Review Article

Evaluation of methods of adding chitosan and potassium silicate on some soil fertility and cowpea plant productivity

ABSTRACT

This work aims to study the evaluation of two methods applied for Chitosan and potassium silicate under irrigation water periods 10, 15, and 20 days on some soil fertility and cowpea productivity.A field experiment was conducted in saline soil located in Sahl El-Hossinia at El-Sharkia Governorate. The location lies between latitude 32° / 00 to 32° / 15, N and longitude 30° / 50 to 31° / 15 E. For two successive summer seasons 2021 and 2022 cultivated with Cowpea, to study the evaluation of two methods applied for chitosan and silicate potassium combined with or without mineral N fertilizers different rate on some soil fertility and cowpea productivity under irrigation water periods. The experiments were carried out in a split-plotdesign with three replicates. Results obtained that the decreases of soil pH and soil salinity, as well as the increase of available macro-micronutrients contents in soil as affected with potassium silicate foliar application combined with mineral N through intervals irrigation period 10 days compared to other treatments. the increase of plant height (cm), No. of pods/plant, No. of branches /plant, weight 100 seeds (g), weight pods (ton/fed), and seeds yield (ton/fed) with increasing mineral N fertilizer rate combined with potassium silicate foliar application under irrigation water interval 10 days compared with other treatments. Also, the highest mean values of N, P, Fe, Mn, and Zn concentrationsin seeds cowpea as affected with potassium silicate foliar application under irrigation water interval of 10 days than other treatments. From the previous results, we found that the method of foliar application of potassium silicate and chitosan under irrigation water at different periods has significant effects on all soil and plant characteristics compared to the soaking method.

Keywords: saline soil, intervals irrigation water, cowpea productivity, methods applied, chitosan, potassium silicate, soil salinity.

INTRODUCTION

Salinity in soils can occur naturally or as a result of human activities. Irrigation water with a high salt concentration,excessive chemical fertilization, and poor soil management are the main reasons for an increase in the area of saline–alkaliland **(Azarmi-Atajan and Sayyari-Zohan 2020).**The soil salinity stress substantially decreased plant growth, and the decline of biomass and yield of maize plants occurred under salinity stress conditions which,may be due to the inhibition of expansion of cells due to low turgor pressure in greater salinity stress causing a reduction in growth of shoot **(Younas et al., 2021).**Salinity conditions areduring all growth stages of plant growth was the decrease in plant growth may be due to the disturbance in metabolic activities affected by the decrease of water absorption and disturbance in water balance **(Salem et al., 2017).**The saline conditions led to significantly reduced chlorophyll contents, and potassium concentrations, and thus distorted photosynthesis and hormonal regulation, causing nutritional imbalance, specific ion toxicity, and osmotic effects in legumes andless number of seeds grain yield and quality**(Farooq et al., 2017).**The increasing of rate of soil salinity was significantly reduced the characteristics of flowering and yield parameters overall in both growing seasons**(Tartoura et al., 2021).**

Egypt's irrigation potential is estimated at 4.42 million hectares. The total actual renewable surface water resources are estimated at 56 km^3 /year (of which 55.5 km^3 /yr from the river Nile and 0.5 km^3 /yr from internal renewable surface water resources). Internal renewable groundwater resources are estimated at 1.3 km^3 /yr. The overlap between surface water and groundwater is considered negligible, the total actual renewable water resources of the country are thus 58.3 km^3 /yr **(FAO-Aquastat, 2015).**Agriculture consumes about 77.5% of Egypt's share of the Nile water, equivalent to about 62 billion m^3, in the cultivation of about 10.84 million feddans in 2019.The total water resources will reach 2030, about 634.8 m^3 /year, and the average period will be about 688.6 m^3 /year, which indicates the need to pay attention to the water resource, which will be exposed to danger in the future **(Abdel Fatah and El-Shahed 2022).**

Chitosan is a polycationic polymer synthesized deacetylation of chitin (a structural material present in multitudinous invertebrates) commonly collected by crustacean's exoskeletons, particularly shrimps and crabs, as well as fungus and yeast cell walls and diatom spines. Because it has been relatively hydrophobic, it is primarily insoluble in water and various organic solvents **(Nguyen and Wan 2017).** Chitosan is a recognized agricultural biostimulant for causing biological effects in plants such as promoting growth and development and anti-stress protection through the activation of plant metabolism. The chitosan stimulation growth and development in plants andphotosynthesisprocesses the accumulation of carbohydrates the activation of enzymes of carbon metabolism and nitrogen and the increase in the content of secondary metabolites **(Mondal et al., 2017).** Chitosan application development of salt-affected soils is one of the processes of soil degradation leading to land desertification and consequently. The effect of chitosan foliar application on soil salinity was slightly for soil salinity and soil sodicity (SAR and ESP) comparing to the untreated plots, **(Elsaka et al., 2018).** Chitosan has an excellent role in improving soil fertility, plant growth, and plant growth promoters. In addition, chitosan has a huge contribution to reducing fertilizers pollution, managing agricultural pests and pathogens in modern-day agriculture**(Yaha et al., 2021).**Application of chitosan substantially improved the morphological and physiological attributes as well as antioxidant enzymes such as superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT) of maize plants, and combined application of Si and Chi was more effective**(Younas et al., 2021).**The coating with chitosan can form a semi permeable film which may modify the internal atmosphere and decrease the transpiration loss of the leaves **(Fouda et al., 2022).**

