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Improving Productivity and Fruit Quality of "Anna" Apple Trees Using Salicylic Acid and Bio Silicon

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Abstract: This study was carried out during two successive seasons of 2019 and 2020 in order to study the effect of salicylic acid (SA) at 0, 100 and 200 ppm as an organic acid and bio Silicon named diatomite as organic matter at 3 gm/L foliar application, soil addition and foliar application with soil addition together as a bio-stimulant matter on yield and fruit quality of twelve years old "Anna" apple trees (*Malus domastica*) grown in clay soil at Aga district, Dakahlia Governorate. Results revealed a significant impact of treatments on all parameters included in the study. Both of salicylic acid and bio silicon improved flowering, fruit set, yield and fruit quality compared by untreated trees. It noticed that salicylic acid at 200 ppm and bio silicon at 3 g/L spraying& soil addition enhanced physical properties (fruit weight, volume, dimension and firmness) and chemical properties (TSS, total acidity, total sugars, pectin and protein content)as well as increased net profit% for 77.92%compare to 32.36%for control and increased investment rate for 6.48LE/1.0LE.

Key words: Organic and bio stimulant substances · Salicylic acid · Bio silicon · Yield · Fruit quality · Anna apple trees

INTRODUCTION

Apple (*Malus domestica* Borkh.) is one among the most widely cultivated fruit crops, most ordinarily consumed fruits within the world and one of the most important deciduous fruit trees in Egypt. The quality and quantity of apple fruit trees are influenced by several factors such as a set of agronomic (fruit size, yield, resistance to bacteria and fungi) and organoleptic (colour, shape, firmness) properties as well as nutrient and vitamin content [1, 2].

A bio-stimulant could also be any substance or mixture of substances of natural origin or microorganism that improves the fruit quality while not inflicting adverse facet effects [3]. Natural stimulants are typically enclosed under the term of bio-stimulants, as well as phenols, Enzymes, amino acids, micronutrients, salicylic acid, humic and fulvic acids, or protein hydrolases [3, 4]. A new approach to enhance crop quality and bioactive compounds is the use of plant growth regulators (PGRs). Some PGRs and natural compounds such as salicylates, nitric oxide, brassinostroides, ascorbic acid (AA) jasmonates and citric acid (CA) are shown to enhance the yield and quality of various crops [5].

Bio Silicon or Diatomaceous earth (diatomite), which originates from fossilized sedimentary deposits of Phytoplankton (diatoms), was applied to plants in China as early as 2000 B.C.E. Silicon has been improved cell wall strength and structural integrity, improve drought and frost resistance, decrease lodging potential. Also, to improve plant vigor and physiology by improving root mass and density and increasing above ground plant biomass and crop yields. Silicon plays an important role in reducing multiple stresses including biotic and a biotic stresses, nutrient and water uptake, photosynthesis, plant pigments synthesis and cell division [6, 7]. In addition to naturally occurring soluble silicon in soil, many crops respond positively to additions of supplemental silicon [8]. Silicon (Si) regarded as one of the most beneficial elements for the plant life [9]. Several studies reported that it is important for various plants to improve growth and yield through improving plant water status, modification

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of ultra-structure of leaf organelles, activation of plant defense systems and mitigation of free radicles [10, 11]. The positive effects of silicon on the growth and development of crops is reported by many researchers [12-15]. The use of all silicon sources has been very effective in enhancing yield and fruit quality in various fruit crops [16-18].

Salicylic acid was very effective in enhancing yield and fruit quality of different fruit crops [19-22]. SA is one of the well-known and effective natural inducers of plant resistance to different diseases. Accumulation of endogenous salicylic acid induces a systemic acquired resistance (SAR) mechanism, which is considered one of the classical forms of induced resistance [23]. Salicylic acid (a simple phenolic compound) is an endogenous hormone, having key roles in different aspects of plant growth is a phenolic phytohormone and development, photosynthesis , transpiration , ion uptake and transport [24-26] and development such as stomatal movement, seed germination, ion absorption and responses to environmental stresses. It is a molecule involved in some signal transduction systems, which induce biosynthesis of defense compounds such as polyphenols, alkaloids or pathogenesis-related (PR) proteins [27, 28].

