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Stimulatory Effect of Some Artificial Regulators on the Growth Rate and Chemical Contents of Jackfruit Seedlings Grown in South Egypt

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Abstract: The jackfruit tree is a rare tropical fruit in Egypt. Although seedlings are created through seed propagation, they grow slowly, especially in the nursery stage. During the period from 2022-2023 to 2023-2024 seasons, research was conducted at the Aswan Botanical Garden in Egypt to examine the effects of gibberellins (GA_3) and combination sodium nitrophenolate (CSN) on the chemical compositions and growth rate of jackfruit (*Artocarpus heterophylls* L.) seedlings. Three replications of the randomized complete block design (RCBD) were used in the experiment. Nine treatments were applied including combinations of CSN and GA_3 with three concentrations (0, 100, and 200 ppm). The results proved that treating seedlings with different treatments improved growth and chemical compositions compared to the control. Among nine treatments spraying seedlings with CSN (200 ppm) + GA_3 (100 ppm), followed by CSN (100 ppm) + GA_3 (200 ppm) gave superior performance in plant height, leaves number/plant, stem diameter, fresh and dry weight of the plant, number of roots, leaf area, and the amount of total chlorophyll, total carbohydrates, flavonoids, N, P, and K in the leaves. The findings indicated that CSN has a good impact on some mechanisms that regulate the growth and development of plants. Additionally, GA_3 promotes apical dominance, enhances growth, and plays a useful part in the physiological functions of the plant.

Key words: Jackfruit tree, plant growth regulators, vegetative growth, sodium nitrophenolate, chemical contents.

1. Introduction

The Jack tree or Jackfruit (*Artocarpus heterophyllus* L.), is a member of the Moraceae family. It is a striking tree reaching up to 15 meters in height, showing a somewhat squat trunk, a broad and rounded crown, rough and brown bark, as well as densely new shoots and underlying leaves **Rahman *et al.* (1999)**. In Africa, including Cameroon, Uganda, Tanzania, and Madagascar, jackfruit is a popular and widely grown food item in countries like Bangladesh, Nepal, Sri Lanka, Cambodia, Vietnam, Thailand, Malaysia, and Indonesia. Fruit has cancer-fighting qualities since it is a good source of protein, antioxidants, vitamin C, vitamin B6, potassium, calcium, iron, flavones,

and phytonutrients **Samaddar (1985)**. The vitality of the jackfruit seeds rapidly declined and delaying seeding by even one or two weeks will result in poor germination. According to observations made at the Aswan Botanical Garden, jackfruits grow slowly, especially in their early phases, when seeded to secure seedlings. After being propagated, trees reach a sufficient size to be planted in a nursery. To produce high-quality seedlings, seedling growth must be accelerated, particularly at the nursery stage. In order to enhance plant quality, the ornamental plant industry frequently uses growth regulators like IBA and NAA **Deotale *et al.*** (**1995**). Numerous investigations have demonstrated that sodium nitrophenolate (CSN) favorably activates some processes that regulate the growth, development, and productivity of plants. CSN is a broad-spectrum plant growth regulator that works well on a variety of plants at any stage of development. By raising the amounts of IAA, ZR, and GA3 in the flower buds during the petal development process, **Zou *et al*. (2020)** discovered that modest concentrations of CSN enhanced the pace of flowering in oil tea. A plant hormone gibberellic acid controls plant growth and affects several essential functions, including sex expression, stem elongation, dormancy, germination, enzyme induction, and fruit and leaf senescence **Campbell *et al*. (2013)**. GA_3 used as bio stimulator for promote plant growth and development as well as accumulate more biomass **Borowski and Blamowski,** (**2009**). According to **Sardoei *et al*. (2024)**, dwarf schefera morphological growth, chlorophyll and carotenoid synthesis, and soluble carbohydrate content were all markedly enhanced by the application of GA3 at a rate of 200 mg/l. It increases transpiration and photosynthesis, but typically without lowering the relative water content. Simultaneously, many growth hormones, such as the Gibberellic acid (GA3) hormone, have shown that the primary purpose of GA_3 treatment is to increase plant height **(Blanchard *et al.*, 2005; Runkle, 2007; Blanchard and Runkle, 2008)**. By influencing cell development and elongation, GA3 controls plant growth; these effects are frequently observed in the growth of the stem and roots. One of the growth regulators utilized to enhance cell division, elongation, and the development of longer internodes in *Euphorbia pulcherrima* is gibberellic acid **El Khoury (2019)**. Therefore, this study aims to assess how CSN and GA3 at varying concentrations affect the growth characteristics and chemical makeup of *A. heterophyllus* seedlings in the Aswan climate.