Potassium silicate is a silica amendment of highly soluble potassium (K) and silicon (Si). It is approved by the USDA for conventional agriculture as a fertilizer compatible with sustainable agriculture. Foliar application of potassium silicates showed a bio-simulative effect under stress conditions for plants such as salinity (**Bayat et al, 2013).** Silicon is one of the beneficial elements in many of physiological processes of plants such as increasing the absorption of roots to necessary elements for plants development and activity of oxidative enzymes, improvement of photosynthesis process as well as reduction of toxicity of sodium accumulation and heavy metals **(Muhammad Adrees, et al., 2015).** The applied of potassium silicate different rates on pea plant was increase of macronutrients with increasing rate **(Ismail and Shata 2017)**. The used of potassium silicate encouraged the vegetative growth and mineral nutrient contents. As well as, the potassium is very paramount for plants physiological functions like, the formation of sugars and starch, the synthesis of proteins, cell division, growth and fruit formation. The potassium has an important role in improving plant water status and reducing the toxic effects of Na element which reflects positively ultimately on the all-growthparameters **(El-Hefnawy 2020).** The foliar spray of potassium silicate, and chitosan single or combined on the faba bean led to significantly reduce the transpiration and increased the yield quality and quantity properties **(Fouda et al., 2022).**

Cowpea, as one of beans crops, has a high nutritional value, and it is rich in proteins, carbohydrates, and mineral salts. Seeds contain 24-28%

protein, 48-56% carbohydrate, 1.5% fat, and good amounts of vitamins C, B and minerals **(Tshovhote et al., 2003).**Cowpea grows well in a wide range of soil texture that makes it proficient as a good cover crop and soil fertility enhancer and has rapid and luxuriant vegetative growth **(Giridhar et al., 2020).** The total area under cultivated of cowpea plant in Egypt was estimated at 1853 ha with a mean production of 7180 tons of dry seeds **(FAOSTAT, 2021).** In addition, it has the ability to fix atmospheric nitrogen in soil at the rate of 40-80kg per ha (**Mafakheri et al., 2017).**

The present study aims investigation to the effect of chitosan, and Potassium silicate under water stress on cowpea crop productivity in saline soil conditions.

MATERIALS AND METHOD

Two field experiments were carried out in saline clay soil at sahl El-Hussina, El-Sharkia Governorate, Egypt during two successive seasons of summer, 2021 and 2022 to study the evaluation between methods organic matter sources application on some soil fertility and cowpea productivity under irrigation water periods. The main physical and chemical properties of the soil was determined before planting according to the methods described by **Cottenie et al (1982), Page et al., (1982).** The obtained data were recorded in Table (1).

Table (1) Physical and chemical properties in soil study before cowpea at Sahl El-Hussinia.

Coarse sand (%)	Fin sand (%)	Silt (%)	Clay (%)	Texture	O.M (%)	$CaCO_3$ (%)
4.60	18.40	41.30	35.70	Clay	0.55	12.77

pH (1:2:5)	EC (dS/m)	Cations(meq/l)				Anions(meq/l)		
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO^{-}_{3}	Cl^{-}	SO^{--}_{4}
8.25	9.45	15.90	25.70	52.01	0.89	10.60	47.20	36.70

Available macronutrients (mg/kg)			Available micronutrients (mg/kg)		
N	P	K	Fe	Mn	Zn
30.85	6.30	188.00	3.49	4.75	0.59

The experiments were carried out in a split plot design with three replicates. The area of eachexperimental unit (plot) was 5 x 10 m which dividedinto rows with 50 cm. All farming processes were carried out beforeplanting. Applied of calcium super phosphate (15.5 % P_2O_5) at rate 300 kg/fed during soil preparation. Seeds of Cowpea(Vigna ungiculata (L.) Walp. Cv Cream 7) seed was obtained from the Legume Research

Institute, Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt. Chitosan and potassium silicate were applied for two methods (soaking and foliar at rates 4 m/L water). The area experiment was one fed = 4200 m^2 divided to three plot, fist plot irrigated with 10 days , second plot irrigated with 15 days and third plot irrigated with 20 days from planting.