The main objective of this study was examined the effect of salicylic acid (as an organic substance) and bio silicon (as a bio- stimulants substances) on flowering, fruit set, yield and fruit quality of "Anna" apple trees.

MATERIALS AND METHODS

This study was carried out during the two successive seasons of 2019 and 2020 on 12- years' old "Anna" apple trees (Malus domastica) onto M.M 106 rootstock grown in sandy clay loam soil under flood irrigation system, irrigated by nile water grown in a private orchard at Aga district, Dakahlia Governorate. Selected trees were at 3.5x3.5m apart; nearly similar in growth vigor and fruiting, free from any visual infections and received regularly the recommended horticultural practices. Dorset Golden and Ein-Shemir apple trees as pollinizers were additionally planted and distributed between Anna apple trees at the proportion of four rows of Anna apple trees per one row of pollinizers to secure open pollination with the assistance of two hives of honeybees per feddan. Trees were treated by salicylic acid as organic acid and bio silicon named diatomite as organic matter (from El-Ahram mining Co. Egypt). Chemical analysis of diatomite are shown in Table (1). This investigation included eighteen trees were treated as the following treatments.

- Control spraying tap water (untreated trees).
- Spraying Salicylic acid at 100 ppm
- Spraying Salicylic acid at 200 ppm
- Spraying Bio Silicon named Diatomite 3 g /1L
- Soil addition Bio Silicon named Diatomite 3 g /1L
- Spraying & Soil addition Bio Silicon named Diatomite 3 g /1L

Each treatment was replicated three times, one tree per each. Salicylic acid and Bio Silicon were treated three times at the growth start (first week of March), after fruit set (April) and one month after fruit set (May). Salicylic acid was dissolved in distilled water and the pH was adjusted at 6.5 with NaOH. Spraying was done till run off. The control trees were sprayed with tap water. The experiment was arranged in a randomized complete block design.

Furthermore, to evaluate the efficiency of the tested treatments on tree growth, fruiting and fruit quality as well as grower return the following measurements were carried out.

Vegetative Growth Measurements

Leaf Area: Ten mature leaves were collected on August after harvest fruits at random from each studied tree to determine leaf area (cm^2) by using Leaf Area meter model (1203, CID, Inc, USA).

Shoot Growth: Four main shoots similar as possible were chosen at the four cardinals of each treated tree.

Shoot Length (cm): Shoots were tagged and the average of the current shoot length was measured with tape measure (cm) on August in both seasons.

Shoot Diameter (cm): This evaluation was performed at the beginning of the experiment and at the fruit harvest date.

Chemical Composition of the Leaves

Chlorophyll Reading: Samples of 20 leaves /tree were taken at random from the middle of shoots from the previously tagged shoots of each tree. Leaf chlorophyll reading was recorded after the fruit harvest using Minolta chlorophyll Meter SPAD-502 (Minolta camera .Co, LtD Japan) at the field [29].

Determination of Leaf Minerals Composition: Leaf minerals contents were determined in August (after harvest) in both seasons. Samples of twenty leaves from

the middle part of shoots according to Chuntanaparb and Cummings [30] were selected at random from each replicate to determine their content of N, P and K according to Evenhuis [31]. Leaf samples were washed with tap water and distilled water twice, dried at 70°C to a constant weight and then ground. In dry ones, the ground samples were digested with sulphoric acid and hydrogen peroxide according to Evenhuis and Dewaard [32] Total nitrogen and Phosphorus were determined calorimetrically according to Evenhuis [31] and Murphy and Riley [33], respectively. Potassium was determined by a flame Photometer model E.E/L [34].

Curd Protein (%):
Calculated as:

$$\text{Curd Protein (\%)} = \text{N\%} \times 6.25$$

Tree Fruiting

Fruit Retention Percentage: Total number of flowers at full bloom stage was counted on the labeled shoots. After month, number of fruits were computed to calculate initial fruit setting (May) and before harvests the yield number of fruits were counted to calculate final fruit setting (last week of June). Percentages were calculated as follow:

$$\text{Fruit retention (\%)} = \frac{\text{No. of fruits before harvest}}{\text{No. of fruits after fruit set by month}} \times 100$$

Yield: Fruits were collected at harvest time (maturity) on last week of June from each tree of various replicates and yield weight (kg/tree) was estimated by multiplying the number of fruits with average fruit weight in both seasons under study.

