19	12.00	12.12	1.92	1.93	0.25	0.25	1.52	1.53
Mineral oil 5%	1.95	1.93	89.90	88.39	12.06	11.31	1.93	1.86	0.24	0.22	1.52	1.53
Potassium nitrate 8%	1.95	1.94	79.17	80.16	11.69	11.37	1.87	1.85	0.23	0.21	1.56	1.55
Calcium nitrate 8%	1.89	1.88	81.67	81.130	11.69	11.12	1.87	1.80	0.21	0.22	1.51	1.50
Thiourea 2%	1.89	1.88	80.63	81.00	11.69	10.68	1.87	1.86	0.21	0.21	1.52	1.51
LSD at 5%	0.04	0.06	1.19	1.12	0.11	0.26	0.08	0.06	0.01	0.01	N.S	N.S

5.5. Chemical Constituents of Fruits

Data of Tables 5 and 6 clearly showed that spraying apple trees with any of the tested substances significantly improved the chemical constituents of fruits (Total Soluble Solids (TSS), total acidity , TSS/ acid ratio ,vitamin C, water content %, total free amino acids, total carbohydrates, total sugars, reducing sugars, total phenols) as compared to the control trees. Such trend was true during the two seasons of the study. The maximum increases were recorded with dormex at 4% which recorded 12.75 and 12.75% for total soluble solids, 12.37 and 12.37 for TSS/acid ratio, 1.52 and 1.52 mg/100 mL juice for vitamin C, 82.86 and 82.60% for water content, 167.91 and 169.55 mg/gFW for total carbohydrates, 100.80 and 102.63 for total sugars , 78.60 and 79.5355 mg/gFW for reducing sugars and 2.19 and 2.1855 mg/gFW for total free amino acids in both seasons respectively, as compared to the control trees. On the other hand, the data in Table 5 also showed a marked decrease in total acidity and total phenols concentrations in fruits when trees were treated with any of the tested substances comparing with the control trees.

Table 5: Effect of Dormex, Mineral Oil, Potassium Nitrate, Calcium Nitrate and Thiourea Treatments on Chemical Fruit Quality of "Anna" Apple Fruits

Treatments	TSS %		Acidity %		TSS/Acidity Ratio		Vitamin C mg/100 mL Juice	
	2016	2017	2016	2017	2016	2017	2016	2017
Control	11.33	11.50	1.05	1.06	10.79	10.77	1.14	1.14
Dormex 4%	12.75	12.75	1.03	1.03	12.37	12.37	1.52	1.52
Mineral oil 5%	13.13	12.50	0.92	0.81	14.27	15.43	1.47	1.47
Potassium Nitrate 8%	12.75	12.30	0.79	0.80	16.35	16.25	1.50	1.45
Calcium Nitrate 8%	12.88	12.86	1.04	1.03	12.38	12.30	1.54	1.45
Thiourea 2%	11.88	12.00	0.99	0.95	12.00	11.97	1.81	1.44
LSD at 5%	0.04	0.05	0.03	0.04	0.80	0.82	N.S	N.S

Table 6: Effect of Dormex, Mineral Oil, Potassium Nitrate, Calcium Nitrate and Thiourea Treatments on Some Chemical Composition of "Anna" Apple Fruits

Treatments	Water Content %		Total Carbohydrates mg/gFW		Total Sugars mg/g FW		Reducing Sugars mg/g FW		Total Free Amino Acids mg/g FW		Total Phenols mg/g FW	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control	77.78	76.90	139.55	138.20	84.60	85.16	53.00	52.13	1.85	1.87	0.47	0.49
Dormex 4%	82.86	82.60	167.91	169.55	100.80	102.63	78.60	79.53	2.19	2.18	0.31	0.27
Mineral oil 5%	80.25	81.30	150.39	151.70	86.80	84.25	64.90	68.25	1.89	1.93	0.33	0.32
Potassium Nitrate 8%	79.88	78.50	155.41	154.35	102.0	103.33	68.20	69.51	1.93	1.99	0.38	0.39
Calcium Nitrate 8%	77.85	79.81	155.49	156.70	85.57	83.31	60.10	60.20	1.78	1.76	0.39	0.39
Thiourea 2%	79.50	78.60	146.24	145.50	85.83	84.63	70.15	70.89	1.96	1.95	0.39	0.37
LSD at 5%	1.18	1.16	2.66	2.75	1.06	1.03	1.10	1.11	0.07	0.07	0.4	0.03