2. Methodology

2.1. Plant materials and the study site

The current study was carried out at Aswan Botanical Garden from two seasons 2022-2023 and 2023-2024. Aswan Governorate, Egypt (N 24°05' E 32°53'). Five-month-old, 40 cm high, homogeneous and healthy *A. heterophyllus* seedlings were used in this experiment. One seedling was transplanted into 30 × 25 cm plastic bag filled with sandy loam soil. Table 1 displays the soil's physical and chemical analysis. Irrigation was done by hand every other day and weeds were manually removed as needed.

Table (1). The soil's physical and chemical properties that are being examined

Physical properties	**Clay (%)**			**Silt (%)**		**Sandy (%)**		**Textural class**	
	17.00			6.00		77.00		Sandy	
Chemical properties {Soluble cations (mmol/l)}	Ca^{++}			Mg^{++}		K^{+}		Na^{+}	
	2.05			2.02		1.83		1.06	
Chemical properties {Soluble anions (mmol/l)}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO^{4-}_{-}	pH (1:1 soil suspension)	EC (dS/cm) at 25°C	N (mg/kg soil)	P (mg/kg soil)	K (mg/kg soil)
	0.00	3.50	2.65	0.60	8.01	0.33	188.30	80.00	172.00

2.2. Nutrient management

The NPK fertilizer was used as 12 g/pot ammonium sulphate (20.5 % N), 10 g/pot of calcium superphosphate (15.5 % P_2O_5), and 5 g/pot of potassium sulphate (48 % K_2O), respectively. Two months

following the transplanting date, this NPK fertilizer was added in four equal parts, with four-week intervals between each addition until August 1st for each season. The fertilizer was applied as a top dressing to the pots then irrigation water was added.

The experimental design and treatments:

Three replicates were used in this experiment including three concentrations of CSN and GA_3: (0, 100 and 200 ppm), resulting in nine combination treatments as follows:

T1- Control – (Seedlings without treatments).

T2- CSN (0) + GA_3 (100) ppm.

T3- CSN (0) + GA_3 (200) ppm.

T4- CSN (100) + GA_3 (0) ppm.

T5- CSN (100) + GA_3 (100) ppm.

T6- CSN (100) + GA_3 (200) ppm.

T7- CSN (200) + GA_3 (0) ppm.

T8- CSN (200) + GA_3 (100) ppm.

T9- CSN (200) + GA_3 (200) ppm.

2.3. Making a solution of growth hormone

A stock solution containing 1000 parts per million of GA3 and CSN was made. Before adding enough distilled water to create the required solution, a tiny amount of absolute alcohol was diluted in each weighed ingredient to create the stock solution. To treat seedlings as a combined foliar spray and guarantee equal coverage of the plant in the greenhouse, solutions with progressively higher concentrations (100 and 200 ppm) were created each time. To guarantee a uniform combination of the two growth regulators, the prepared solutions were combined before spraying. Water was the only treatment used as a control. The treatments were applied every month, from the 1st of March to the 1st of September that is seven times every season.

2.4. Measurements

2.4.1. Growth aspects

The following measurements were taken on 30 September, the end of each season: Plant height (cm), stem diameter, leaves number/plant, the leaf area (cm^2) was measured by measuring the 5th leaf from the plant top according to **Abd El-Maksoud (1988)**, number of roots, plant fresh and dry weight (g).

2.4.2. Chemical analysis

A Minolta SPAD-501 chlorophyll meter (Minolta Co. Ltd., Tokyo, Japan) was used to measure the total amount of chlorophyll in leaves. The chlorophyll meter's reading was instantly converted to digital values. The method of **Doubios *et al*. (1956)** was used to measure the total carbohydrates (%) in the dried leaves. Leaf-water extract's flavonoid concentration, expressed as mg/100g, was calculated using the **A.O.A.C. (2012)** technique. The **A.O.A.C. (1995)** method was used to measure the percentages of nitrogen (N), phosphorous (P), and potassium (K) in the dry leaves.

2.5. Analysis of statistics

The average data of the chemical composition and vegetative development for both seasons were statistically examined by **Snedecor and Cochran (1980)** using the analysis of variance. Means were differentiated at the 5% level of probability using least significance differences (LSD). The statistical software version 9 **(Analytical software, 2008)** was used to compare means.