Fruit Quality: Fruit samples were collected from those branches (three represented fruit from each branch, repeated on three trees per treatment) at commercial maturity on last week of June 2019 and 2020, for determining fruit characteristics.

Fruit Physical Properties:

- Average fruit weight (g).
- Average fruit volume (ml^3).
- Average fruit length (cm).
- Average fruit diameter (cm).
- Fruit firmness was estimated as $Ib/inch^2$ using the Magness and Taylor [35] pressure tester of 5/16 inch plunger.

Fruit Chemical Properties:

- Total soluble solids (%).
- Juice acidity (%) (as g malic acid/100 ml juice) were determined according to A.O.A.C [36].
- TSS/ Acidity
- Total sugars (%) according to Lane and Eynon procedure outlined in A.O.A.C [36].
- Protein%:- Calculated as:

$$\text{Curd Protein (\%)} = \text{N\%} \times 6.25$$

- Pectin% were determined according to Furong *et al*. [37] and Auribi *et al*. [38]

Net Profit (LE): Fruit yield was used in estimating crop monetary value considered a farm-gate price of 4LE/Kg for the first season and 6 LE/Kg for the second season, control treatment cost % /fed had considered equal 14000 & 16000 LE for two seasons under study. In considered that the price of stimulant substances used in addition to the cost of agricultural practices for trees (as well as, fertilizers, irrigation, pests control, workers and breaking dormancy agents…. etc). Whereas , the prices were Salicylic acid 200 LE/ kg and Bio Silicon 75 LE/1Kg. The cost % is counted by adding total agricultural practices cost (14, 000 LE /Fed at 1st season & 16, 000 at 2nd season) plus the stimulant substances cost. Here in, counted the net profit /Fed. which led to count the net profit % and Investment return rate (LE) according to Hudson and Gregoriou [39].

Net profit LE/ fed for treatments were calculated as follows:

Net profit = Yield price (LE/fed) - Agriculture practices cost (LE/Fed).

Net profit % = Net profit LE/ fed ÷ Yield price (LE/fed) ×100

Treatment cost (%) = 100 - Net profit %

Investment return rate (LE) = Net profit (LE)/fed / treatment - Net profit (LE)/ ` fed/control ÷ Net profit (LE) /fed /control

Statistical Analysis: All obtained data were, statistically analyzed according to the method of Duncan multiple range tests [40] were used for comparison between means of each treatment.

Table 1: Chemical analysis of Diatomite (mg/100 g dry weight as El-Ahram mining Co. Egypt analysis)

Hormones (µg/100g)		Amino acids (ppm)		Organic acid (ppm)		Minerals (%)	
GA3	*	L. Glutamic acid	5097.88	Fumaric	485839.73	C.N	31.56
IAA	*	L. Tyrosine	1599.89			D .N	2
ABA	*	L. Methionine	1496.87	Succinic	6941.25	SiO_2	46.37
Kinten		L. Serine	1339.33	Oxalic	1251.37	TiO_2	0.37
Zeatin	489.88	L. Threonine	1213.20	Malic	772.62	Al_2O_3	8.04
		L. Alanine	797.77	Tatraric	383.39	Fe_2O_3	1.23
		L. Isoleiucine	751.70	Citric	114390.25	Mn O	0.10
		L. Phenylalanine	675.92			MgO	1.68
		L. Leucine	647.35			CaO	17.72
		L. Aspartic acid	609.18			Na_2O	1.00
		L. Histidine	430.24			K_2O	0.66
		L. Valine	364.25			P_2O_5	1.68
		L. Proline	289.54			SO_3	0.79
		L. Glycine	217.83			Cl	2.31
		L. Cystine	214.54			L.O. L	17.68
		L. Arginine	156.71				
		L. Tryptophan	25.57				
		L. Cystein	8.34				

