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Response of Photosynthetic Pigments and Pod Quality of Sugar Pea to Some Eco- Friendly Substances

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Abstract

The present study was conducted at the experimental Farm, El-Kassasein Research Station, Ismailia Governorate, Egypt, during the two successive winter seasons of 2022/2023 2023/2024, to investigate the effects of natural foliar applications, i.e., Salicylic Acid, Ascorbic Acid, Citric Acid, Aloe vera Extract and Borpota fertilizer on photosynthetic pigments and quality of sugar snap pea cultivar "Sugar Snap". This experiment included 11 treatments which arranged in a randomized complete block design (RCBD) with three replicates. The foliar application of 11 treatments as follows: Control (sprayed with tap water only),Salicylic acid 100 mg L^{-1} (ppm), Salicylic acid 200 mg L^{-1} (ppm) ,Ascorbic acid 100 mg L^{-1} (ppm), Ascorbic acid 200 mg L^{-1} (ppm) ,Citric acid 100 mg L^{-1} (ppm), Citric acid 200 mg L^{-1} (ppm), Aloe vera extract 20 ml/l, Aloe vera extract 40 ml/l, Borpota 1 ml/l and Borpota 2 ml/l. The obtained results are summarized as follows; all the foliar studied treatments significantly increased the photosynthetic pigments, i.e., chlorophyll a, chlorophyll b, total chlorophyll and carotenoids of sugar pea leaves. These results indicated that foliar application of ascorbic acid (vitamin c), being the most effective of all photosynthetic pigments of sugar pea leaves, chemical content and active compounds of sugar peas pods. These treatments followed by the treatments of salicylic acids, citric acid, Aloe vera extract and borpota fertilizer, respectively. Conclusively: it can be concluded that using the bio- stimulants substrates (ascorbic acid, salicylic acid, citric acid, Aloe vera extract and Borpota fertilizer increased the photosynthetic pigments, chemical content and active compounds of sugar peas pods.

Keywords: Sugar pea - bio- stimulants substrates- Borpota fertilizer

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1. Introduction

Sugar peas are a significant addition to Egypt's vegetable crop, supporting local market and export purposes. There are two genotypes: snow peas and sugar snap peas. Snow peas, also known as Pisum sativum var. macrocarpon, are edible-podded due to their lack of cross fibres in pod wall. They can be consumed whole, unlike garden peas. Snow peas, also known as "mange-tout" in England and France, are a botanical cultivar or subspecies of Pisum sativum. The snow pea pod is flat and consumed before string formation and pea enlargement [1]. The sugar snap pea, also known as snap pea, is a legume originating from a crossbreeding between a snow pea and an unusual pea variety with thick walls. Its pods have thick walls and a pleasant sweetness. Harvested at a more advanced stage of maturity, the sugar snap pea has a fully rounded shape [1-2]. Its pods contain beneficial nutrients like the dietary fiber, folic acid, vitamin C, iron, manganese, riboflavin, vitamin B6, magnesium, phosphorus, potassium, vitamin A, and the vitamin K [3]. Existing agricultural methods confront enormous difficulties in maintaining food supply and quality in the face of global warming and its far-reaching effects [4]. The intricate interaction of changing climate conditions has intensified abiotic stresses on plants across the world, including drought, salt, high temperatures, and lack of nutrients [5]. In addition, ecosystems and soil health have further compromised due to chemical inputs, thus there has to be immediate effort to find sustainable agricultural alternatives [6]. Using Bio- stimulants as natural compounds impact plant nutrition, enhance water absorption and influence of plant growth and biomass generation, and increase both primary and secondary metabolism [7]. Salicylic acid (SA) is a naturally occurring plant hormone functions as an endogenous signal molecule in resistance of plants to environmental stresses [8], and when applied SA has found to improve various characteristics of pea plants, including pod number per plant, seed weight, pod length, pod width, pod yield per plant, and pod yield per hectare, under both irrigated and water-deficit conditions [9].

