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Influence of sodium alginate on growth and elements content of Corchorus olitorius, Vicia faba & Zea mays plants as well as soil properities.

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Abstract: Sodium alginate (SA) has proved as a plant growth promoting substance for various medicinal and agricultural crops. A pot experiment was carried out to explore the effect of different SA concentrations (25, 50 & 100 ppm) on plant growth and physiological activities in *Corchorus olitorius*, *Vicia faba* and *Zea mays* after 10, 20 and 40 days from sowing. Presoaking in the used SA concentrations significantly improved the performance of the tested plants. Results demonstrated that the used SA concentrations significantly increased growth parameters (root length, shoot length, fresh &dry weight, and water percentage/ plant), soil physical and chemical properties and the determined elements (N, P, K and Na) especially 50 ppm which caused the best influences.

keywords: alginate, growth, elements &soil.

1.Introduction

Nowadays there is an increase in the world population, especially developing countries as Egypt so, there is an urgent need for food especially that of plant origin which should be safe for human consumption or animal that used for human being. There are many substances used as growth stimulators to increase the growth, density and productivity of the plant through the activation of vegetative growth and vital processes, but some of them are harmful and dangerous to human health so, it was necessary to search for the safe ones for humans and animals such as sodium alginate**.**

Alginates possess very important position among the natural polysaccharides considered as structural part of the brown algae *Sargassum* **[5]** in very huge amounts. Sodium alginate (SA), a recent multifunctional marine bioactive substance derived from the brown algae, consists of homopolymeric poly-β-(1,4) D-mannuronic acid residue and poly-α-(1,4) L-gluronic acid residues. Sodium alginate in its depolymerized form, known as oligo-alginate, is prepared by hydrolysis of acid or degradation of enzyme of sodium alginate. Oligomers with comparatively low molecular weight. Application of these oligomers on plants results in different vital and physiological activities, including growth promotion of plant generally, germination of seed, elongation of shoot, root development, production of flower, antimicrobial activity, amelioration of heavy metal stress, phytoalexin induction, etc. **[17, 28, 18, 16, 1, 20].**

Corchorus olitorius may be a vegetable, commonly known as "Jew's mallow", "tossa jute", "bush okra", "krinkrin", "molokhia", "West African sorrel" and "jute mallow", it contains large amount of vitamins, minerals and other factors used in nutrition **[7].** This is often one of the most consumed widely conventional vegetables in Africa **[37]** and is also consumed in Asia **[24].** Obtained from both wild and cultivated sources. The leaves are consumed as a component of vegetable-based dish that go with starchy dishes. It may be arranged aloneorin blends with vegetable tak es off (East Africa) or other wild vegetables or in blend enhanced with fish sauce. In this wayit playsan amazingly c,
ritical part in nourishment security and the fight against destitution in Africa **[6].**

One of versatile crop is *Vicia faba* (faba bean). It belongs to the Fabaceae family and has the ability to develop in different climates **[50].** Besides, it can be utilized around the year, as it can be consumed in both processed and raw forms. The seed grain mostly consumed in the human diet, while the pods are used as feed. However, as the pods also provide micro-, macro and non-nutrient phytochemicals, they have potential to be utilized as a source of functional compounds **[34].** The nutritional importance of faba bean is prominent, approximatly 250 g protein/kg seed **[33]** and it gives a valuable amount of energy: 320 kcal/100 g dry weight **[40]**.

Maize (*Zea mays*), called corn in some positions of the world, belongs to graminaceous plants of tropical origin that has become the main grain crop in the world in terms of total production **[36]**. About 45–50% of oil that is used in cooking, salads and is obtained from wet milling process comes from maize germs **[41].** The oil contains 14% saturated fatty acids, 30% monounsaturated fatty acids, and 56% polyunsaturated fatty acids. The refined maize oil contains linoleic acid 54–60%, oleic acid 25–31%, palmitic acid 11–13%, stearic acid 2–3% and linolenic acid 1% **[12].** Maize silk contains various constituents essential for human diet such as maizaniid acid, fixed oils, resin, sugar, mucilage, salt, and fibers **[27].**

So, this experiment was conducted with an objective to study the effect of sodium alginate at different concentrations on growth parameters, soil physical and chemical properties and some elements content during vegetative stages of *Corchorus olitorius, Vicia faba* and *Zea mays*plants.