RESULTS AND DISCUSION

Vegetative Growth: Regarding the effect of salicylic acid and bio silicon treatments under study on the leaf area (cm^2), shoot length and shoots diameter of "Anna" apple trees (Table 2) revealed that they had significantly positive effect in both seasons (2019 & 2020) under study. Also, it noticed that growth parameters data go in the same line in both seasons under study. It was found that highest growth parameters were obtained from spraying salicylic acid at 200ppm as foliar application followed by bio silicon 3 g/L as foliar application & soil addition and bio silicon 3 g/L as foliar application, whereas, the lowest growth parameters included: leaf area (cm^2), shoot length and shoot diameter (cm) were obtained from untreated trees in the both seasons. Generally, the obtained data showed a significant positive relation between salicylic acid and bio silicon and vegetative growth parameters under study. Jain *et al.* [41] indicated that seedlings sprayed with silicon increased the seedling length of rice compared to the unsprayed.

Chemical Composition of Leaves: Results in Table (3) indicate that salicylic acid and bio silicon had a positive effect on leaf content of N, P and K than control in both seasons. Spraying with Salicylic acid100 &200 ppm as foliar application recorded higher values of leaf content of N %, K% and followed in a descending order by spraying with all treatments during the two seasons under study. While, best resulted for P was noticed with spraying 200 ppm salicylic acid or 3g/L bio silicon in both seasons under study compared with other treatments. In this respect, Jain *et al*. [41] cleared that foliar spray of silicon (named Silixol as a proprietary formulation with stabilized orthosilicic acid 0.8 %) enhanced uptake of essential nutrient (viz. P, Ca and K), when applied in the nursery.

Chlorophyll Reading and Curd Protein: Results in Table (4) indicated that salicylic acid bio silicon had a positive relation between chlorophyll content and curd protein with either salicylic or bio silicon in both seasons 2019 & 2020. It was noticed that curd protein goes in the same trend with nitrogen in both seasons, respectively. Spraying salicylic acid at 200ppm and bio silicon soil addition & spraying enhanced Chlorophyll content during 2019 & 2020 seasons. Jain *et al.* [41] indicated that seedlings of rice sprayed with Silixol (a proprietary formulation with stabilized orthosilicic acid 0.8 %) had higher levels of chlorophyll content over the control, accounting for a higher rate of photosynthesis.

Tree Fruiting

Fruit Retention (%): Results cleared that studied salicylic acid and bio silicon have significantly affected on the fruit retention (%) of "Anna" apple trees in both seasons (Table, 5). The maximum percentages were obtained from spraying Salicylic acid at 200ppm followed in a descending order by bio silicon as soil addition & spraying at 3g/L and bio silicon spraying at 3g/L. Untreated trees produced the minimum number of flowers, fruit set% and fruit retention during both seasons, respectively.

Table 2: Effect of some stimulant substances on average of shoot length(cm), shoot diameter (cm) and leaf area (cm^2) of" Anna" apple trees during (2019 and 2020) seasons

	Shoot length (cm)		Shoot diameter (cm)		Leaf area (cm^2)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Salicylic acid at 100 ppm	105.51C	129.50D	0.88B	0.98B	39.80D	43.48B
Salicylic acid at 200 ppm	122.66A	138.83B	0.97A	1.05AB	43.20A	45.13A
Bio silicon spraying 3 g/L	122.50A	136.00C	1.01A	1.06AB	41.40BC	44.73A
Bio silicon soil addition 3 g/L	116.34B	125.00E	1.00A	1.02AB	41.14C	41.27C
Bio silicon soil addition & spraying	124.17A	147.00A	0.97A	1.07A	42.53AB	45.33A
Control	84.50D	104.72F	0.81B	0.87C	33.83E	37.27D

Means within each column followed by the same letter (s) are not significantly different at 5% level

Table 3: Effect of salicylic acid and bio silicon on leaf N%, P%, K% of "Anna" apple trees during 2019 and 2020 seasons