SA also enhances particular biological processes involved in plant growth [10], so study discovered that applying salicylic acid to cowpea plants resulted in most significant effects. This treatment enhanced vegetative growth, including plant height, number of compound leaves

per plant, fresh weight of shoots per plant, and dry weight of shoots per plant. Additionally, it increased productivity, photosynthetic pigments, and concentrations of nitrogen, phosphorus, and potassium [11]. Also, Vitamins and antioxidants classified as bio-regulators or hormone precursors. When added in small amounts, that enhancing plant growth and development, and may affect energy metabolic process [12]; ascorbic acid (ASA) and citric acid (CA) act as antioxidants and anti-stress agents, as well as signaling molecules in some plant physiological and defense mechanism [13]. Ascorbic acid plays an important role in various activities as photosynthesis, cell wall development, expansion, resistance to environmental stresses, and production of ethylene, gibberellins, anthocyanine, and hydroxyl proline [14]. Ascorbic acid, when used as a foliar treatment, improves resistance of cowpea plants to NaCl stress by stimulating growth of roots and shoots, increasing weight of fresh and dry plant material, and enhancing levels of chlorophyll pigments and carotenoids [15].

Additionally, applying Ascorbic Acid as a foliar treatment has positive effects on the growth and development of French bean and resulted in highest yield per plant, as documented by [14]. Citric acid (CA) plays a crucial role in various signal transduction systems, maintaining stability and function of membranes, activating transporter enzymes, facilitating metabolism, and facilitating translocation of carbohydrates [16]. Also [17] showed that application of CA may mitigate decrease in germination, mineral uptake, hormone balance, and overall growth and productivity caused by Pb-induced stress. Likewise, Plant extracts, such as Aloevera leaf extract, are one of the various types of bio-stimulants [18-19]. Belongs to Liliaceae family. It is an evergreen perennial herb that grows mostly in tropical and subtropical climates, and its leaf produces yellow latex gel [20]. ALE has a high concentration of auxins, gibberellins, salicylic acid, lignin, antioxidants, phenols, flavonoids, amino acids, vitamins, macro- and micronutrients, and polysaccharides [21]. Scientific research has verified that using aloe vera extract stimulates the process of seed germination and enhances the growth of plants throughout both the vegetative and flowering stages [22-23] especially had the most significant impact on eggplant.

Plants of the leguminous family require Boron in order to enhance the efficiency of nitrogen fixation. Furthermore, B is essential for the development and stability of cell walls, maintains structural and functional properties of biological membranes, facilitates the transportation of sugar or energy to growing sections of plants, and has a good impact on pollination and seed production [24]. Moreover Boron enhances the uptake of K+ ions and stimulates the activity of ATPase enzymes located in the cell membrane, resulting in the hyperpolarization of plasma membrane. It enhances opening and closing of stomata [25]. It reported that growth, yield, and seed production of various pea cultivars are greatly increased by foliar application of boron The number of leaves on a plant (120.8), the height of the plant (103.5 cm), the number of main branches (13.1), the number of pods (16.6), the length (11.1 cm), the diameter (13.8 mm), and number of seeds [26]. This study aims to investigate the effects of several bio-stimulants i.e., salicylic acid, ascorbic acid, citric acid, aloe vera extract, and boron as a foliar spray on growth, chemical content, pod yield, and quality of sugar pea cv. (*Pisum sativum* var. saccharatum) These substances are eco-friendly and can be applied to plants to improve nutritional efficiency, abiotic stress tolerance, and crop quality traits.

2. Materials and Methods

The present study was conducted at the experimental Farm, El-Kassasein Research Station, Ismailia Governorate, Egypt, during the two successive winter seasons of 2022/2023 2023/2024, to investigate the effects of natural foliar applications, *i.e*., Salicylic Acid, Ascorbic Acid, Citric Acid, Aloe vera Extract and Borpota on photosynthetic pigments and quality of sugar snap pea cultivar “Sugar Snap”. Representative samples were collected randomly from the experimental soil before sowing at 0-30 cm depth to determine some physical and chemical properties of the soil according to the method described by [27].

2.1. The experimental design and treatments

Seeds of sugar peas were obtained from Horticulture Research Institute, Agriculture Research Center, and Giza, Egypt. Seeds were inoculated directly before sowing with root nodules bacteria (*Rhizobium leguminosarum*) and sown, two seeds per hill on one side (two seeds / hill) and sown on October 18th and 22th in the first and the second seasons, respectively. This experiment included 11 treatments which arranged in a randomized complete blocks design (RCBD) with three replicates. The experimental unit area was 10.5 m^2 (3 ridges, 5m length and 0.7 m width) and one row was left between each two plots without treating as a guard row. The agricultural practices for sugar pea production were followed according to the Egyptian Ministry of Agriculture recommendations. The foliar application of 11 treatments as follow: Control (sprayed with tap water only) ,Salicylic acid 100 mg L^{-1} (ppm) ,Salicylic acid 200 mg L^{-1} (ppm),Ascorbic acid 100 mg L^{-1} (ppm), Ascorbic acid 200 mg L^{-1} (ppm), Citric acid 100 mg L^{-1} (ppm) ,Citric acid 200 mg L^{-1} (ppm), Aloe vera extract 20 ml/l ,Aloe vera extract 40 ml/l, Borpota 1 ml/l ,and Borpota 2 ml/l.