2. Materials and methods

Plants used and growth conditions

Pure stains of *Zea mays* L. (maize), *Vicia faba* (bean) and *Corchorus Olitorius* (mallow) were obtained from the Research Centre of Agriculture, Agriculture Ministry, Egypt. The utilized chemicals in this investigation were of analytical grade.

Time course of experiment:

A homogenously-sized lot of *Zea mays* L. (maize), *Vicia faba* L.(bean) and *Corchorus olitorius* (mallow) seeds were selected and sterilized by soaking in 0.01% $HgCl_2$ solution for 3 minutes. After the seeds had been washed by distilled water, the seeds of each plant were divided into 4 equal groups each contains 100 seeds and were soaking for four hours as follow:

Group (1): Socked in water to serve as a control.

Group (2): Soaked in 25 ppm sodium alginate solution.

Group (3): Soaked in 50 ppm sodium alginate solution.

Group (4): Soaked in 100 ppm sodium alginate solution.

Seeds of the four groups were cultivated at 10/10/2018 in earthen pots (20 cm in width) containing the same soil amounts (sand: clay, 1:2 v/v). Some physical and chemical analysis were carried out to the used soil sample according to **[9]**. After that super phosphate fertilizer (0.5 g/pot) addition to the soil before sowing, ten seeds were sown in each pot and irrigated as usual practice by addition of the same amounts of water to each pot when required. Plants were exposed to normal day night conditions. After 10 days from sowing thinning takes places where 5 uniformed seedlings only left to grow in each pot.

Three successive sampling, during vegetative stage takes place; after 10، 20 and 40 days from sowing, representing the first, the second and the third (I, II and III) stages respectively.

The collected samples of the three stages were used for assessment of growth parameters (shoot length، root length, plant fresh & dry weights and plant water percentage)/ plant. some elements (N, P, K and Na). in addition soil physical and chemical properities were also determined but only for maize plant (after 20 days from sowing of treated and untreated plant); as this plant have the best response for alginate treatments.

Data were analyzed by least significant difference (LSD) test at probability of 0.05 to identify significant effect of a treatment. ANOVA analysis was done with the IBM SPSS-20 statics software **[51]**

1- Determination of growth parameters:

The collected samples of the three stages were used for assessment of growth parameters (shoot length, plant fresh & dry weights، root length and water percentage).

2-Soil sampling and analysis:

Collection of samples of soil from different pots (5-10 cm depth) representing the treated and untreated *Zea mays* after 20 days from planting. Bring these samples to the laboratory in closed plastic bags after collection. Samples were brought to the laboratory, air dried, thoroughly mixed, passed through a 2 mm sieve to remove debris and gravel and then packed in plastic bags to be ready for physical and chemical analyses.

Physical characteristics: The heavy textured samples of soil were determined by using Bouyoucous hydrometer method as described by **[44].** While the coarse textured soil samples determined as recommended by **[39]**. Meanwhile the available water (AW) determined according to **[26]** by the following formula

$$AW = FCV - PWP$$

Chemical characteristics:

The chemical variables estimated in the present study included, calcium carbonate, organic carbon, pH, electrical conductivity, chlorides, sulphates, carbonates, bicarbonates, total nitrogen, total dissolved phosphorous and extractable cations (K^+, Ca^{++} and Mg^{++}). Calcium carbonate and organic matter were estimated by using air dry soil samples, while other variables were determined using soil water extract (1:5).