3. Results and Discussion

3.1. Growth-related factors

3.1.1. Seedling height and stem diameter

The seedling height and stem diameter of *A. heterophyllus* is significantly influenced by different treatments of CSN and GA_3 (Table 2). The maximum seedling height (91.40 and 91.53 cm) and stem diameter (8.80 and 9.10 mm) were recorded in CSN (200) + GA_3 (100) ppm, the lowest stem diameter (6.70 and 6.87 mm) and seedling height (65.77 and 66.90 cm) were observed in the control group in the first and second seasons, respectively. The increased height of the seedlings following GA3 treatment may have been brought on by the growth hormone's enhanced osmotic uptake of the nutrients, which in turn caused cell elongation **Shanmugavelu (1966)**. Additionally, GA3 may have boosted cell proliferation and elongation in the collar regions, which would account for the maximum stem diameter. These results were in parallel with **Rawat *et al*. (2023)**, who studied the impact of different rates of GA_3 on seedling growth of *Citrus sinensis* L., they pointed out that, the best results in terms of shoot length, shoot diameter, leaves number, leaf area, shoot fresh and dry weight, and number of roots were obtained with GA_3 at (200 ppm), moreover, gibberellins are used to change the behavior and development of plants, as well as stimulate the elongation of the stem **Wasfi (1995).** Additionally, according to **Al-Chalabi (2020)**, GA3 stood out for its capacity to raise the plant's height, leaf count, seed germination, chlorophyll percentage, and fresh and dry weight. The beneficial effect of CSN was also reported by **Yao *et al*. (2023)** who suggested that CSN has a promising application in improving plant growth. **El-Fouly *et al*. (2014)** found that spraying *Ficus deltoidea* seedlings with low and medium concentrations of CSN increased growth and chemical compositions including chlorophylls, carotenoids, and leaves content of N, P and K. The obtained results were in accordance with that of **Ashvathama *et al*. (2020).**

Table (2). The effect of compound sodium nitrophenolate (CSN) and Gibberellic acid (GA_3) on plant height (cm), stem diameter (mm), leaves number and leaf area (cm^2) of jackfruit seedlings during the two seasons of (2022-2023 and 2023-2024)

Treatments	Seedling height (cm)		Stem diameter (mm)		Leaves number		Leaf area (cm^2)	
	First	Second	First	Second	First	Second	First	Second
T1	65.77	66.90	6.70	6.87	18.40	18.80	41.97	41.40
T2	71.50	72.30	7.20	7.30	20.77	20.97	42.83	42.50
T3	75.90	75.93	7.40	7.33	22.43	22.27	45.00	45.40
T4	73.80	74.07	7.70	7.80	24.00	23.40	46.60	46.37
T5	83.87	84.30	8.00	8.20	25.80	25.97	47.37	47.27
T6	88.17	87.60	8.60	8.73	28.67	28.93	54.43	56.13
T7	74.00	74.23	7.80	7.87	26.73	26.87	47.10	47.07
T8	91.40	91.53	8.80	9.10	29.17	28.97	59.20	58.77
T9	86.90	86.80	8.20	8.30	27.77	27.80	47.90	47.67
LSD (5%)	1.31	1.28	0.19	0.21	0.46	0.79	1.29	0.90

3.1.2. Leaves number and leaf area (cm^2)

The substantial influence of the two growth regulators (CSN and GA_3) on the leaves number/seedling and leaf area (cm^2) of *A. heterophyllus* is significantly influenced by different spraying treatments (Table 2). The maximum leaves number (29.17 and 28.97) and leaf area (59.20 and 58.77 cm^2) in the 1st and 2nd seasons, respectively, was registered with CSN (200) + GA_3 (100) ppm. While the lowest leaves number (18.40 and 18.80) and leaf area (41.97 and 41.40 cm^2) was produced with

untreated plants in the 1st and 2nd seasons, respectively. According to **Shaban (2010)**, the increase in the number of leaves per seedling may be caused by the maximum height of the seedlings under GA3 at 100 ppm, as well as by the enhanced cell division and growth brought about by GA3 movement to the shoot apex, which induces the young leaves **(Salisbury and Ross, 1988)**. These results were in a good line with **Rawat *et al*. (2023)**, who studied the impact of different rates of GA_3 on seedling growth of *Citrus sinensis* L. They pointed out that the best results in terms of shoot length, shoot diameter, leaves number, leaf area, shoot fresh and dry weight, and number of roots were obtained with GA_3 at 200 ppm. **Zou *et al*. (2020)** reported that low concentrations of sodium nitrophenol (CSN) lead to improve the growth and flowering in oil tea by increasing IAA, ZR and GA_3 contents, while decreasing content of abscisic acid. The results of **Attia (2022)** indicated that treatment with (200 ppm) of sodium nitrophenolate improved productivity of LeConte pear trees. These results were similar to **Suseendran *et al.* (2020); Das *et al*. (2022) and Yao *et al*. (2023).**