2.2. Antioxidants

Antioxidants (ascorbic acid, salicylic acid and citric acid) were obtained from El-Gomhoria Company for Chemicals, Egypt.

2.3. Salicylic acid Application

SA was initially submerged in pure ethanol and then gradually added to water (ethanol/water, 1/1000, v/v) [28]. Borpota: It was obtained from the Ministry of Agriculture and Land Reclamation, Giza, Egypt, which contains of boron, potassium oxide and Amino acid as shown in Table (2).

2.4. Aloe vera leaves Extract Preparation

Aloe vera leaves were collected from cultivated plants, separated from the plant, cleaned to eliminate dirt, air-dried, and subsequently sliced into pieces. The chopped leaves were then crushed either manually or using an electric juicer. The gel was separated from the solid components by straining it through a cheesecloth or fine screen to remove the fibrous component. [29] The aloe vera

solution was kept at a temperature of 5°C in a refrigerator until it was utilized to prevent the oxidation of phenolic compounds. The mineral and phytohormone levels in the Aloe vera leaf extract were analysed following procedure presented by [30] specifically focusing on gibberellic acid (GA3), indole-3-acetic acid (IAA), and abscisic acid (ABA). However, mineral content and sugar percentage determined by [31] In addition, analysis of various chemical components conducted according to criteria provided by [32] for protein determination [33] (Tables 3a and b). Foliar treatments applied three times, first one at 15 days after sowing, and repeated at 15-day, intervals (15, 30 and 45 days from sowing).

2.4.1. Data recorded

At 50 days after sowing, five plants from each experimental unit were randomly taken for determining the following data:

➢ ***Chemical composition of pods***

- ***Nitrogen (N %)***

Total nitrogen determined by using modified Micro-kjeldahl apparatus of Parnars and Wagner described by [34].

- ***Phosphorus (P %)***

Total phosphorus was determined spectrophotometrically by Milton Roy spectronic 120 at wave length of 725 nm according to the method described by [35].

- ***Potassium (K %)***

Total K was estimated according to [36].

- ***Chlorophyll and carotenoid contents***

Chlorophyll a and b (mg/g FW), Total chlorophylls (a+b) and carotene were extracted from fresh pods (0.5 g from the center of pod) by acetone (80%) and determined spectrophotometrically according to **[37]** Leaves samples were taken from the fourth leaf from stem top from every treatment after 50 days from sowing, then the chlorophyll a and b determination were conducted using methanol solvent (pure) as a blank at wavelength of 666 and 653 nm, respectively. Chlorophyll a, b and total chlorophyll were calculated as follows:

▪ Chl.a = 15.65 A666 - 7.34 A653 (X1).
▪ Chl.b = 27.05 A653 - 11.21 A666 (X2).
- The content (mg/g FW) = X × volume of alcohol/weight of sample (mg) × 1000
▪ Total chlorophyll content (mg/g FW) = chl.a content + chl.b content.

➢ ***Chemical composition of green pods***

- ***Total soluble solids (TSS)***

It was determined in juice by Carl Zeiss refractometer**.**

- ***Ascorbic acid (mg/100 gFW)***

It was determined in juice using 2, 6-dichlorophenol indophenol dye according to [38].

- ***Total carbohydrates (%)***

Total carbohydrates are initially broken down into simple sugars through the process of hydrolysis using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxymethyl furfural. This compound forms with antherone a green coloured product with an absorbtion maximum at 630 nm standard curve was prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of glucose.
Amounts of carbohydrate present in 100 g of the sample = (mg of glucose / volume of test sample) x 100.

- ***Total sugars (%)***

The estimation of reducing sugars was conducted using Nelson-Somogy method, as stated by [39] Total soluble sugars was determined according to method described by [40]
Non-reducing sugars were calculated as the differences between total soluble sugars and reducing sugars.