Soluble cations and anions

in the soil paste extract were determined according to methods described by **[22]. Calcium and magnesium** were determined by titrating with versenate (EDTA) using murxide as an indicator for calcium, eriochrome black T as an indicator for Ca^{++} and Mg^{++}. **Potassium** was determined by flame photometer. **Carbonate and bicarbonate** were determined by titration with HCl using phenolphthalein as an indicator for the former and methyl orange as an indicator for the latter. **Chloride** was determined using Mohr's method. **Sulphate** was calculated by subtracting the total soluble anions from the total soluble cations.

Soil pH was determined in the saturated soil paste using a Gllenkamp pH meter (Model pH Tester 2™) and total soluble salts were determined by measuring the **electrical conductivity (EC)** both according to **[49].**

Organic matter content was determined using Walkely's rapid titration method **[21]. Calcium carbonate** was determined using Collin's calcimeter as described by **[43].**

3-Estimation of elements

Estimation of total-N:

Determination of total nitrogen by the conventional semi-micropropagation of Kjeldahl method of **[48]** and described by **[14].**

Estimation of phosphorus:

This method depends on the formation of a blue complex between phosphate and molybdic acid in presence of a reducing agent. The following method of **[29]** as described by **[19]** and adopted by **[14],** for compounds extraction of the total phosphorus were essentially similar to those described by **[8]**.

Estimation of K and Na:

Wet ashing method, plant materials were dried in an oven at 80° C till constant weight. The dried matter digested according to the method of **[10].** Digested the samples on electric heater until dense white fumes appeared and finally the solution after filtraton became clean and was about 5 ml. The solution was stored for potassium (K) determination by the technique of the flame emission as adopted by **[47]**, while to determine leaf content of Na^+ was determined using a flame photometer type M7D, according to **[3].**

3. Results and Discussion

Changes in growth parameters:

A- *Corchorus olitorius* plant:

At first vegetative stage of *Corchorus olitorius* plant growth, the obtained results in table (1) showed that, the treatment with 25 and 50 ppm sodium alginate increased the tabulated growth parameters either significantly (shoot & root lengths) or non-significantly (fresh & dry weights and water percentage/ plant). The treatment with 100 ppm sodium alginate increased shoot length significantly and fresh weight, root length & water percentage non significantly and there was nearly no change in dry weight as compared to control values.

In the second stage, a non-significant decrease in water content with the three used treatments, also, in the fresh weight affected by 100 ppm SA, the trend of changes in the other determined parameters was more or less similar to that at the first vegetative stages of

Corchorus olitorius plant, comparing to the untreated values.

At the third vegetative stages, as compared to control values, except water percentage which recorded a non-significant decrease, while, the data recorded a significant increase in the shoot length. Also a non- significant increase in the other parameters (fresh & dry weights and root length), as compared to control.

B- *Vicia faba* plant:

The obtained results in table (2) showed that, at first vegetative stage of *Vicia faba* plant growth, the treatment with 25, 50 and 100 ppm sodium alginate increased the tabulated growth parameters either significantly (shoot length) or non-significantly (fresh & dry weights, root length and percent of water content of seedling) as compared to control values .

It was recorded at second vegetative stage of faba bean, that 25 ppm sodium alginate caused a significant increase in shoot length and non-significant increase in the other determined parameters. Treatment with 50 ppm and 100 ppm sodium alginate caused a non-significant increase in dry weight and root length and significant increase in shoot length, fresh weight and water percentage as compared to control values.

In relation to control values, at the third vegetative stage the effect of 25, 50 and 100 ppm sodium alginate on *Vicia faba* plant showed a significant increase in shoot and root lengths, while a non-significant increase showen in plant fresh and dry weight. On the other hand, water percentage showed non-significant decrease as compared to control values.