6. Discussion

Spraying apple trees with any of the tested treatments (dormex 4%, mineral oil 5%, potassium nitrate 8%, calcium nitrate 8% and thiourea 2%) resulted in vigorous plant (tree) growth as well as high productivity with good fruit quality. The favorable effects of treatments on the date of floral bud opening may be due to their stimulation effects on natural gibberellins (Luna *et al.*,1993). Some different spray treatments, including Dormex, may release buds from dormancy by decreasing their ABA content (Nashaat,1996). Regarding the effects of (dormex 4%, mineral oil 5%, potassium nitrate 8%, calcium nitrate 8% and thiourea 2% on nitrogen (N) fractions, our results showed that leaves of "Anna" apple trees had higher contents of total N and amino acids when sprayed with any of these compounds than the control in which trees were sprayed with tap water. This finding agreed with the suggestion of Yang *et al*. (1990). They concluded that cyanamide ion may play a role in inducing enzyme activity, promoting there translocation of stored reserves and increasing the uptake of nitrogen leading to bud break. In early work, hydrogen cyanamide is directly involved in nitrogen metabolism and the production of protein (Miller and Hall, 1963). Treatments increased the measured growth characters. This was due to the fact that these treatments resulted in more availability of macronutrients (N, K and Ca) to plants. Enhancement of growth parameters with N application would be expected since nitrogen is of extreme importance to plants. It is a constituent of many important substances within plant cells such as protoplasm, in addition to amino acids, nucleic acids, protein and chlorophylls (Salisbury and Ross, 1992).The high levels of endogenous auxin and gibberellins were found in those plants sprayed with high N fertilizer **(**Rajagopal and Rao, 1974**)**, which encourage cell division and cell elongation, increases leaf number and produce a sufficient assimilation area for maximum rate of photosynthesis (Greenwood and Hunt, 1986). Moreover, Mengel and Kirkby (1987) reported that, the role of K in metabolism, growth and yield formation can be characterized by two major function: as an activator of enzymes and as K^- ions are very mobile within the plant as well as within a cell are transported through biological membranes with high rate and specificity. More than 60 enzymes are known to require K^+ as an activator. The high mobility of K^+ on photosynthesis phloem loading and phloem transport …etc. Such important physiological roles enable potassium to perform its functions, which lead to an increase in various vegetative growth and yield. Moreover, the effect of hydrogen cyanamide and other substances used on nitrogen and protein content, it is clear from the present data that, buds of apple trees contained higher concentrations of total nitrogen under foliar spray with any of the treatments than the control. These findings agreed with the suggestion of Kuroi (1985), which concluded that cyanide ion may play a role in inducing enzyme activity, promoting the translocation of stored reserves and the uptake of nitrogen with water for leading to bud break. Moreover, Miller and Hall (1963) indicated that hydrogen cyanamide is directly involved in nitrogen metabolism and the production of protein. The degradation of cyanamide was demonstrated to occur through urea to other compounds and both are utilized in production of amino acids. Also, Foot (1987) found that hydrogen cyanamide penetrate the bud scals, gets absorbed in the buds and initiates the processes leading to bud break. It is rapidly metabolized in the plant and helps in the synthesis of amino acids. Also, the favorable effect of the used substances on date of flower bud opening may be due to their stimulation effect of natural gibberellin. In this connection Luna *et al.* (1993); Subha-Drabandhu (1995), concluded that the induction of flowering could be correlated with a natural rise in gibberellin which promote flower formation in plants by either facilitating the formation of flowering hormone in the leaves or expressing it in the growing buds. Gibberellins also may be a primarily responsible for bolting which may be essential for the formation of the floral stimulus in leaves. Moreover, Subha- drabandhu (1995); Nashaat (1996) reported that some different spray treatments may break dormancy by decreasing ABA content in buds.