Urea (46 % N) was applied as N fertilizers at rates 15, 30 and 45 kg/fed after 30, 50 and 70 days from planting. Potassium sulphate (48 % K_2O) was applied at rate 75 kg/fed after 30, 50 and 70 kg /fed).

The chitosan and potassium silicate were two methods applied. First methods were soaking seeds in chitosan and potassium silicate at rate 4 ml /L. Second methods were foliar application at rate 4 ml/L. the foliar application of chitosan and potassium silicate was foliar application on soil and plant during 30, 45 and 70 days from sowing at rate 1.6 L/ 400 L water. Sowing seeds was carried out 15 may 2021 and 2022. Two to three of seeds were sown in hole with 3 cm depth between each two holes was 25 cm. After 30 days of sown the plant of each hole were thinned to one plant.At harvesting stage, the plants of the six replicates were harvested. Each dry plant sample was separated into plant height (cm), No. of branches /plant. No. of pods /plant, weight of 100 seeds (g), weight of pods /(ton/fed) and weight of seeds (ton /fed) were counted.Seeds were air-dried and oven dried at $70C^o$ for 48 hrs. Ether of oven-dried seeds were ground and kept in plastic bags for chemical analysis. A 0.5 g of each oven dried ground plant sample was digested using $H_2SO^{-}_4$, HCIO4 mixture according to the method described by **Chapman and Pratt (1978).** The plant content of N, P, K, Fe, Mn, Zn and Cu was determined in plant digestion using the methods described by **Cottenieetal.(1982).**

Soil analysis

The mechanical analysis was determined according to Piper (1950).described by Piper (1950). Electrical conductivity (EC) was measured in soil paste extract using the method described by Page et al. (1982). Soluble cations: Ca++ and Mg++ were titrated using the versinatemethod, while Na+ and K+ were determined using flame photometer.Soluble anions: CO3--, HCO3-, and Cl- were determined titrimetrically according to Page et al. (1982). pH value was determined in 1:2.5 soil-water suspension using a glass-electrode pH-meter.Available N was extracted by KCl and determined by the Kjeldahl method. All such determinations were according to methods cited by Black et al. (1965) and USDA (1954). Available P, K, Fe, Znand Mn were extracted by Ammonium-Bicarbonate-DTPA, (AB+DTPA according to **Soltanpour (1985)**. Field capacity was determined according to **USDA (1954).**

Astatically Analysis

The obtained data were statistically analysis using the COSTAT program and L.S.D. test at the probability levels of 5% was calculated" according to **Gomez and Gomez (1984).**

RESULTS AND DISCUSIONS

Effect of chitosan and potassium silicate methods and different irrigation water periods on some soil properties.

Soil pH.

Data presented in Table (2) show that the effect of methods application for chitosan and potassium silicate with or without N mineral rates fertilizer under different period's irrigation water were positive effect on soil pH. The minimum mean values 8.05 as treated with foliar application of potassium silicate combined with mineral N rates under irrigation at 10 days. Reductions in soil pH value may be related to the residual organic compounds. The active organic acids led to reduction in soil pH.The Soil pH was slightly to moderately alkaline conditions, where the pH value is always around 8.20-8.01. However, there was no clear effect for the applied chitosan and potassium silicate combined with mineral N different rate on the pH values of the studied soils. These results are in agreement by **Nosheen et al., (2015)** reported that potassium silicate is also helpful in decreasing pH of saline sodic soil as it contains silicon. Potassium silicate + reacts with Na on exchange sites and sodium silicate is formed. These the pH of saline sodic soils decreased by application of potassium silicate. **Fouda et al., (2022)** found that the soil pH decreases as treated with potassium silicate and chitosan foliar application under drought stress. The effect of chitosan and potassium silicate on soil pH may be attributed to the increase in numbers of microbial populations in soil, and the transformation of organic nutrients into inorganic nutrients that are absorbed easily by plant roots.

Soil salinity (EC dSm^{-1}).

Data presented in Table (2) illustrated that the soil salinity decrease with increase of mineral N rates alone or combined with potassium silicate and chitosan foliar application. The effect of methods application of chitosan and potassium silicate (Soaking and foliar) on soil salinity (EC) was no significant under irrigation water period.

Table (2). Soil pH and soil salinity after Cowpea harvest.