C- *Zea mays* plant:

The obtained results in table (3) showed that, at first vegetative stage of *Zea mays* plant, the treatment with 25 ppm sodium alginate increased the tabulated growth parameters either significantly (fresh weight and water percentage) or non-significantly (shoot length, dry weight and root length). In corresponding to 50 ppm sodium alginate treatment, significant increases in shoot length, fresh weight, root length and water percentage of the plant was obtained. On the other hand, dry weight increased non-significantly. The treatment with 100 ppm sodium alginate increased fresh & dry weights and root length non significantly but shoot length & water percentage increased significantly, as compared to control values.

At second vegetative stage of *Zea mays*, it was recorded that 25, 50 and 100 ppm sodium alginate caused non significant increase in fresh & dry weights and water percentage and significant increase in shoot length and root length was obtained as compared to control values.

At the third vegetative stage, 25 ppm sodium alginate caused a significant increase in root length and non-significant increase in fresh & dry weight and shoot length but decreased water percentage non 1significantly. The treatment with 50 ppm sodium alginate caused significant increase in shoot length , fresh weight, root length & water content and non-significant increase in dry weight .The application of 100 ppm sodium alginate showed significant increases in shoot & root lengths while, a non-significant increases in fresh & dry weights and a non significant decrease in water percentage as compared to control values. In this connection, many studies indicated that marine algae polysaccharides and derived oligosaccharides can stimulate growth in different plants **[13, 56, 57, 15]**

In a study, to evaluate the effect of the concentration of NaAlg submicroparticles (0–100 µg/mL) on germination, shoot & root lengths, the number of nodes & leaves, fresh & dry weight and NPK and Na contents **[31].** The results had showed that NaAlg submicroparticles can exert biological activity at higher concentrations (100 µg/mL). They concluded that special properties of submicroparticles can improve the absorption and utilization in plant.

Of interest to observed that 50 ppm SA caused the best influence in most cases, in this concern, the concentration is important for its resulting effect. Algae polysaccharides can promote the elongation of roots of rice and carrot at the concentration of 500µg/mL **[54]**. Other study showed that at a concentration of 2×10^4 µg/mL alginate can stimulate the germination of seed and plant length of sunflower **[4]**. Moreover, a previous study also showed that at a concentration of 2000 µg/mL alginate-derived oligosaccharides can promote the growth of cucumber and tomato plants **[32,30]**. In addition, at concentrations of 750 µg/mL and 1500 µg/mL alginate-derived oligosaccharides stimulate germination *via* the promotion of the activity and acceleration of amylase of the metabolic activities of the maize seed **[18]**. It was previously reported that the high concentrations of oligosaccharides can induce cell apoptosis in plants **[53, 56]**. They speculated that the high concentrations of CaAlg submicroparticles may have a similar effect on plants

Table (1): Effect of different sodium alginate concentrations on growth parameters of *Corchorus olitorius* plant during three vegetative stages.

Stages	Treatments	Parameters/ plant				
		Shoot Length(cm)	Plantfresh weight(g)	plant dry weight(g)	Root length(cm)	Water percentage(%)
Stage I	Control	7.04	16.72	1.98	12.78	88.15
	25 ppm	13.68*	18.32	1.99	14.42	89.95
	50 ppm	16.28*	20.30	2.39	14.84	88.22
	100 ppm	13.96*	19.97	2.30	14.06	88.48
Stage II	Control	14.84	13.17	1.75	13.24	86.71
	25 ppm	25.7*	15.94	1.78	15.3	88.83
	50 ppm	26.24*	21.03*	2.25	15.9	89.30*
	100 ppm	21.98*	20.47*	1.92	14.54	90.62*
Stage III	Control	27.42	31.47	3.38	14.66	89.25
	25 ppm	32.02*	32.72	3.59	17.87*	89.02
	50 ppm	36.92*	32.73	5.05	20.66*	84.54
	100 ppm	32.54*	32.33	3.78	18.18*	88.30