	N%		P%		K%	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Salicylic acid at 100 ppm	2.13B	2.40B	0.35C	0.38AB	2.23C	2.43A
Salicylic acid at 200 ppm	2.31A	2.52A	0.39A	0.41A	2.35A	2.46A
Bio silicon spraying 3 g/L	2.01D	1.90F	0.36B	0.40A	2.27B	2.29B
Bio silicon soil addition 3 g/L	1.96E	2.01D	0.31D	0.34C	2.28B	2.25C
Bio silicon soil addition & spraying	2.08 C	2.03C	0.30D	0.28D	2.09D	2.05D
Control	1.79F	1.90F	0.16E	0.21E	1.85E	1.90E

Means within each column followed by the same letter (s) are not significantly different at 5% level

Table 4: Effect of some stimulant substances on Curd Protein % and Chlorophyll reading of "Anna" apple trees during 2019 and 2020 seasons

	Curd Protein %		Chlorophyll reading	
Treatments	1st season	2nd Season	1st Season	2nd Season
Salicylic acid at 100ppm	13.31B	15.00B	56.57C	58.13B
Salicylic acid at 200ppm	14.44A	15.75A	60.87A	61.83A
Bio silicon spraying 3 g/L	12.56D	11.88 E	60.53AB	61.93A
Bio silicon soil addition 3 g/L	12.25E	12.56D	56.97C	58.66B
Bio silicon soil addition & spraying	13.00 C	12.69C	59.23B	62.08A
Control	11.19F	11.88E	53.53D	55.93C

Means within each column followed by the same letter (s) are not significantly different at 5% level

Yield: Table (5) displays clearly that productivity of Anna apple tree (yield expressed as harvested fruits in Kg/tree) influenced significantly by both the salicylic acid and bio silicon. Herein, all treatments had positively affected on "Anna" apple tree yield as compared to the control during both 2019 & 2020 experimental seasons significantly. In addition, it noticed that fruit retention, number of fruits /tree and yield Kg/tree go in the same trend to give a significant positive respond to both salicylic acid and bio silicon compared with untreated ones in both seasons under study, respectively.

Flowering is another important parameter that is directly related to yield and productivity of plants. Salicylic acid has been reported to induce flowering in several plants [42]. Hayat *et al*. [43] reported that salicylic acid application promotes cell division and cell enlargement. According to many others, the positive effect of salicylic acid on growth and yield can be due to its influence on other plant hormones. Salicylic acid altered the auxin, cytokinin and ABA balances and increased the growth and yield under both normal and saline conditions [44, 45]. Increasing yield under foliar application of salicylic acid could be ascribed to the well-known roles of salicylic acid on photosynthetic parameters and plant water relations. Ahmed *et al*. [46]; Abd El- Mageed [47]; Randa [48] and Emad [49] reported that exogenous application of salicylic acid enhanced the net photosynthetic rate, internal CO_2 concentration and water use efficiency. Salicylic acid and Bio Silicon were significantly very effective in enhancing flowering, fruit setting and yield. Also, improving yield and fruit quality in various fruit crops due to the positive effects of silicon [10-18].

Table 5: Effect of spraying salicylic acid and bio silicon on average of number of fruits/tree, Fruit retention (%) and yield (kg/tree) of" Anna" apple trees during 2019 and 2020 seasons

	Fruit retention (%)		No. of fruits /tree		Yield /tree (Kg/tree)	
Treatments	1stSeason	2ndSeason	1stSeason	2ndSeason	1stSeason	2ndSeason
Salicylic acid at 100 ppm	22.49C	22.92C	188.7D	208.0D	27.83D	38.12D
Salicylic acid at 200 ppm	29.75A	32.34A	267.7A	300.0A	47.01A	59.16A
Bio silicon spraying 3g/L	23.56C	23.02C	202.7C	216.0C	28.32C	38.12C
Bio silicon soil addition3g/L	17.93D	20.92D	148.0D	176.0E	19.99E	29.06E
Bio silicon soil addition & spraying	25.37B	26.63B	239.7B	268.43B	35.09B	48.29B
Control	16.23E	17.01E	113.7F	138.7F	15.13F	22.54F

Means within each column followed by the same letter (s) are not significantly different at 5% level