Treatments	N rates (kg/fed)	pH (1 :2.5)				EC (dSm^{-1})			
		Irrigation water period (day)							
		10	15	20	Mean	10	15	20	Mean
Mineral	15	8.16	8.18	8.20	8.18	6.10	7.06	7.95	7.69
	30	8.12	8.14	8.17	8.14	5.71	6.79	7.50	7.51
	45	8.07	8.09	8.13	8.10	4.23	5.42	6.80	6.98
Mean		8.12	8.14	8.17	8.14	5.35	6.42	7.42	7.39
Soaking chitosan	15	8.15	8.16	8.18	8.16	5.86	6.85	7.65	7.57
	30	8.10	8.13	8.15	8.13	4.32	6.23	7.10	7.17
	45	8.04	8.07	8.12	8.08	3.85	5.77	6.25	6.88
Mean		8.10	8.12	8.15	8.12	4.68	6.28	7.00	7.21
Chitosan foliar	15	8.12	8.14	8.16	8.14	5.52	6.55	7.35	7.43
	30	8.06	8.10	8.11	8.09	4.10	5.29	6.95	6.96
	45	8.01	8.05	8.07	8.04	3.25	4.89	6.24	6.65
Mean		8.06	8.10	8.11	8.09	4.29	5.58	6.85	7.01
Soaking of Silicate potassium	15	8.12	8.13	8.15	8.13	6.05	6.14	7.14	7.41
	30	8.09	8.09	8.10	8.09	4.95	5.08	6.55	6.99
	45	8.03	8.06	8.07	8.05	4.70	4.95	5.24	6.73
Mean		8.08	8.09	8.11	8.09	5.23	5.39	6.31	7.04
Foliar silicate potassium	15	8.10	8.12	8.14	8.12	5.63	6.07	6.75	7.28
	30	8.05	8.07	8.10	8.07	4.25	5.01	5.95	6.79
	45	8.01	8.04	8.07	9.04	3.41	4.33	5.37	6.47
Mean		8.05	8.08	8.10	8.08	4.43	5.14	6.02	6.84
LSD. 5 % methods						ns	ns	ns	
LSD. 5 % N Rates						ns	0.73	0.47	
Interaction						***	*	**	

Also, the significant increase of soil salinity at different mineral N rates during irrigation water at 15 and 20 days, while the rate mineral N during irrigation at 10 days was no significant. The interaction of methods application combined with mineral N different rates under irrigation water periods were high significant decrease of soil salinity. The relative decreases of mean values soil salinity were 2.44 % and 5.14 % for treated with soaking chitosan and chitosan foliar application combined with different rates of N mineral fertilizers and irrigation water different periods compared with mineral N fertilizer different rates. Also, the relative decreases of mean values soil salinity were 4.74 % and 7.44 % as affected with soaking and foliar application of potassium silicate compared with mineral N different rates. These results are in agreement by **Michael *et al* (2010)** indicated that soil salinity decreased with foliar application of potassium silicate. **Ghafoor et al (2004)** suggested that potassium silicate foliar application led to decreasing the ECe of soil. Potassium silicate was improving the soil structure by replacing Na on exchange sites and turn soil structure to flocculate. In this way drainage of soils improved and leaching of salts becomes possible.

Macronutrients available in soil.

The increase of available macronutrients (N, P and K) in soil was increasing mineral N rate as different irrigation water periods and methods application of chitosan and potassium silicate show data presented in Table (3) was no significant under irrigation water periods, while the K content was significant in soil irrigation interval at 10 days as well as no significant with irrigation interval at 15 and 20 days. The significant increase of available N and K content in soil was increasing rate of N mineral fertilizer. The interaction between different mineral N fertilizer rate and methods application of chitosan and potassium silicate under different irrigation periods led to no significant of P under different irrigated periods while the N and K content in soil was significant in soil treated with irrigated at 20 and 10 days respectively.The maximum values of available N, P and K contents in soil were 47.85, 8.35 and 198.94 mg/kg respectively as affected with foliar application 0f potassium silicate combined by 45 kg/fed mineral fertilizer under irrigation water interval 10 day compared with other treatments. The relative increase of mean values available N, P and K contents in soil were 4.54, 2.71 and 0.16 % respectively as affected with soaking chitosan combined with different mineral N rates and irrigation water different periods compared with N mineral fertilizer. Also, the relative increases of mean values were 8.99, 4.33 and 1.06 % for N, P and P contents in soil as affected with foliar application combined with mineral N different rate and different irrigation periods compared with mineral N fertilizer different rate.

Table (3). Macronutrients available in soil after harvest.