(*)=significant increase or decrease at 0.05 LSD

Table (2): Effect of different sodium alginate concentrations on growth parameters of *Vicia faba* plant during three vegetative stages. (*)=significant increase or decrease at 0.05

Stages	Treatments	**Parameters/ plant**				
		ShootLength (cm)	plant fresh weight(g)	plant dry weight(g)	Root length(cm)	Water percentage(%)
Stage I	Control	5.12	5.49	0.96	12.28	82.51
	25 ppm	6.86	6.47*	0.96	13.5	85.61*
	50 ppm	8.66*	6.59*	0.97	16.08*	85.28*
	100 ppm	7.78*	6.36	0.96	13.44	84.90*
Stage II	Control	7.3	9.71	1.30	14.78	86.61
	25 ppm	9.14*	13.86	1.58	21.78*	88.60
	50 ppm	10.58*	13.97	1.59	24.46*	88.61
	100 ppm	9.88*	13.91	1.37	21.90*	90.15
Stage III	Control	15.9	38.25	4.91	18.22	87.16
	25 ppm	21.7	45.34	8.15	24.02*	82.02
	50 ppm	29.20*	88.67*	9.51	35.56*	89.27*
	100 ppm	21.94*	51.96	7.56	27.24*	85.45

Table (3): Effect of different sodium alginate concentrations on growth parameters of *Zea mays* plant during three vegetative stages.

Stages	Treatments	**Parameters/ plant**				
		Shoot Length(cm)	plant fresh weight(g)	plant dry weight(g)	Root length (cm)	Water percentage (%)
Stage I	Control	5.12	5.49	0.96	12.28	82.51
	25 ppm	6.86	6.47*	0.96	13.5	85.61*
	50 ppm	8.66*	6.59*	0.97	16.08*	85.28*
	100 ppm	7.78*	6.36	0.96	13.44	84.90*
Stage II	Control	7.3	9.71	1.30	14.78	86.61
	25 ppm	9.14*	13.86	1.58	21.78*	88.60
	50 ppm	10.58*	13.97	1.59	24.46*	88.61
	100 ppm	9.88*	13.91	1.37	21.90*	90.15
Stage III	Control	15.9	38.25	4.91	18.22	87.16
	25 ppm	21.7	45.34	8.15	24.02*	82.02
	50 ppm	29.20*	88.67*	9.51	35.56*	89.27*
	100 ppm	21.94*	51.96	7.56	27.24*	85.45

Table (4) : Effect of different concentrations of sodium alginate on the nitrogen , phosphorus, potassium and sodium percentages (%)of Corchorus olitorius, Vicia faba and Zea mays through the second vegetative stage (after 20 days from sowing)

Treatment		**Parameters**			
		N%	**P%**	**K%**	**Na%**
Corchorus olitorius	Control	25.2	1.89	1.14	0.092
	25 ppm	30.5*	2.68*	2.60*	0.095*
	50 ppm	35.7*	2.29*	3.10*	0. 100*
	100 ppm	18.3*	1.37*	3.00*	0.120*
Vicia faba	Control	26.1	1.95	0.70	0.149
	25 ppm	33.9*	2.54*	0.71	0.152*
	50 ppm	47.0*	3.41*	0.73*	0.160*
	100 ppm	46.1*	3.46*	0.71	0.181*
Zea mays	Control	62.6	2.7	0.25	0.101
	25 ppm	42.6*	3.19*	1.02*	0.195*
	50 ppm	41.2*	3.21*	1.29*	0.152*
	100 ppm	40.9*	3.07*	1.16*	0.166*

(*) = significant increase or decrease at 0.05 LSD

Changes in some elements content:

A - Corchorus olitorius plant:

The data in table (4) revealed that, treatment with 25 and 50 ppm sodium alginate significant increase nitrogen, phosphorus, potassium and sodium content. A marked significant increment in K and Na content was detected in the *Corchorus olitorius* plant, at the second vegetative stage by application of 100 ppm sodium alginate, meanwhile N and P showed a significant decrease as compared to control values.