- ***Protein (%)***

Crude protein of each sample was calculated by multiplying the total nitrogen by the factor 6.25 according to [41]. All obtained data were subjected to the statistical analysis of variance and treatment means were compared using least significant difference (LSD) method described by Snedecor and Cochran [42] at 5 % significance level. The statistical analyses were performed using SAS Computer Software program (SAS, 2004) [43].

3. Results and discussion

3.1. Photosynthetic pigments

Data illustrated in Table (4) reveal that all the foliar studied treatments significantly increased the photosynthetic pigments, i.e., chlorophyll a, chlorophyll b, total chlorophyll and carotenoids of sugar pea leaves. These results indicated that foliar application of ascorbic acid (vitamin c), being the most effective of all photosynthetic pigments of sugar pea leaves. These treatments followed by the treatments of salicylic acids, citric acid, Aloe vera extract and borpota fertilizer respectively. As vital role of the studied treatments on photosynthetic pigments, [44] concluded that ascorbic acid had an important physiological and biochemical functions on structure of photosynthetic pigments, as well as, ascorbic spray significantly increased chlorophyll a, chlorophyll b and carotenoids. [45] And [46] illustrated that salicylic acid dramatically affected chlorophyll content which might be due to biosynthesis chloroplast.

[47] Demonstrated that citric acid had an important role in increasing photosynthetic pigments, which may be attributed to significant role of adjustment of metabolism and physiology of the plants. Moreover, [48] stated that Aloe vera extract contains more than 160 chemical compounds such as anthraquinone compounds, glucoside, lipid, polysaccharides, organic acids enzymes, amino acids and vitamins which have vital role in enhancing photosynthetic pigments. According to the important role of borpota fertilizer which contains highest amount of boron, [49] reveled that boron has crucial role in nitrogen metabolism and photosynthesis, which increased the photosynthetic pigments of plants. These results are agreement by those obtained by [50-54] who working with ascorbic acid, salicylic acid, citric acid, Aloe vera extract and boron fertilizer on legume plants, respectively.

3.2. Chemical pod content

Results in Table (5) clearly showed that all foliar application studied treatments of ascorbic acid, salicylic

acid, citric acid, aloe vera extract and borpota fertilizer significantly increased chemical pod content i.e. N, P, and K. Generally, the best results in this respect were obtained from ascorbic acid at high concentration of 200 ppm, followed by the treatments of 200 ppm of salicylic acid, 200 ascorbic acid, salicylic acid, citric acid, aloe vera extract and borpota fertilizer, [55] concluded that ascorbic acid has antioxidant properties and act as a primary substrate in pathway for enzymatic detoxification, such as H_2O_2, ascorbic acid participates in variety of processes including photosynthesis, cell wall growth, and cell wall expansion, gibberellin and increased chemical content of plant tissues. In addition, [14] illustrated that salicylic acid has direct involvement in plant growth, flower induction and uptake of ions, and then increased chemical content of plant parts. Moreover, [56] and [47] pointed out that foliar spray with citric acid significantly increased the chemical content of plants, because it's important role in the adjustment of metabolism and physiology of the plants.

As for the important role of aloe vera extract as foliar application in increasing the chemical content of N, P, K in pods, [57-58] demonstrated that aloe vera is rich in essential amino acids, mono- and polysaccharides, lignin, macronutrients, micro-nutrients, vitamins, gibberellins and salicylic acid which these compounds improve vegetative growth, and translocate the chemical content to store parts of plant (pods). Regarding important role of borpota fertilizer which contains highest amounts of boron and small amounts of potassium, [59] indicated that boron plays an important role in increasing the level of N, P, K in plants to the effective growth area during the reproductive plant stage and encourage the IAA formation and enzymes activation to increase the chemical in plant parts, especially in store parts. Moreover, potassium is necessary for synthesis and nutrients transportation in plant and help to eliminate adverse effects of some plant nutrients in the soil and it is also effective in regulating water uptake activity, as well as potassium an active element in many important metabolic processes in plants that is important for transportation in phloem, osmotic balance and photosynthesis and thus increased the nutrient in different parts of plants [48]. These results are in close agreement with those reported by [44-60-63], who worked as foliar application with the ascorbic acid, salicylic acid, citric acid, aloe vera, and boron with potassium on the legumes plants.