Treatments	N rates (kg/fed)	N				P				K			
		Irrigation water period (day)											
		10	15	20	Mean	10	15	20	Mean	10	15	20	Mean
Mineral	15	35.26	34.65	32.95	34.29	7.25	7.12	6.85	7.07	189.00	188.85	187.95	188.60
	30	38.12	36.85	35.41	36.79	7.85	7.55	6.93	7.44	192.45	190.32	188.32	190.36
	45	39.20	38.71	36.12	38.01	8.05	7.85	7.08	7.66	193.21	191.58	189.75	191.51
Mean		37.53	36.74	34.83	36.36	7.72	7.51	6.95	7.39	191.55	190.25	188.67	190.16
Soaking chitosan	15	37.52	35.42	33.85	35.60	7.68	7.45	6.95	7.36	190.23	190.00	188.52	189.58
	30	39.20	38.91	36.84	38.32	8.04	7.88	7.06	7.66	190.75	190.32	189.74	190.27
	45	42.13	40.12	38.13	40.13	8.12	7.93	7.16	7.74	193.85	190.75	189.98	191.53
Mean		39.63	38.15	36.27	38.01	7.95	7.75	7.06	7.59	191.61	190.36	189.41	190.46
Chitosan foliar	15	38.95	37.98	34.95	37.29	7.85	7.69	7.01	7.52	192.13	190.75	189.12	190.67
	30	41.23	39.52	37.23	39.33	8.14	7.90	7.22	7.75	194.35	192.32	190.42	192.36
	45	44.52	42.13	40.12	42.26	8.19	8.02	7.35	7.85	195.26	1.93.85	191.75	193.51
Mean		41.57	39.88	37.43	39.63	8.06	7.87	7.19	7.71	193.91	191.54	190.43	191.96
Soaking of Silicate potassium	15	39.23	38.52	36.12	37.96	7.95	7.75	7.08	7.59	194.00	191.24	190.10	191.78
	30	42.85	40.23	38.52	40.53	8.16	7.95	7.33	7.81	196.32	194.56	191.52	194.13
	45	44.95	43.12	41.23	43.10	8.22	8.07	7.48	7.92	197.85	195.62	193.14	195.54
Mean		42.34	40.62	38.53	40.53	8.11	7.92	7.30	7.78	196.06	193.81	191.59	193.82
Foliar silicate potassium	15	42.15	40.15	38.12	40.14	8.12	7.89	7.14	7.72	196.77	192.10	190.85	193.24
	30	45.63	43.12	40.41	43.05	8.19	8.05	7.44	7.89	198.32	195.36	193.75	195.81
	45	47.85	44.96	42.69	45.17	8.35	8.15	7.58	8.03	198.94	197.23	195.42	197.20
Mean		45.21	42.74	40.41	42.79	8.22	8.03	7.39	7.88	198.01	194.90	193.34	195.42
LSD. 5 % methods		ns	ns	ns		ns	ns	ns		1.39	ns	ns	
LSD. 5 % N Rates		1.38	3.77	1.90		ns	ns	0.26		0.59	1.88	0.78	

Interaction	**ns**	**ns**	**		**ns**	**ns**	**ns**		*	**ns**	**ns**	

On the other hand, the relative increases of mean values available N, P and K contents in soil as affected with soaking potassium silicate combined with different N rates and irrigation water different periods were 11.47, 5.28 and 1.92 % respectively compared with mineral N fertilizers different rates. As well as, the relative increases of mean values were 17.68, 6.63 and 2.77 % for N, P and K respectively, as affected of foliar application potassium silicate combined with mineral N fertilizers different rate and irrigation water different period compared with mineral nitrogen different rates.

Available micronutrients contents in soil.

Data presented in Table (4)indicated that the increase of available micronutrients contents (Fe, Mn and Zn) in soil treated with interval irrigated at 10 days and foliar potassium silicate or chitosan method combined with 45 kg/fed mineral N fertilizers other treatments.The methods application potassium silicate or chitosan combination with mineral N fertilizer different rates under irrigation water different periods was no significantly by Fe. Also, the effect of methods application and different irrigation periods were no significant, while the Mn was significant as affected with mineral N different rates under interval irrigation water at 15 days.

Table (4). Micronutrients available in soil after harvest.

Treatments	N rates (kg/fed)	Fe				Mn				Zn			
		Irrigation water period (day)											
		10	15	20	Mean	10	15	20	Mean	10	15	20	Mean
Mineral	15	3.88	3.75	3.60	3.74	4.98	4.82	4.63	4.81	0.65	0.61	0.56	0.61
	30	3.97	3.80	3.77	3.85	5.44	4.95	4.77	5.05	0.68	0.63	0.61	0.64
	45	4.03	3.88	3.80	3.90	5.69	5.17	4.85	5.24	0.69	0.64	0.64	0.66
Mean		3.96	3.81	3.72	3.83	5.37	4.98	4.75	5.03	0.67	0.63	0.60	0.63
Soaking chitosan	15	3.92	3.84	3.78	3.85	5.03	4.89	4.86	4.93	0.67	0.64	0.59	0.63
	30	4.05	3.94	3.86	3.95	5.86	5.41	5.12	5.46	0.69	0.65	0.63	0.66
	45	4.09	3.98	3.94	400	6.04	5.63	5.27	5.65	0.72	0.68	0.66	0.69
Mean		4.02	3.92	3.85	3.97	5.64	5.31	5.08	5.34	0.69	0.66	0.63	0.66