Table 6: Effect of some salicylic acid and bio silicon on weight (g), size (cm^3) and firmness ($Ib/Inch^2$) of Anna apple fruits during 2019 and 2020 seasons

	Fruit weight (g)		Fruit volume (cm^3)		Firmness ($Ib/Inch^2$)	
Treatments	1stSeason	2ndSeason	1stSeason	2ndSeason	1stSeason	2ndSeason
Salicylic acid at 100 ppm	147.5B	183.2B	145.0C	170.6D	7.45B	8.12B
Salicylic acid at 200 ppm	175.6A	197.2A	163.3A	188.5A	7.20D	7.00C
Bio silicon spraying 3g/L	139.7C	176.5D	136.7D	183.3B	7.80C	8.25B
Bio silicon soil addition 3g/L	135.1D	165.1E	148.4B	182.2BC	8.58A	8.76A
Bio silicon soil addition & spraying	146.4B	179.9C	149.5B	180.0C	8.25B	8.30B
Control	133.1E	162.5F	124.4D	162.2E	8.62A	8.73A

Means within each column followed by the same letter (s) are not significantly different at 5% level

Table 7: Effect of salicylic acid and bio silicon on length (cm), diameter (cm) and L/D of Anna apple fruits

	Fruit length (cm)		Fruit diameter (cm)		L/D	
Treatments	1stSeason	2ndSeason	1stSeason	2ndSeason	1stSeason	2ndSeason
Salicylic acid at 100 ppm	7.25BC	7.71B	6.88B	7.45AB	1.05A	1.03A
Salicylic acid at 200 ppm	7.96A	8.12A	7.17A	7.55A	1.11A	1.08A
Bio silicon spraying 3g/L	6.93C	7.67B	6.72BC	7.30BC	1.03A	1.05A
Bio silicon soil addition 3g/L	7.57B	7.51BC	6.69BC	7.34BC	1.13A	1.02A
Bio silicon soil addition & spraying	7.17C	7.41C	6.57CD	7.22C	1.09A	1.03A
Control	7.04C	7.37C	6.41D	7.19C	1.10A	1.03A

Means within each column followed by the same letter (s) are not significantly different at 5% level

Table 8: Effect of salicylic acid and bio silicon on some chemical properties of Anna apple fruits during 2019 and 2020 seasons

	TSS %		Acidity %		TSS/ Acidity	
Treatments	1stSeason	2ndSeason	1stSeason	2ndSeason	1stSeason	2ndSeason
Salicylic acid at 100ppm	13.81C	13.92AB	0.63C	0.60D	22.62C	23.20B
Salicylic acid at 200ppm	14.25AB	13.92AB	052D	0.59D	26.85B	23.74B
Bio silicon spraying 3g/L	14.50A	14.17A	0.87A	0.83B	16.67E	17.07D
Bio silicon soil adding 3g/L	13.83C	13.83B	0.73B	0.71C	18.95D	19.48C
Bio silicon soil &spraying	14.08BC	14.17A	0.43E	0.49E	32.74A	28.92A
Control	13.50D	13.50C	0.95A	0.91A	14.22F	14.84E

Means within each column followed by the same letter (s) are not significantly different at 5% level

Table 9: Effect of salicylic acid and bio silicon on total sugars (%), pectin (%) and protein (mg/100g) of Anna apple fruits during 2019 and 2020 seasons.

	Total sugars %		Pectin%		Protein (mg/100g)	
Treatments	1stSeason	2ndSeason	1stSeason	2ndSeason	1stSeason	2ndSeason
Salicylic acid at 100ppm	12.27C	12.38C	0.73C	0.74BC	1.76B	1.82B
Salicylic acid at 200ppm	12.75B	12.94B	0.66C	0.70C	1.87A	1.88AB
Bio silicon spraying3g/L	11.33D	11.46E	0.91A	0.93AB	1.50D	1.58D
Bio silicon soil addition 3g/L	11.15D	11.90D	0.82B	0.92B	1.68C	1.68C
Bio silicon soil addition &spraying	13.33A	13.52A	0.93A	0.96A	1.97A	1.97A
Control	10.67E	10.95F	0.55D	0.60C	1.32E	1.39E