3.3. The nutritive value of sugar peas pods

Data of the nutritive value of sugar peas pods as affected by the studied bio-stimulants and borpota fertilizer treatments are given in Tables (6 and 7). Results in these tables clearly illustrated that all the studied bio-stimulants (ascorbic acid, salicylic acid, citric acid, Aloe vera extract) and Borpota fertilizer significantly increased nutritive value of sugar peas pods, i.e., TSS, total sugars, total carbohydrates, protein and vitamin C. From these results, foliar application of the treatments of ascorbic acid, being most effective of all nutritive value of pods as mentioned before. In this concern, this result followed by foliar application treatments of salicylic acid, citric acid, Aloe vera extract and then Borpota fertilizer, respectively. Regarding the important role of these treatments on chemical composition nutritive value of legumes crops, [64] stated that ascorbic acid plays a very important role in the synthesis of oxalate and tartrate in addition to being an antioxidant and cofactor for enzymes. The effect of oxidative stress on photosynthesis in mitigated by ascorbic acid binding to chloroplasts. Furthermore, ascorbic acid harms alteration of cell division and works as a primary substrate in cycle pathway of hydrogen peroxide enzymatic detoxification and then increased chemical content of active compound in stored parts of plant. [65] Indicated salicylic acid is an organic substance used to promote plant growth and increase chemical content of store parts of plant. It can be applied to plants as foliar application for activating several enzymes such as phenylamine, ammonia-lyase, nitrate reductase, glucanase etc. which enhances plant growth and increases chemical content of active compounds.

[52] Concluded that citric acid is a vital organic acid as an enzyme cofactor in plants, important for respiratory cycle and other physiological processes, such as plant growth and translocate the minerals and building the active compounds, i.e., vitamin c, carbohydrates, total sugars and protein [66]. Respecting the vital role of Aloe vera extract, [20] confirmed that Aloe vera have a large leaf parenchymatic cell contain liquid of yellow latex and clear, which is rich in essential amino acids, mono and poly-saccharides, lignin, macro-nutrients, micronutrients, vitamins, gibberellins and salicylic acid [56], as well as, it has been used to improve the vegetative growth of plant and increase the active compounds in plants [67]. In addition, important role of boron (B) as micro-nutrients in increasing active compounds in plants, [68] indicated that Boron plays an important role in increasing level of carbohydrates, sugar and protein transported to effective growth area during reproductive plant stage, as well as, protecting and moving the IAA, which in courage's increase in vegetative growth and translocate active compounds to different store parts in plants [69]. Similar finding was obtained by [44] who worked on ascorbic acid, [60] who worked on salicylic acid, [61] who worked on citric acid, [70] who worked on Aloe vera leaf extract, and [59] who worked on boron. These researchers used bio stimulants substrates and Borpota fertilizer as foliar application.

Table (1): The physical and chemical properties of the experimental soil

Physical properties			Chemical properties		
	2023	**2024**		**2023**	**2024**
Sand (%)	90.5	95.6	Organic matter (%)	0.03	0.08
Silt (%)	4.7	1.6	Available K (ppm)	55	66
Clay	4.8	2.8	Available p (ppm)	5.7	6.8
Field capacity	6.8	7.2	Available N (%)	5.9	6.3
Wilting point	2.5	2.6	Calcium carbonate (%)	0.28	0.26
Available water	4.5	4.5	pH	8.1	8.1
Water holding capacity	13.9	14.6			

Table (2): The chemical analysis of Borpota fertilizer

Borpota – content	%
Boron	15
Potissum oxide	5
Amino acid	2

Table (3-a): The chemical analysis of Aloe vera extract:

Characters	Units	Cont.
GA3	mg g-100	15.00
IAA	mg g-100	0.63
ABA	mg g-100	3.06
Ascorbic acid	mg g-1	154.64
Protein	%	3.70
Carbohydrates	%	8.70
Polysaccharide	%	90

Table (3-b): The minerals content of Aloe vera extract

Minerals	Values
N	82.65 mg g^{-100}
P	7.95 mg g^{-100}
K	57.14 mg g^{-100}
Fe	766.11 ppm
Zn	166.87 ppm
Mn	478.88 ppm
Ca	37.00 mg g^{-100}
Cu	42.73 ppm
Mg	15.55 mg g^{-100}
Na	48.27 mg g^{-100}