Chitosan foliar	**15**	**3.98**	**3.88**	**3.85**	**3.90**	**5.08**	**4.95**	**4.88**	**4.97**	**0.69**	**0.66**	**0.62**	**0.66**
	30	**4.06**	**3.94**	**3.90**	**3.97**	**5.93**	**5.77**	**5.22**	**5.64**	**0.72**	**0.69**	**0.65**	**0.69**
	45	**4.09**	**4.02**	**3.98**	**4.03**	**6.08**	**5.89**	**5.75**	**5.91**	**0.76**	**0.73**	**0.69**	**0.73**
Mean		**4.04**	**3.95**	**3.91**	**3.97**	**5.70**	**5.54**	**5.28**	**5.51**	**0.72**	**0.69**	**0.65**	**0.69**
Soaking of Silicate potassium	**15**	**3.95**	**3.89**	**3.86**	**3.90**	**5.13**	**5.04**	**4.96**	**5.04**	**0.72**	**0.68**	**0.64**	**0.68**
	30	**4.07**	**3.97**	**3.93**	**3.99**	**5.98**	**5.95**	**5.38**	**5.77**	**0.76**	**0.72**	**0.68**	**0.72**
	45	**4.12**	**4.05**	**3.98**	**4.05**	**6.12**	**5.98**	**5.79**	**5.96**	**0.78**	**0.74**	**0.72**	**0.75**
Mean		**4.05**	**3.97**	**3.92**	**3.98**	**5.74**	**5.66**	**5.38**	**5.59**	**0.75**	**0.71**	**0.68**	**0.72**
Foliar silicate potassium	**15**	**3.98**	**3.92**	**3.89**	**3.93**	**5.22**	**5.07**	**4.98**	**5.09**	**0.74**	**0.72**	**0.66**	**0.71**
	30	**4.13**	**4.04**	**3.96**	**4.04**	**6.14**	**6.01**	**5.44**	**5.86**	**0.78**	**0.74**	**0.71**	**0.74**
	45	**4.23**	**4.12**	**4.02**	**4.12**	**6.18**	**6.07**	**5.89**	**6.05**	**0.79**	**0.76**	**0.73**	**0.76**
Mean		**4.11**	**4.03**	**3.96**	**4.03**	**5.85**	**5.72**	**5.44**	**5.67**	**0.77**	**0.74**	**0.70**	**0.74**
LSD. 5 % methods		**ns**	**ns**	**ns**		**ns**	**ns**	**ns**		**ns**	**0.01**	**ns**	
LSD. 5 % N Rates		**ns**	**ns**	**ns**		**ns**	**0.52**	**ns**		**0.06**	**0.09**	**0.04**	
Interaction		**ns**	**ns**	**ns**		**ns**	**ns**	**ns**		**ns**	**	**ns**	

As well as, the effect methods application on Zn was significant under irrigation interval 15 days while the used mineral N different rates on Zn were significant under interval irrigation water different periods. The interaction between all treatments were no significant for Fe and Mn, while the Zn was significant under interval irrigation water at 15 days. On the other hand, the relative increases of mean values were 3.66, 6.16 and 4.76 % for Fe, Mn and Zn contents in soil respectively, as affected with soaking chitosan combined with different mineral N rates under interval irrigation water different periods compared mineral N fertilizers different rates. The highest mean values percentage were 3.66, 9.54 and 9.52 % for Fe, Mn and Zn contents in soil as affected by foliar application of chitosan combined with mineral N rates under interval irrigation water periods than mineral N different rats. The relative increases of mean values were 3.92, 11.13 and 14.29 % for Fe, Mn and Zn contents in soil as affected methods soaking potassium silicate combined with different mineral N rates under interval irrigation water different period compared mineral N different rates. Concerning, the relative increases of mean values available Fe, Mn and Zn contents in soil were 5.22, 12.72 and 17.46 % respectively as affected with chitosan foliar application methods combined with different rates of N rates compared mineral N different rates.

It is worthy to mention that the contents of all the available Fe, Mn and Zn in the studied soil at the highest rates of N, in generally within the sufficient limits of Fe Mn and Zn in the critical limits.

Effect of all treatments on cowpea productivity.

Morphology plant.

