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Metabolic Changes in Chemical Constituents, Flowering Behavior, Yield And Fruit Quality of 'Anna' Apple (*Malus sylvestris*, Mill) Trees with Foliar Application Some Compounds

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Abstract

This investigation was carried out during the two successive seasons of 2006 and 2007 to investigate the effect of potassium nitrate, garlic extract and onion extract on bud break, growth, yield and some chemical constituents of "Anna" apple (*Malus sylvestris*, Mill) variety. The trees were grown in loamy sand soil, and sprayed with six treatments (potassium nitrate 10%), garlic extract (20%), onion extract (20%), potassium nitrate (5%) mixed with garlic extract (10%), potassium nitrate (5%) mixed with onion extract (10%) and control. Generally, it was found that all studied growth parameters, date of flower bud break, percentage of bud break, fruit-setting ,fruit weight, fruit size, fruit number/tree, yield/tree (kg) and some chemical constituents of leaves (total chlorophyll ,total carbohydrates, total protein, nitrogen, phosphorous and potassium contents) and some chemical constituents of fruits (Total Soluble Solids (T.S.S.), T.S.S/ acid ratio, vitamin C, water content %, total free amino acids, total carbohydrates, total sugars and reducing sugars) were increased with the application of the different treatments. The best results were obtained from the treatments of potassium nitrate at 5% mixed with onion extract at 10%, potassium nitrate at 5% mixed with garlic extract at 10% and potassium nitrate at 10%. On the contrary, the same treatments decreased total acidity and total phenols in fruits as compared to the control. It could be recommended to use potassium nitrate at 5% in combination with onion extract or garlic extract at 10% for improving bud break, growth, yield and chemical constituents of apple trees or fruits.

Keywords: *Apple (Malus sylvestris, Mill), Potassium nitrate, Garlic extract, Onion extract, Bud break, Growth, yield, Chemical constituents*

1. Introduction

The apple tree is a fruit-bearing deciduous temperate climate, which requires a certain amount of winter cold to overcome its lethargy, a physiological condition that occurs annually to survive cold winters (Petri and Leite, 2010; Seif El-Yazal *et al*., 2012; and Seif El-Yazal, 2021). However, it is difficult to determine the precise amount of cold that is required to get out of lethargy (Carvajal-Millan *et al*., 2000). This deficiency of cold affects a late sprouting in terminal buds, a poor and

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irregular flowering, large number of buds without sprouting, low fruit tie, low production and poor quality, as well as an increased risk of fire blight (Quintana, 2006; and Seif El-Yazal, 2019). 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: potassium nitrate, garlic extract, onion extract, mineral oils, dormex (hydrogenated cyanamide), aminoburts, semitrol, break trhu, Tecno Oil 100EW, calcium nitrate, revent, promalin, biozyme, thidiazuron (TDZ) and erger which widely used for stimulating bud break in various fruit species (Quintana, 2006; and Botelho and Muller, 2007).

The beneficial effect of potassium nitrate, garlic and onion extract on bud break, growth, yield and some chemical constituents of different fruit species were studied by several workers (Khayat *et al.*, 2010; Petri and Leite, 2010; Abd El-Rzeket *et al.*, 2011; Rady and Seif El-Yazal, 2014; Seif El-Yazal and Rady, 2014; Seif El-Yazal *et al.*, 2018 and 2019; Parra *et al.*, 2020; and Seif El-Yazal and Seif El-Yazal, 2021).

2. Materials and Methods

This study was carried out during the two successive seasons of 2006 and 2007 in the orchard of the Horticulture Farme of Faculty of Agriculture, Fayoum University in an attempt to break dormancy of "Anna" apple variety (*Malus sylvestris*, Mill) grafted on Malling-Merton 106 (MM 106) root stock. The trees were 10 years old when experiment started and grown in loamy sand soil. Trees were selected in November, 2005 a uniform as possible for spray treatments.

The experiment involved the following treatments:

1. Control (spraying with tap water)
2. Spraying with potassium nitrate at rate 10%
3. Spraying with garlic extract at rate 20%
4. Spraying with onion extract at rate 20%
5. Spraying with potassium nitrate at rate 5% + garlic extract at rate 10%
6. Spraying with potassium nitrate at rate 5% + onion extract at rate 10%

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.