3.1.3. Number of roots, plant fresh and dry weight

The number of roots, plant fresh and dry weight (g) of *A. heterophyllus* is significantly influenced by different spraying treatments of CSN and GA_3 (**Fig. 1**). The maximum number of roots (11.65), plant fresh weight (141.65 g), and plant dry weight (34.56 g), in the average of 1st and 2nd seasons, were obtained with CSN (200 ppm) + GA_3 (100 ppm). On the other hand, the lowest values of roots number (6.63), plant fresh weight (97.53g), and plant dry weight (22.58 g) was produced with untreated plants (control) in the average of 1st and 2nd seasons. According to **Brain (1954)** and **Shanmugavelu (1966)**, this outcome appears to be the result of the mobilization of nutrients and water transported at maximum rate, which may have increased the production of photosynthetic products and translocated them to the plant parts, which may have improved the seedling's growth and resulted in more roots and fresh and dry weight of the seedling. **Sardoei *et al*. (2024)** found that 200 mg/l GA3 significantly increased the morphological growth, chlorophyll and carotenoid production, and soluble carbohydrate content of dwarf schefera. In addition to its efficient function in photosynthesis, **Saleh (1991)** described how GA3 enhances axillary bud development and induces apical dominance. According to several studies, CSN has a good impact on some processes that regulate the growth, development, and production of plants. CSN is a broad-spectrum plant growth regulator that works well on a variety of plants at any stage of development. By increasing the plant's levels of indole-3-acetic acid, gibberellic acid, and zeatin-ribosides while lowering its levels of abscisic acid, CSN functions as a stimulator and has been shown to enhance oil tea development and blooming **(Zou *et al*., 2020 and Yao *et al*., 2023)**.

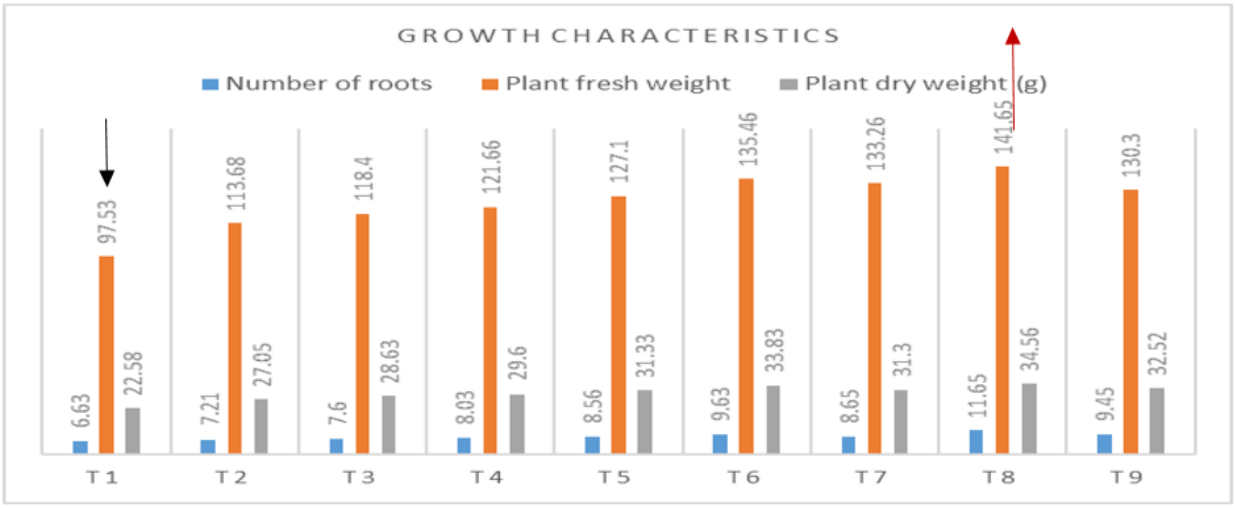

Fig. (1). The effect of spray treatments of CSN and GA_3 on growth characteristics of jackfruit seedlings. Number of roots/seedlings, plant fresh weight (g) and plant dry weight (g) during the mean of two seasons