Table (4): Effect of foliar application with some natural substances on photosynthetic pigments content of sugar pea leaves in the two seasons of 2022/2023 and 2023/2024

Treatments	Chlorophyll (a) (mg/100gFw)		Chlorophyll (b) (mg/100gFw)		Total. Chlorophyll (a+b)(mg/100gFw)		Carotenoids (mg/100gFw)	
	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024
Control	12.17 f	12.17 f	2.58 g	2.58 g	14.76 h	14.75h	12.68 h	12.68 i
CA 100 ppm	12.43 d	12.47 d	2.75 efg	2.80 e	15.19 gf	15.28 e	12.83 gf	12.86 g
CA 200 ppm	12.75 ab	12.75 b	3.27 ab	3.16 b	16.05 ab	15.91 b	13.21 c	13.23 c
AVE 20 ml/l	12.32 e	12.29 e	2.62 fg	2.62 g	14.94 gh	14.92 g	12.72 h	12.74 h
AVE 40 ml/l	12.74 b	12.75 b	3.12 cb	3.08 c	15.78 cb	15.80 bc	13.12 d	13.16 d
Borpota 1 ml/l	12.37 de	12.35 e	2.68 fg	2.71 f	15.05 g	15.06 f	12.76 gh	12.76 h
Borpota 2 ml/l	12.63 c	12.64 c	3.04 cd	3.05 c	15.75 cd	15.72 c	12.96 e	12.98 e
ASA 100 ppm	12.56 c	12.61 c	2.91 ecd	2.94 d	15.48 ed	15.53 d	12.89 ef	12.94 ef
ASA 200 ppm	12.84 a	12.86 a	3.41 a	3.27 a	16.14 a	16.13 a	13.49 a	13.49 a
SA 100 ppm	12.55 c	12.59 c	2.82 efd	2.85 e	15.37 ef	15.45 d	12.87 f	12.91 f
SA 200 ppm	12.78 ab	12.81 ab	3.29 ab	3.24 a	16.10 a	16.05 a	13.40 b	13.39 b
LSD (0.05)	0.1059	0.0712	0.2268	0.0721	0.2853	0.109	0.0797	0.0432

*Means followed by the same letter within a column are not significantly different at 0.05 level of probability according to Dunken multiple range test.
CA (Citric acid), AVE (aloe vera leaf extract), **ASA** (Ascorbic acid), **SA** (salicylic acid)

Table (5): Effect of foliar application with some natural substances on N, P, and K contents of sugar pea pods in the two seasons of 2022/2023 and 2023/2024

Treatments	N (%)		P (%)		K (%)	
	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024
Control	5.24 f	5.40 h	0.216 i	0.214 i	3.78 e	3.66 h
CA 100 ppm	5.58 d	5.59 d	0.257 g	0.276 g	4.52 cd	4.10 ef
CA 200 ppm	6.42 b	6.42 b	0.322 b	0.322 c	4.23 a	4.25 c
AVE 20 ml/l	5.41 e	5.43 g	0.238 h	0.216 i	3.87 e	4.70 g
AVE 40 ml/l	6.15 b	6.15 c	0.299 c	0.298 d	4.22 a	4.02 cd
Borpota 1 ml/l	5.58 d	6.06 f	0.241 h	0.244 h	4.42 d	4.88 gf
Borpota 2 ml/l	6.13 c	6.11 c	0.290 d	0.2906 e	4.92 b	4.81 d
ASA 100 ppm	6.07 c	6.09 fe	0.278 e	0.282 f	4.88 b	4.31e
ASA 200 ppm	7.09 a	7.04 a	0.373 a	0.377 a	4.30 a	4.64 b
SA 100 ppm	5.83 c	5.84de	0.267 f	0.281 fg	4.64 c	4.31 e
SA 200 ppm	7.23 b	7.23 ab	0.322 b	0.328 b	4.31 a	4.20 a
LSD (0.05)	0.0679	0.0472	0.0074	0.0058	0.159	0.3277

*Means followed by the same letter within a column are not significantly different at 0.05 level of probability according to Dunken multiple range test.
CA (Citric acid), AVE (aloe vera leaf extract), **ASA** (Ascorbic acid), **SA** (salicylic acid)

Table (6): Effect of foliar application with some natural substances on reducing, non-reducing, total sugars and TSS (total soluble solids) of sugar pea in the two seasons of 2022/2023 and 2023/2024