Table 1: Chemical and Physical Analysis of the Soil

Physical Characteristics										
Depth	Particle Size Distribution				Texture	Bulk Density g/cm³	Organic Mater %	Soil Moisture Constant %		
	Coarse sand %	Fine sand %	Silt %	Clay %				F. C	W.P	A.W
0-30	57.24	28.99	7.07	6.60	Loamy	1.39	0.81	17.5	7.16	10.75
30-60	52.87	28.98	8.86	8.37	Sand	1.41	0.74	20.1	8.74	11.77

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	17.65	15.88	12.23	1.31	7.21	4.49	7.67	2.82	33.44
30-60	10.20	11.81	5.01	0.62	7.45	2.63	3.65	2.95	22.46

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, potassium nitrate (containing 13% nitrogen and 44% potassium), garlic extract and onion extract were sprayed at two equal doses, the first was sprayed before the end of dormancy (nearly 30th of December), and the second was applied two weeks later 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.

2.1. Preparation of Garlic and Onion Extracts

Garlic or onion samples were ground using mortar and pestle and the active ingredients were extracted by ethyl alcohol (95%). The garlic or onion ethanol mixture was filtered and the alcohol was removed by evaporating under vacuum (30 C°) using rotary evaporator, Buchi model 011. The extract was kept cool in refrigerator (4 C°) until use. Garlic or onion extract was diluted by water to give the final concentration required (10 and 20 %) directly before use.

3. Data Recorded

3.1. Morphological Characteristics

In both the two successive seasons, bud counts were made for each tree. The dates on which flower and vegetative bud started to open were recorded. Number of vegetative and flower buds was counted when all buds were opened and the percentages were estimated. The dormant buds were also counted and were expressed as percentage from the total number of buds. The dates at which flowering reached 25, 50, 75 and 100% of the total flowers were estimated in each treatment. Flowers whose calyx began to extend were tagged in order to determine the percent of fruit set. The yield of fruits in kg/tree as well as the number of mature fruits/tree were recorded when fruits reached the commercial color 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.

4. 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).

5. Statistical Analysis

The experiment was in a complete randomized block design with 18 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 (1983).

6. Results

6.1. Date of Flower Bud Break

Data presented in Table 2 clearly indicated that spraying apple trees with all the tested substances hastened the beginning of flower bud break as compared to the control. This earliness reached about 31 and 29 days for potassium nitrate at 10%, 25 and 22 days for garlic extract at 20%, 27 and 28 days for onion extract at 20%, 28 and 25 days for potassium nitrate at 5% mixed with onion extract at 10% and 38 and 38 days for potassium nitrate at 5% mixed with onion extract at 10% over the control in both seasons, respectively.

Table 2: Effect of Potassium Nitrate, Garlic and Onion Extract 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)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Control	15/3	17/3	19/3	20/3	1/4	3/4	7/4	7/4	10/4	9/4	26	25
Potassium nitrate10%	12/2	16/2	16/2	18/2	24/2	26/2	1/3	2/3	8/3	12/3	24	24
Garlic extract 20%	18/2	23/2	20/2	24/2	1/3	3/3	10/3	12/3	13/3	19/3	23	24
Onion extract 20%	16/2	17/2	20/2	20/2	1/3	2/3	5/3	6/3	9/3	12/3	21	23
KNO_3 5%+ Garlic 10%	15/2	20/2	18/2	21/2	26/2	25/2	3/3	6/3	10/3	14/3	23	22
KNO_3 5%+ Onion 10%	5/2	7/2	8/2	10/2	20/2	24/2	22/2	26/2	25/2	1/3	20	22

As regards to the effect of the tested substances on 50% bud break, the present results clearly show that all treatments hastened 50% bud break as compared to the control. This earliness reached about 35 and 36 days for potassium nitrate at 10%, 31 and 31days for garlic extract at 20%, 30 and 31 days for onion extract at 20%. 34 and 37 days for potassium nitrate at 5% mixed with onion extract at 10%, and 40 and 38 days for potassium nitrate at 5% mixed with onion extract at 10% over the control in both seasons, respectively.

6.2. 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 potassium nitrate at 5% mixed with onion or garlic extract at 10% which recorded 12.56 and 11.33% in both seasons over the control for potassium nitrate plus onion extract and 9.32 and 10.94% for potassium nitrate plus garlic extract, respectively.

6.3. 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 potassium nitrate at 5% mixed with onion extract at 10% and potassium nitrate at 5% mixed with garlic extract at 10% which recorded 6.97 and 5.91 for fruit-setting, 33.86 and 33.28% for fruit weight, 26.52 and 25.47% for fruit size, 6.72 and 5.23% for fruit number and 42.82 and 40.22% for apple yield/tree in the first season, respectively over the control trees. Moreover, in the second season such increases were 7.13 and 6.42 for fruit-setting, 32.05 and 30.91% for fruit weight, 25.26 and 25.05% for fruit size, 5.56 and 5.30% for fruit number and 39.32 and 37.81% for yield/tree, over the control level, respectively.