3.2. Chemical Analysis

3.2.1. Total chlorophyll, total carbohydrate and flavonoid contents

The total chlorophyll (SPAD), total carbohydrate (%) and flavonoid contents (mg/100g) of *A. heterophyllus* leaves are significantly influenced by different spraying treatments of CSN and GA_3 (Table 3). The maximum total chlorophyll (42.53 and 42.33 SPAD), total carbohydrates (5.76 and 5.69 %), and flavonoid content (3.62 and 3.64 mg/100g) was recorded with CSN (200 ppm) + GA_3 (100 ppm) in the two seasons, respectively. While lowest total chlorophyll (36.67 and 36.87 SPAD), total carbohydrate (4.53 and 4.58 %), and flavonoid content (3.26 and 3.27 mg/100g) was produced with control treated plants in the two seasons, respectively. According to **Sardoei *et al.* (2024)**, dwarf schefera's morphological growth, chlorophyll and carotenoid synthesis, and soluble carbohydrate content were all markedly enhanced by the application of GA3 at a rate of 200 mg/l. These results were in agreement with **Czeczko and Mikos-Bielak (2004); Kositorna and Smolinski (2008). Al-Layla (2006)** suggested that applying gibberellic acid led to increase the chlorophyll content in *Ficus elastica* var. decora compared to the control. Bio stimulant-treated plant is more advanced in increasing the photosynthesis, transpiration rate, and plant chemical composition **Borowski and Blamowski (2009). El-Fouly *et al.* (2014)** found that using the liquid CSN to *Ficus deltoidea* seedlings as soil drench or as a foliar spray attained the best growth performance and chemical composition.

Table (3). The effect of compound sodium nitrophenolate and Gibberellic acid on total chlorophyll content (SPAD), total carbohydrates content (%) and flavonoid content (mg/100g) of jackfruit seedlings during the two seasons of 2023 and 2024

Treatments	Total chlorophyll content (SPAD)		Total carbohydrates content (%)		Flavonoid content (mg/100g)	
	First	Second	First	Second	First	Second
T1	**36.67**	**36.87**	**4.53**	**4.58**	**3.26**	**3.27**
T2	37.23	37.50	4.78	4.83	3.37	3.38
T3	37.83	38.07	5.18	5.29	3.39	3.40
T4	38.73	38.63	5.36	5.36	3.54	3.49
T5	39.27	39.20	5.43	5.44	3.42	3.36
T6	41.20	40.93	5.59	5.63	3.45	3.46
T7	38.80	38.40	5.23	5.28	3.58	3.58
T8	42.53	42.33	5.76	5.69	3.62	3.64
T9	38.83	38.67	5.35	5.37	3.43	3.47
LSD (5%)	0.53	0.61	0.11	0.07	0.06	0.09

3.2.2. Nitrogen, phosphorus and potassium contents

The nitrogen, phosphorus and potassium content of *A. heterophyllus* leaves is significantly impacted by different spraying treatments of CSN and GA_3 in the two studied seasons (**Fig. 2**). Maximum nitrogen (N) content (1.34 %), phosphorus (P) content (0.44 %), and potassium (K) content (0.92 %) was registered with CSN (200) + GA_3 (100) ppm, in the mean of first and second seasons. While lowest N (0.79 %), P (0.18%), and K (0.68%) recorded in the control plants in the mean of first and second seasons, respectively. **El-Fouly *et al.* (2014)** investigated how CSN affected the growth performance and chemical makeup of *Ficus deltoidea* whether applied as a soil drench or foliar spray. They reported that the chlorophylls, N, P, and K contents in leaves were higher than in the leaves of control plants. **Khattab *et al.* (2000 a and b)** claimed that applying GA3 to the gladiolus plant had an

impact on photosynthesis since it enhanced vegetative development, which increased nutrient accumulation in the plant's storage sections as well as the plant's height and chlorophyll content. Growth promoters can regulate cell growth, metabolism, and chemical components and are widely utilized in plant growth and development **(Voß *et al.*, 2014; Ma *et al.*, 2016 and Zhou *et al.*, 2019). Also, Martinka *et al*. (2013) and Li *et al*. (2012).**