The improving effect of dormex, mineral oil, potassium nitrate, calcium nitrate and thiourea on yield and its components was mainly attributed to its positive action on enhancing growth parameters (Table 2) and photosynthetic pigments of plant leaves (Table 4). In this respect, Skene (1969) reported that when a bud opens and attains the shape of a shoot, its tip acts as a strong sink for metabolites and thus being interception center for photosynthates and nutrients results in earlier start of the bloom. The promotive effect of dormex, mineral oil, potassium nitrate, calcium nitrate and thiourea on chlorophyll formation might be attributed to their enhancing effect on the nutritional status of apple trees. Also the increase of total chlorophyll by spraying with N and K may be due to that N and K play an important role for stimulating chlorophyll synthesis enzymes which can be reflected on the formation of chlorophyll molecule. Moreover, the stimulating effect of dormex, mineral oil, potassium nitrate, calcium nitrate and thiourea as foliar spray on total carbohydrates concentrations in leaves of sprayed trees may be directly or indirectly due to certain enzymes which activate the anabolic processes leading to the accumulation of these substances. The increase of all mentioned constituents by foliar N application may be due to that certain enzymes may be activated as a result of these treatments leading to the accumulation of such substances. The increase of macronutrients (N, P, and K) and protein content were supported by the results of El-Shewy *et al.* (1999a) on apple trees. In this connection Tromp (1970) found that there was a decrease in the nitrogen concentration of the woody tissues in the spring, particularly in the bark tissues of shoots. This might be attributed to the movement of nitrogenous compounds from the bark and wood to the developing flower buds and growing points. Moreover, the stimulating effect of dormex, mineral oil, potassium nitrate, calcium nitrate and thiourea on physical characters (fruit weight and size) and chemical fruit characters (TSS, total acidity, vitamin C, total carbohydrates, total sugars, reducing sugars, total free amino acids and total phenols) was mainly attributed to its positive action on enhancing growth parameters (Table 2) and photosynthetic pigments of plant leaves (Table 4).

Concerning the effect on TSS and acidity in fruits, the results showed that all treatments increased TSS significantly and decreased the total acidity. This increase in TSS may be due to the increase in synthesis of carbohydrates and its accumulation in the developing fruits of the treated trees. In this connection, Boghdadi (1964) mentioned that sugars represented about 70% of the Total Soluble Solids (TSS) in apple fruits and the increase in sugars lead to increase in TSS. He also added that the increase in cellular sap lead to decrease in acidity as a result of dilution of the organic acids. Moreover Dame *et al.* (1956); Mann and Singh (1990) on pear, found that the increase in TSS may be due to rapid conversion of starch, and the decrease in total acids content with advancement of ripening period may be due to that the acids are converted into soluble solids. The increase in vitamin C may be due to that fruits synthesize ascorbic acid from hexose sugars and hence the adequate supply of these precursors would greatly depend on the photosynthetic activity (Mapson, 1970). In this connection George *et al.* (1990) suggested that water and nutrients may also be mobilized to the growing points at the expense of the developing fruits. Also, Ahmed (1995) found that large "Anna" apple fruits had significantly higher reducing and total sugars as well as lower starch and non-reducing sugars than small sized fruits. Moreover, Dame *et al.* (1956) found that the increase in accumulation of TSS and sugars during maturation has been related to accumulation of glucose, sucrose and higher levels of fructose in "Bartlett" pear. On the other hand, Mann and Singh (1990) found that the total phenols content (as tannic acid) decrease during ripening period. The reduction in phenolic content during ripening process may be attributed to its hydrolysis to different components such as sugars, acids and other compounds (Gangwar, 1972).

7. Conclusion

The foliar application with hydrogen cyanamide (Dormex), mineral oil, potassium nitrate, calcium nitrate and thiourea for "Anna" apple trees has shown to hastens floral buds release from dormancy, shortens flowering duration, improves bud growth and apple yield as well as improved fruit apple quality and its chemical constituents. The foliar spray with these compounds, particularly Dormex, significantly improved the contents of soluble nitrogen and amino acids. They found to be participated in the different metabolic processes which increased the synthesis of essential metabolites, leading to an increase in the percentages of bud break and fruit-set and subsequently shortening the flowering duration. Since Dormex was found to be more effective in this connection, were commending using this compound for the increase in "Anna" apple trees productivity. It may provide a well strategy for increasing the percentages of bud break and fruit-set, and shortening the flowering duration to protect the floral buds against the high temperature in late winter.

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