6.4. Chemical Constituents of Leaves

6.4.1. 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 potassium nitrate at 5% mixed with onion extract at 10% and potassium nitrate at 5% mixed with garlic extract at 10% which recorded 3.19 and 3.19% for total chlorophyll, 16.81 and 16.77% for total carbohydrates and 1.44 and 1.44 for total protein in the first seasons and 7.73 and 7.73% for

total chlorophyll, 17.08 and 17.00% for total carbohydrates and 1.18 and 1.12 for total protein in the second seasons over the control plants, respectively.

6.4.2. 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

Table 3: Effect of Potassium Nitrate, Garlic and Onion Extract Treatments on Percentage of Bud Break, Fruit Weight (g), Fruit Size (CC^3) Total Number of Fruits/Tree and Yield/Tree in "Anna" Apple Trees

Treatments	Bud Break %		Fruit Set%		Fruit Weight (g)		Fruit size (CC^3)		Total Number of Fruits/Tree		Yield per Tree (kg)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Control	79.6	78.33	13.13	13.18	84.63	86.28	95.00	95.64	154.79	153.56	13.10	13.25
Potassium nitrate10%	86.30	86.70	18.31	19.13	111.62	112.70	118.10	119.10	161.98	160.57	18.08	18.09
Garlic extract 20%	84.60	84.36	16.13	16.58	111.15	112.16	117.60	118.00	157.61	156.91	17.51	17.59
Onion extract 20%	86.60	86.30	18.15	18.25	107.14	108.43	116.00	117.11	158.20	158.01	16.95	17.13
KNO_3 5%+ Garlic 10%	86.95	86.90	19.04	19.60	112.80	112.95	119.20	119.60	162.90	161.70	18.37	18.26
KNO_3 5%+ Onion 10%	89.60	87.21	20.10	20.31	113.29	113.94	120.20	119.80	165.20	162.10	18.71	18.46
L.S.D at 5%	2.24	2.66	1.39	1.42	1.12	1.13	1.56	1.63	2.89	2.93	1.04	1.05

Table 4: Effect of Potassium Nitrate, Garlic and Onion Extract Treatments on Chemical Contents of Leaves in "Anna" Variety

Treatments	Total Chlorophyll mg/g.f.w		Total Carbohy-drates mg/g.d.w		Total Protein %		N %		P %		K %	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Control	1.88	1.81	76.20	76.15	10.56	11.00	1.69	1.76	0.20	0.21	1.52	1.50
Potassium nitrate10%	1.93	1.94	88.10	89.01	11.94	12.06	1.91	1.92	0.24	0.24	1.53	1.55
Garlic extract 20%	1.93	1.92	87.09	86.60	11.68	11.56	1.87	1.85	0.23	0.22	1.52	1.51
Onion extract 20%	1.93	1.94	88.06	87.15	11.93	12.06	1.91	1.92	0.24	0.29	1.53	1.54
KNO_3 5%+ Garlic 10%	1.94	1.95	88.98	89.10	12.00	12.12	1.92	1.94	0.24	0.25	1.54	1.56
KNO_3 5%+ Onion 10%	1.94	1.95	89.10	89.16	12.00	12.18	1.92	1.94	0.25	0.26	1.55	1.56
L.S.D at 5%	0.04	0.08	1.11	1.20	0.23	0.22	0.04	0.04	0.01	0.01	N.S	N.S

when potassium nitrate at 5% mixed with onion extract at 10% as well as potassium nitrate at 5% mixed with garlic extract at 10% which recorded 0.23 and 0.23 for nitrogen, 0.05 and 0.04 for phosphorous and 0.03 and 0.06 for potassium in the first seasons and 0.18 and 0.18 for nitrogen, 0.05 and 0.04 for phosphorous and 0.06 and 0.06 for potassium in the second seasons respectively as over the control trees.

6.5. 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 (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

Table 5: Effect of Potassium Nitrate, Garlic and Onion Extract Treatments on Chemical Fruit Quality of "Anna" Apple Fruits

Treatments	TSS %		Activity %		TSS/Activity Raio		Vitamin C mg/100 ml Juice	
	2006	2007	2006	2007	2006	2007	2006	2007
Control	11.30	11.40	1.05	1.05	10.76	10.85	1.13	1.15
Potassium nitrate10%	13.10	12.60	0.88	0.87	14.26	14.36	1.48	1.48
Garlic extract 20%	12.55	12.60	0.92	0.91	13.58	13.84	1.45	1.48
Onion extract 20%	12.75	12.60	0.90	0.89	14.16	14.15	1.49	1.46
KNO_3 5%+Garlic 10%	12.80	12.66	0.82	0.82	15.60	15.43	1.50	1.49
KNO_3 5%+Onion 10%	12.80	12.78	0.80	0.81	16.00	15.77	1.52	1.51
L.S.D at 5%	0.05	0.07	0.04	0.05	0.89	0.89	N.S	N.S