Treatments	Reducing sugars (%)		Non-Reducing sugars (%)		Total sugars (%)		TSS (Brix)	
	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024
Control	3.103 h	3.126 i	15.493 e	16.560 e	18.613 g	19.713 i	8.046 d	8.03 e
CA 100 ppm	3.773 e	3.806 f	16.646 d	17.00 d	20.420 e	20.470 g	8.14 c	8.15 c
CA 200 ppm	4.220 cb	4.223 b	19.223 a	19.620 b	23.400 b	23.823 cb	8.21 b	8.19 b
AVE20 ml/l	3.310 g	3.220 h	16.526 d	16.586 e	19.836 f	19.843 h	8.06 d	8.08 d
AVE40 ml/l	4.190 cb	4.120c	18.426 b	19.600 b	22.616 c	23.770 c	8.21 b	8.19 b
Borpota 1 ml/l	3.490 f	3.470 g	16.533 d	16.623 e	20.326 e	210.366 g	8.08 d	8.09 d
Borpota 2 ml/l	4.176 cd	4.053 cd	17.496 c	17.633 c	21.763 d	21.753 d	8.20 b	8.18 bc
ASA 100 ppm	4.100 d	4.013 d	17.353 c	17.560 c	21.573 d	21.613 e	8.18 bc	8.16 bc
ASA 200 ppm	4.266 ab	4.283 ab	19.250 a	19.633 ab	23.566 ab	23.903 ab	8.32 a	8.26 a
SA 100 ppm	3.793 e	3.886 e	17.290 c	17.100 d	20.780 e	20.986 f	8.16 bc	8.15 c
SA 200 ppm	4.316 a	4.310 a	19.693 a	19.756 a	23.960 a	23.943 a	8.29 a	8.25 a
LSD (0.05)	0.0807	0.0696	0.5059	0.136	0.4768	0.1068	0.0547	0.039

*Means followed by the same letter within a column are not significantly different at 0.05 level of probability according to Dunken multiple range test.
CA (Citric acid), AVE (aloe vera leaf extract), **ASA** (Ascorbic acid), **SA** (salicylic acid)

Table (7): Effect of foliar application with some natural substances on carbohydrate, Protein and Vitamin C content of sugar pea pods in the two seasons of 2022/2023 and 2023/2024

Treatments	Total carbohydrates (%)		Protein (%)		Ascorbic acid (Vitamin C) (mg/100 g F w)	
	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024
Control	40.086 e	40.283 g	32.736 i	33.743 h	65.271 h	65.791 f
CA 100 ppm	43.503 d	46.167 de	34.866 g	34.960 g	67.438 ef	67.958 d
CA 200 ppm	51.440 a	51.173 ab	40.136 c	40.110 c	71.188 a	70.791 c b
AVE 20 ml/l	42.086 d	43.113 fg	33.796 h	33.946 h	66.667 g	66.833 e
AVE 40 ml/l	49.350 b	50.250 ab	38.430 d	38.413 d	69.750 b	69.958 c
Borpota 1 ml/l	42.100 d	44.503 fe	34.853 g	37.870 g	67.083 f	67.416 de
Borpota 2 ml/l	48.930 bc	49.380 cb	38.300 d	38.163 de	68.146 c	68.187 d
ASA 100 ppm	47.020 c	48.990 dcb	37.946 e	38.080 e	67.875 cd	68.145 d
ASA 200 ppm	53.226 a	52.487 a	44.340 b	44.030 b	71.479 a	71.750 a
SA 100 ppm	45.593 d	47.190 dce	36.436 f	36.516 f	67.688 ed	67.958 d
SA 200 ppm	51.703 a	51.907 ab	45.173 a	45.206 a	71.417 a	71.437 ab
LSD (0.05)	1.9125	2.9929	0.2828	0.2661	0.3735	0.9078

*Means followed by the same letter within a column are not significantly different at 0.05 level of probability according to Dunken multiple range test.
CA (Citric acid), AVE (aloe vera leaf extract), **ASA** (Ascorbic acid), **SA** (salicylic acid)

4. Conclusions

It can be concluded that using bio- stimulants substrates (ascorbic acid, salicylic acid, citric acid, Aloe vera extract and Borpota fertilizer increased photosynthetic pigments, chemical content and active compounds of sugar peas pods.

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