B- Vicia faba plant:

According to the data in table (4), the treatment with 25, 50 and 100 ppm sodium alginate increased nitrogen, phosphorus and sodium content significantly, meanwhile K showed a non-significant increase at 25 and 100 ppm but a significant increase at 50 ppm, as compared to control values.

C- Zea mays plant:

Perusal of the data in table (4) revealed that, except for treatment with 25, 50 and 100 ppm sodium alginate which decreased nitrogen content significantly, a marked significant increment in P, K and Na content was detected in the *Zea mays* plant, as compared to the corresponding values of the untreated plants.

In this regard, absorption and utilization of mineral nutrients facilitated by irradiated SA **[23,46]**. Similar stimulation in leaf N, P and K contents due application of irradiated SA to various other crops has been reported by **[23, 25]**. Application of different concentrations of irradiated SA on the *Papaver somniferum L.* leaves and reported that at 120 ppm concentration of irradiated SA improved leaf nitrogen content to the maximum **[2].** Compared to control, the Na concentration in roots of plants exposed to CeO2 NPs alone decreased by 10.5%. In the CeO2 NP

alginate treatments, Na in roots reduced up to 16%. This could be associated with the increase in K absorption. As a C4 plant, corn needs Na for phosphoenolpyruvate regeneration, the carboxylation substrate **[52, 58]. [35]** study the influence of irradiated sodium alginate (ISA) on *foeniculum vulgare* and found that leaf N, P &K contents increased significantly as a result of application of ISA.

Polysaccharide submicroparticles have been applied in the agricultural field, such as the incorporation of (NPK) fertilizer into the submicroparticles to save fertilizer consumption. **[11]**. A researche data **[38]** reported that at higher concentrations of alginate-derived oligosaccharides exerts its biological functions Furthermore

,submicroparticles have a nanometer size effect, which can stimulate its bioactivities

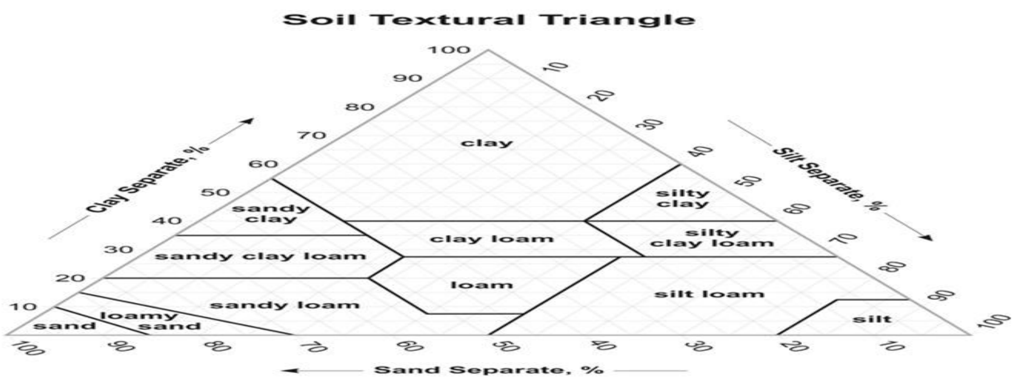
.**Changes in soil physical and chemical properities:**

As mentioned before, the soil properties were carried out only in the soil where the treated and untreated *Zea mays* plant sowing at stage II.

Table 5 indicated that, the clay, silt and porosity percent increased by treatment with 25,50 and 100 ppm sodium alginate except for porosity% which decreased by treatment with 25 ppm sodium alginate when compared with control. Meanwhile the sand percent decreased as compared to control values. In soils planted with that treated by 50 and 100 ppm sodium alginate the field capacity percentage (F.C.P) and wilting point (W.P) percents increased whereas no change detected at 25 ppm sodium alginate as compard to control values. The soil texture not changed by treatment with 25 ppm sodium alginate but changed from sandy loam (in the untreated plants) into loamy soil at 50 ppm sodium alginate and to sandy clay loam by application of 100 ppm sodium alginate; according to **[44]** as illustrated in table 5 & fig(1).