Table 6: Effect of Potassium Nitrate, Garlic and Onion Extract Treatments on Some Chemical Composition of "Anna" Apple Fruits

Treatments	Water Content %		Total Carbohydrates mg/F.W		Total Sugars mg/g F.W		Reducing Sugars mg/g F.W		Total Free Amoni Acids mg/g F.W		Total Phenols mg/g F.W	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Control	77.60	76.50	141.60	145.10	85.61	87.10	55.50	56.10	1.81	1.82	0.45	0.47
Potassium nitrate10%	79.88	80.26	156.6	159.60	100.60	102.60	68.60	69.10	2.20	2.30	0.31	0.28
Garlic extract 20%	79.60	80.20	150.10	152.50	90.10	91.20	60.61	63.15	1.99	1.98	0.35	0.36
Onion extract 20%	79.20	79.90	151.10	152.30	91.60	92.30	61.20	62.20	1.97	1.98	0.36	0.37
KNO_3 5%+ Garlic 10%	80.61	81.01	164.20	166.50	102.60	103.30	71.15	72.25	2.26	2.38	0.30	0.28
KNO_3 5%+ Onion	80.90	81.40	165.60	169.90	103.30	104.60	72.30	73.10	2.30	2.39	0.28	0.27
L.S.D at 5%	1.15	1.26	2.95	2.99	1.01	1.05	1.11	1.09	0.06	0.08	0.3	0.04

during the two seasons of the study. The maximum increases were recorded with potassium nitrate at 5% mixed with either onion or garlic extract at 10% which recorded 1.5 and 1.5 for total soluble solids, 5.24 and 4.84 for TSS/acid ratio, 34.51 and 32.74% for vitamin C, 3.30 and 3.01 for water content, 16.94 and 15.96% for total carbohydrates, 20.66 and 19.84% for total sugars, 30.27 and 28.19% for reducing sugars and 27.07 and 24.86% for total free amino acids in the first seasons respectively, as compared to the control trees, and 1.38 and 1.26 for total soluble solids, 4.92 and 4.58 for TSS/ acid ratio, 31.30 and 29.56% for vitamin C, 4.9 and 4.51 for water content , 17.09 and 14.74% for total carbohydrates, 20.09 and 18.59% for total sugars, 30.30 and 28.78% for reducing sugars and 31.31 and 30.76% for total free amino acids in the second 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.

7. Discussion

Spraying apple trees with any of the tested treatments (potassium nitrate at 10%, garlic extract at 20%, onion extract at 20%, potassium nitrate at 5% mixed with either garlic or onion extract at 10%) resulted in vigorous plant (tree) growth as well as high productivity with good fruit quality. Treatments increased the measured growth characters. This was due to the fact that these treatments resulted in more availability of macronutrients (N, K and S) 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, Also, Kubota *et al*. (1999) investigated the active substances in garlic which is responsible for breaking bud dormancy in grapevines. The compounds were identified as diallyl mono-, di-, tri-, and tetra-sulfides, but only trace amounts of dimethyl mono- and di-sulfides were present. Exposure to volatiles of diallyl di- and tri-sulfides was the most effective treatment in promoting bud break, irrespective of the concentration and the duration of exposure. However, the effects of dimethyl sulfide and diallyl sulfide on budbreak varied among the concentrations and the duration of exposure. These results indicate that the active substances in garlic, responsible for breaking bud dormancy in grapevines, are sulfur- containing compounds with an allyl group (CH_2CHCH_2), particularly dially disulfide. Moreover, garlic and onion extract used in this study, have an improving effect on vegetative growth parameters. This may be attributed to the essential role of these substances in the synthesis of some amino acid and consequently, formation of growth regulators especially auxin, and ethylene.

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) and Subhadrabandhu (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, Subhadrabandhu (1995) and Nashaat (1996) reported that some different spray treatments may break dormancy by decreasing ABA content in buds.

The improving effect of potassium nitrate, garlic extract and onion extract 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 potassium nitrate, garlic extract and onion extract 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 potassium nitrate, garlic extract and onion extract 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.* (1999) 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 potassium nitrate, garlic extract and onion extract 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 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) and 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).

Finally, from the results of the present investigation, it could be concluded that the application of potassium nitrate, garlic extract or onion extract greatly increased growth and apple yield as well as improved apple quality and its chemical constituents. The constituents of these substances participate in the different metabolic processes which increased syntheses of chlorophyll, carbohydrates, total free amino acids, and absorption of essential nutrients, so that the use of potassium nitrate, garlic extract and onion extract could increase apple productivity with high fruit quality.

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