Means within each column followed by the same letter (s) are not significantly different at 5% level

Table 10: Effect of salicylic acid and bio silicon on the net profit (LE) of "Anna" apple trees during 2019 and 2020 seasons

	Productivity (Ton/fed.)		Agriculture practices cost (LE/fed)		Yield price (LE) /fed		Cost (%)/ fed		Net profit (LE/ fed)		Net profit%		Investment return rate (LE)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Salicylic acid at100 ppm	9.518	13.037	14200	16200	38071	78222	37.3	20.71	23871	62022	62.70	79.29	2.56	1.05
Salicylic acid at200 ppm	16.077	20.233	14200	16200	64310	121398	22.08	13.43	50110	105098	77.92	86.57	6.48	2.47
Bio silicon spraying 3g/1L	9.685	13.037	14150	16150	38742	78222	36.52	20.65	24592	62072	63.48	79.35	2.67	1.05
Bio silicon soil addition 3g/1L	6.837	9.939	14150	16150	27346	59631	51.74	27.08	13196	43481	48.26	72.92	0.97	0.43
Bio silicon soil addition &spraying	12.001	16.515	14300	16300	48003	99090	29.79	16.45	33703	82790	70.21	83.55	4.03	1.73
Control	5.175	7.709	14000	16000	20698	46254	67.64	34.59	6698	30254	32.36	65.41	—	—

Fruit Physical Properties

Fruit Weight, Volume and Firmness: It is clear from the data in Table (6) that spraying salicylic acid and bio silicon, significantly, improved fruit quality in terms of increasing fruit weight and fruit volume but decreased fruit firmness in relative to the control treatment. Spraying salicylic acid especially at 200ppm gave the best results regarding fruit quality. Where it gave the heaviest fruit (175.6 & 197.2g), largest (163.3 & 188.5cm^3) and the least firmness (7.20 & 7.00 lb/inch^2). On the other hand, untreated trees resulted in the least fruit weight and volume subsequently the highest firmness.

A noticeable promotion was observed on fruit quality owing to use salicylic acid. favorable effects on yield and fruit quality were observed on treated trees. The effect of salicylic acid on increasing fruit set and promoting productivity of "Anna" apple trees might be attributed to its beneficial effect on reducing reactive oxygen, species that are responsible for destroying plasma membrane as well as enhancing the biosynthesis of IAA and minimizing the unfavorable effects of different stresses on plant development [19-21].

Fruit Dimensions: It's noticed that the dimensions of Anna apple fruits go in same trend with the weight where there is a positive significant increasing in both seasons under study parallel to the increment in fruit weight (Table 7). Data revealed that spraying with salicylic acid and bio silicon had a positive effect on fruit dimensions compared with control in both seasons under study. It was found that spraying Salicylic acid at 200 ppm and bio silicon soil addition & spraying at 3 g /L significantly recorded the highest value of fruit length and diameter in both seasons. With respect to effect of salicylic acid and bio silicon, it was clear that fruit dimensions recorded the highest values. Whereas the lowest values were obtained from untreated trees in both seasons. Nevertheless, fruit length/diameter ratio has non-significant differences may be as a reflection of the fact of similar round shape of "Anna "apple cultivar.

Fruit Chemical Properties: Data concerning the values of TSS and total acidity as affected by some stimulant substances treatments as shown in Table 8. It shows that apple trees treated by salicylic acid at 200PPm, bio silicon as spraying and bio silicon at 3 g/L as foliar & soil addition had a higher TSS.% Also, it was noticed that total acidity for fruits in vice versa TSS during two seasons under study. Low acidity determines a good quality for human consumption. In spite of fruit juice acidity, control treatment induced the lowest TSS/acidity ratio so, it can be used as a remarkable on "Anna" apple cultivar.

Results of Table (9) illustrated those total sugars (%) and protein (%) increased in fruits from trees treated by salicylic acid200ppm and 3g/L bio silicon as soil addition & spraying. Meanwhile, pectin (%) was affected by bio silicon more than salicylic acid, generally. The sugar content of apples differs depending on the weather conditions, cultivars, culture technology, position and exposition of the fruits in the crown [50, 51]. Chandra *et al.* [52] reported that application of salicylic acid increased total soluble sugar and soluble protein of cowpea plants.