Data indicated in Table (5) the increase of plant height (cm), No. of pods/plant and No. of branches /plant with increasing mineral N combined with potassium silicate foliar application under irrigation intervals 10 days than other treatments. Also, the effect of methods application (soaking or foliar application) chitosan and potassium silicate on plant height (cm), No. of pods /plant and No. of branches /plant was significant under intervals irrigation water periods. The different rates of mineral N fertilizer application led to significant increase of plant height (cm), No. of pods/plant and No. of branches /plant. As well as, the interaction between all treatments were significant increase of plant height (cm), No. of pods/plant and No. of branches /plant. The relative increases of mean values were 27.43, 45.82 and 26.39 % for plant height (cm), No. of pods/plant and No. of branches /plant respectively as treated with soaking chitosan combined with mineral N fertilizer at different rates under intervals irrigation water periods comparedmineral N different rates. The highest mean values of plant height (cm), No. of pods/plant and No. of branches /plant were 32.37, 58.17 and 37.34 % respectively, as affected with chitosan foliar application combined with mineral N different rates under irrigation water periods than with mineral N different rates. The relative increases of mean values plant height (cm), No. of pods/plant and No. of branches /plant were 35.60, 60.94 and 50.86 % respectively, as affected soaking potassium silicate combined with mineral N fertilizer different rates under intervals irrigation water periods compared with mineral N fertilizer different rates.

Table (5). Morphology of cowpea.

Treatments	N rates (kg/fed)	Plant height				No. of pods/ plant				No. of branches /plant			
		Irrigation water period (day)											
		10	15	20	Mean	10	15	20	Mean	10	15	20	Mean
Mineral	15	60.41	57.63	52.13	56.72	12.70	10.69	8.96	10.78	5.73	3.80	2.65	4.06
	30	66.23	59.32	56.34	60.63	14.69	13.65	10.33	12.89	6.33	4.10	3.55	4.66

	45	**69.21**	**64.21**	**62.14**	**65.19**	**17.63**	**15.95**	**12.65**	**15.41**	**7.22**	**4.85**	**3.70**	**5.26**
Mean		**65.28**	**60.39**	**56.87**	**60.85**	**15.01**	**13.43**	**10.65**	**13.03**	**6.43**	**4.25**	**3.30**	**4.66**
Soaking chitosan	**15**	**77.52**	**70.32**	**66.32**	**71.39**	**18.63**	**15.88**	**12.96**	**15.82**	**6.44**	**4.72**	**3.87**	**5.01**
	30	**88.32**	**76.32**	**69.25**	**77.96**	**22.36**	**19.36**	**15.67**	**19.13**	**7.90**	**5.88**	**4.55**	**6.11**
	45	**94.32**	**81.20**	**74.32**	**83.28**	**25.96**	**22.14**	**18.00**	**22.03**	**8.65**	**6.10**	**4.88**	**6.54**
Mean		**86.72**	**75.95**	**69.96**	**77.54**	**22.32**	**19.13**	**15.54**	**19.00**	**7.66**	**5.57**	**4.43**	**5.89**
Chitosan foliar	**15**	**85.32**	**73.65**	**68.32**	**75.76**	**19.52**	**17.85**	**15.63**	**17.67**	**7.66**	**5.23**	**4.10**	**5.66**
	30	**89.66**	**78.96**	**70.23**	**79.62**	**23.63**	**20.63**	**18.66**	**20.97**	**8.44**	**6.30**	**4.60**	**6.45**
	45	**98.32**	**84.32**	**76.14**	**86.26**	**25.22**	**23.45**	**20.88**	**23.18**	**9.20**	**6.88**	**7.09**	**7,09**
Mean		**91.10**	**78.98**	**71.56**	**80.55**	**22.79**	**20.64**	**18.39**	**20.61**	**8.43**	**6.14**	**4.63**	**6.40**
Soaking of Silicate potassium	**15**	**88.23**	**75.26**	**71.38**	**78.29**	**21.30**	**18.52**	**17.24**	**19.02**	**8.21**	**5.95**	**4.65**	**6.27**
	30	**92.17**	**80.46**	**73.00**	**81.88**	**25.31**	**19.47**	**18.32**	**21.03**	**9.63**	**6.75**	**5.10**	**7.16**
	45	**99.39**	**87.23**	**75.44**	**87.35**	**27.63**	**21.30**	**19.63**	**22.85**	**9.88**	**7.22**	**5.88**	**7.66**
Mean		**93.26**	**80.98**	**73.27**	**82.51**	**24.75**	**19.76**	**18.40**	**20.97**	**9.24**	**6.64**	**5.21**	**7.03**
Foliar silicate potassium	**15**	**92.14**	**79.32**	**73.14**	**81.52**	**22.36**	**19.65**	**18.55**	**20.19**	**8.96**	**6.12**	**5.10**	**6.73**
	30	**97.36**	**85.96**	**75.32**	**86.21**	**27.53**	**22.34**	**20.13**	**23.33**	**10.32**	**6.95**	**5.96**	**7.74**
	45	**110.16**	**88.12**	**77.96**	**92.08**	**28.13**	**25.49**	**20.55**	**24.72**	**12.63**	**7.88**	**6.20**	**8.90**
Mean		**99.89**	**84.47**	**75.47**	**86.61**	**26.01**	**22.49**	**19.74**	**22.75**	**10.64**	**6.98**	**5.75**	**7.79**
LSD. 5 % methods		**2.18**	**1.87**	**1.97**		**1.29**	**1.26**	**1.28**		**0.58**	**0.031**	**0.22**	
LSD. 5 % N Rates		**1.31**	**0.78**	**1.26**		**1.20**	**1.72**	**0.65**		**1.13**	**0.033**	**0.24**	
Interaction		***	***	***		***	***	***		***	***	***	