Table (5) The physical properties for the planting soils of *Zea mays* plant after 20 days from sowing.

Parameters Treatment	Sand%	Clay%	Slit%	Prosity%	F.C.P%	W.P%	Soil texture
Control	62.16	16.05	19.44	17.91	18.00	36.00	Sandy loam
25 ppm	57.99	16.17	23.73	17.38	18.00	36.00	Sandy loam
50 ppm	48.83	18.35	36.00	23.00	28.00	56.00	Loamy
100 ppm	52.90	20.18	22.80	19.60	27.00	54.00	Sandy clay loam



F.C.P: field capacity percentage W.P: wilting point

Fig. (1): Soil texture pyramid **[44]**

Chemical properties, in table 6 detected increases in calcium carbonate & organic matter and potassium cations in response to treatment with 25, 50 and 100 ppm sodium alginate, while there was a decrease in nitrogen and phosphorus contents, as compared to control values.

According to table (6), as compared to control values, application of 25, 50 and 100 ppm sodium alginate caused increases in EC, (HCO_3^{--}, SO_4^{--}) anions ,(K^+, Na^+, Ca^{++}) cations and T.S.S ,whereas Cl^- anion increased only at 50 and 100 ppm sodium alginate but decreased at 25 ppm sodium alginate. Meanwhile there was a decrease in pH and Mg^{++} cations by application of 25, 50 and 100 ppm sodium alginate**.** In this

connection**,** it was recorded that sodium alginate in smallest amounts brings about relatively the greatest increments in the contents of water of the soil at which the aeration factor (A.F). Also in the alginate treated soils the water-holding power and pH increased. As the beginning pH (7.3) of the medium and the final pH. (7.7) at the termination of the experiments, were unaltered by the presence of the sodium alginate. Hence it may be concluded that the changes of hydrogen-ion concentration in the soil brought about by sodium alginate addition cannot account for, and may not even be contributing to, the increased A.F. **[45].** They suggested that the results make it evident that the change in A.F. value with increase in water content is a function of both water-holding power and crumb stability.

Moreover, the experimental results showed that as sodium alginate in the soil increased, the liquid limit and plastic limit of the soil also increased. The above results indicated that the soil properties in both the physical structure and chemical composition can be changed significantly by using sodium alginate. Large amount of -COO- groups included in Sodium alginate. Sodium alginate when dissolved in water giving rise to adhesion and it becomes polyanionic. Under mild conditions, sodium alginate can combine quickly with water to form a hydrogel **[42, 59].**

Table (6): The chemical properties for the planting soils of *Zea mays* after 20 days from sowing.

Treatments	**$CaCO_3$** %	**Organic matter** %	**N** ppm%	**P** ppm %	**K** ppm%
Control	0.85	0.61	661.50	15.10	20.67
25 ppm	0.95	1.14	581.00	14.30	20.72
50 ppm	1.40	2.01	487.00	12.83	21.02
100 ppm	1.60	2.52	395.50	8.92	22.16

Table (7): The chemical properties for the planting soils of *Zea mays* plant after 20 days from sowing.

Treatments	**CaC** %	**Organic matter** %	**N** ppm%	**P** ppm %	**K**pp%
Control	0.85	0.61	661.50	15.10	20.67
25 ppm	0.95	1.14	581.00	14.30	20.72
50 ppm	1.40	2.01	487.00	12.83	21.02
100 ppm	1.60	2.52	395.50	8.92	22.16

Conclusion

In conclusion, the result of this study showed that the application of SA especially 50 ppm had a promotive effect on plant growth by enhancing growth parameters, elements absorption and changing soil physical and chemical properties.

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