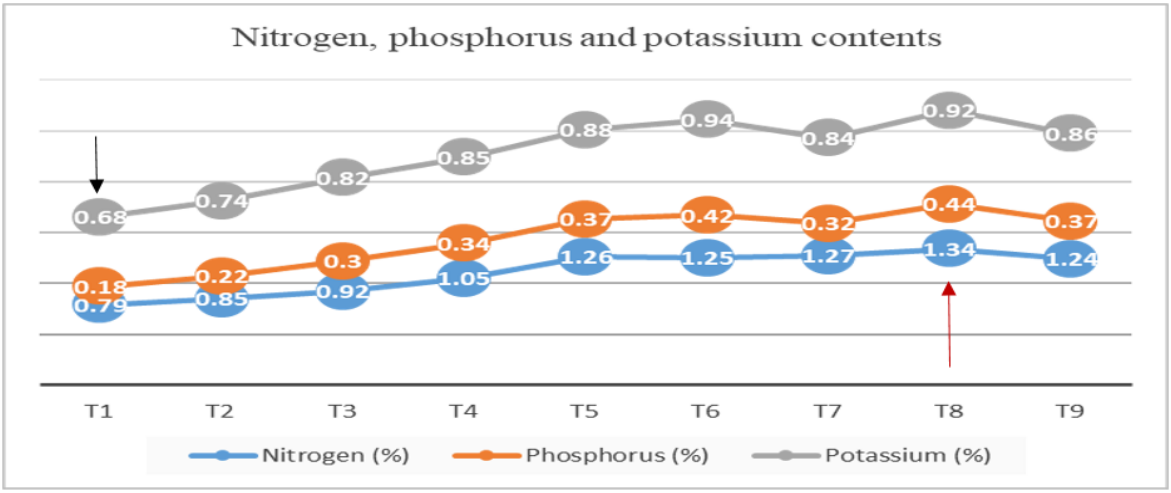

Fig. (2). Effect of the compound sodium nitrophenolate (CSN) and Gibberellic acid (GA_3) on chemical analysis of jackfruit seedlings during the mean of two seasons

4. Conclusion

Sodium Nitrophenolate (CSN) and Gibberellic acid (GA_3) showed promising effects for enhancing plant growth, as well as supporting the induction of physiological processes and chemical stimulatory action in plants. spraying jackfruit seedlings with CSN and GA3 increased growth and chemical compositions, all chemical analyses, including the maximum seedling height, stem diameter, number of leaves per seedling, leaf area, number of roots, plant fresh weight, and plant dry weight, were recorded in CSN 200 ppm + GA3 100 ppm. The control group showed the lowest results.

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التأثير التحفيزي لبعض المنظمات الصناعية على معدل النمو والمحتويات الكيميائية لشتلات الجاك فروت المزروعة في جنوب مصر

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يعتبر الجاك فروت من أشجار الفاكهة الاستوائية النادرة بمصر والتي يمكن اكثارها بالبذرة، وتنتج شتلات بطيئة النمو، خاصة بمرحلة المشتل. أجريت هذه الدراسة بغرض دراسة تأثير اضافة نوعين من منظمات النمو النباتية هما مركب نيتروفينولات الصوديوم (CSN) والجبريللين (GA_3) علي النمو والمكونات الكيميائية لشتلات الجاك فروت خلال مواسم ٢٠٢٢ حتى ٢٠٢٤ بالحديقة النباتية بأسوان. وقد صممت التجربة بنظام القطاعات كاملة العشوائية في ثلاث مكررات واستخدام تسع معاملات. أوضحت النتائج أن رش النباتات بأي من المعاملات المختلفة نتج عنه تحسن في صفات نمو الشتلة والمكونات الكيميائية مقارنة بنباتات المقارنة. من بين المعاملات التسع، رش النباتات بمستوي ٢٠٠ جزء في المليون CSN + ١٠٠ جزء في المليون GA_3، يليه المعاملة بمستوي ١٠٠ جزء في المليون CSN + ٢٠٠ جزء في المليون GA_3 أدي الي الحصول علي أفضل النتائج في صفات النمو متمثلة في ارتفاع الشتلة وعدد الأوراق/ شتلة وقطر الساق والوزن الطازج والجاف للنبات وعدد الجذور ومساحة سطح الورقة، وأيضا أفضل النتائج في المحتوي الكيميائي متمثلا في محتوي الورقة من الكلوروفيل الكلي والكربوهيدرات الكلية والفلافونيدات وعناصر النيتروجين والفوسفور والبوتاسيوم. أشارت النتائج إلى أن مركب نيتروفينولات الصوديوم له تأثير جيد على بعض الآليات التي تنظم نمو وتطور النباتات، بالإضافة إلى ذلك، يعزز الجبريللين السيادة القمية والنمو ويلعب دورًا مفيدًا في الوظائف الفسيولوجية للنبات.