Crop Monetary Value (LE/Fed.): Data in Table (10) and Fig. (1) show the effect of salicylic acid and bio silicon on the net profit (LE/fed) for treatments during the two seasons of study (2019&2020).It noticed that all treatments gave better net profit compare with untreated ones.-Moreover,-the-highest-net-profit % and the lowest cost % were obtained from salicylic acid 200 ppm and-bio-silicon-3g/L(soil-addition-& spraying) in the two seasons followed with salicylic acid 100 ppm, spraying bio silicon 3g/L and 3g/L as soil addition in a comparison with the untreated one in the two seasons under study. Also, it is noticed that all treatments gave the highest investment rate during the two seasons per control costs (LE) especially both salicylic acid 200 ppm and spraying Bio Silicon-3g/L-plus-3g/L-as-soil-addition-treatments. Also, data revealed that salicylic acid treatment induced the

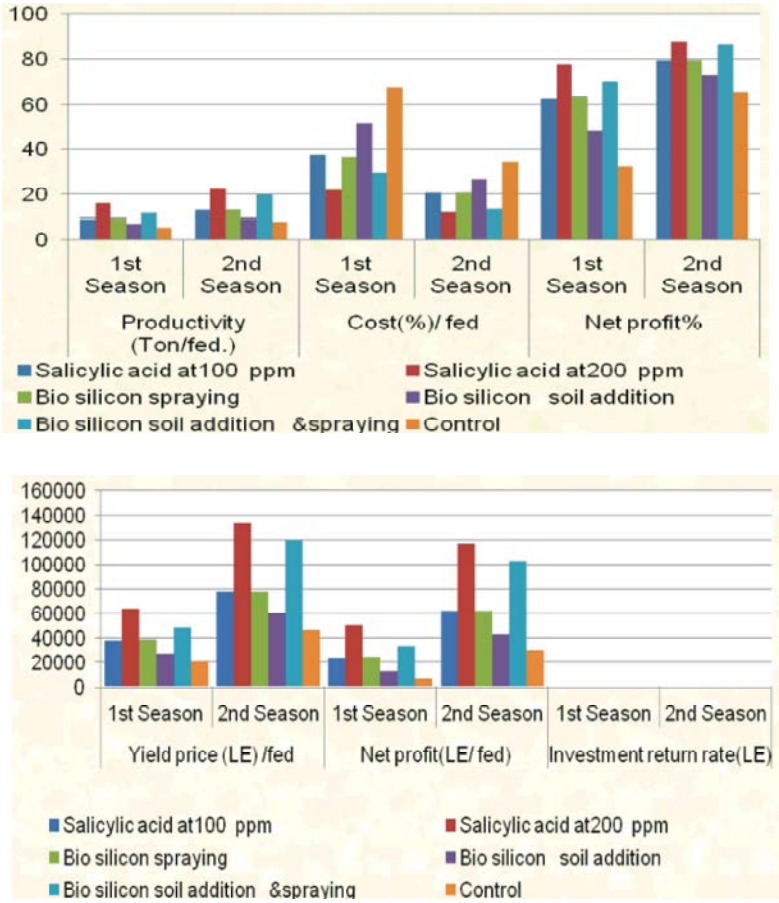

Fig. 1:

highest net profit (43412 LE in the first season and 87090LE-in-2nd- season)- over- the- check-treatment. The highest increase in second season than 1st season reflects the beneficial effect of the present treatments.

CONCLUSION

Both salicylic acid and bio silicon reflected best results regarding vegetative growth parameters and fruit retention. This revealed promoting effects of both salicylic acid and bio silicon. Also was reflected on achieving the highest macro nutrients and chlorophyll reading in the leaves of these treatments. Here in, it could be summarized that spraying salicylic acid (as an organic acid) at 200 ppm and 3/L bio Silicon (as a bio substance named Diatomite) as soil addition &spraying enhance growth, fruit set, yield and fruit quality of "Anna" apple trees as well as their income.

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