The relative increases of mean values were 42.33, 74.60 and 67.17 % for plant height (cm), No. of pods/plant and No. of branches /plant respectively, treated by foliar application of potassium silicate combined with mineral N different rates under interval irrigation water periods compared with mineral N fertilizer different rates. These results are in agreement by **Merwad (2018)** indicated that foliar potassium silicate concentration (500 mg/l) was increase of values of plant height, No. of Pods/plant and No. branches /plant. **Tatoura, et al (2021)** reported that the chitosan foliar application improvement of increasing flowers and pod number, plant length and branches /plant for cowpea.

The applications of K-silicate caused significant increases in plant height as well as leaf area of salinity stressed wheat plants at different growth stages as compared to those of the untreated stressed plants may be due to the enhancement effect of K -silicate could be attributed to activating antioxidant defense system or through their protective effect on the photosynthetic pigments in salt stressed plant.The potassium silicate solution sprayed on plants was significantly improved growth and mitotic index if compared to non-sprayed plants **(El-Hefnawy 2020).**

Yield component.

Data presented in Table (6) show that the increase of weight 100 seeds (g), weight pods (ton/fed) and seeds yield (ton/fed) with increasing mineral N fertilizer rate combined with potassium silicate foliar application under irrigation water interval 10 days compared with other treatments.

Table (6). Yield components of cowpea.

Treatments	N rates (kg/fed)	Weight of 100 seeds (g)				Weight of pods (ton/fed)				Weight of seeds yield (ton/fed)			
		Irrigation water period (day)											
		10	15	20	Mean	10	15	20	Mean	10	15	20	Mean
Mineral	15	9.50	8.10	7.65	9.42	1.110	1.080	1.026	1.07	0.950	0.910	0.887	0.92
	30	12.85	10.32	8.99	10.72	1.160	1.120	1.055	1.11	0.985	0.932	0.894	0.94
	45	13.64	11.85	10.42	11.97	1.185	1.175	1.095	1.15	1.035	0.943	0.899	0.96
Mean		12.00	10.09	9.02	10.37	1.15	1.13	1.06	1.11	0.99	0.93	0.89	0.94
Soaking chitosan	15	12.36	10.32	8.85	10.51	1.290	1.120	1.043	1.15	1.056	1.020	0.998	1.02
	30	15.32	14.36	11.36	13.68	1.298	1.157	1.089	1.18	1.145	1.066	1.032	1.08
	45	19.32	16.32	13.65	16.43	1.355	1.188	1.143	1.23	1.189	1.085	1.045	1.11
Mean		15.67	13.67	11.29	13.54	1.310	1.160	1.09	1.19	1.13	1.06	1.03	1.07
Chitosan foliar	15	18.32	14.96	10.52	14.60	1.356	1.175	1.089	1.21	1.125	1.045	0.990	1.05
	30	22.63	18.32	13.65	18.20	1.395	1.195	1.140	1.24	1.175	1.085	1.057	1.11
	45	25.47	20.65	15.82	20.65	1.425	1.210	1.185	1.27	1.210	1.094	1.068	1.12
Mean		22.14	17.98	13.33	17.82	1.39	1.19	1.14	1.24	1.17	1.07	1.04	1.09
Soaking of	15	16.32	15.85	13.65	15.27	2.100	1.892	1.723	1.91	1.590	1.260	1.150	1.33

Silicate potassium	**30**	**24.31**	**19.36**	**15.28**	**19.65**	**2.150**	**1.953**	**1.825**	**1.98**	**1.630**	**1.400**	**1.190**	**1.41**
	45	**28.96**	**21.69**	**16.34**	**22.33**	**2.175**	**2.048**	**1.850**	**2.02**	**1.720**	**1.560**	**1.210**	**1.50**
Mean		**23.20**	**18.97**	**15.09**	**19.08**	**2.14**	**1.96**	**1.80**	**1.97**	**1.65**	**1.41**	**1.18**	**1.41**
Foliar silicate potassium	**15**	**18.52**	**16.38**	**15.66**	**16.85**	**2.350**	**1.950**	**1.832**	**2.04**	**1.680**	**1.400**	**1.180**	**1.42**
	30	**27.64**	**22.13**	**17.32**	**22.36**	**2.389**	**2.090**	**1.944**	**2.14**	**1.820**	**1.580**	**1.230**	**1.54**
	45	**31.62**	**24.16**	**18.00**	**24.59**	**2.410**	**2.140**	**1.982**	**2.18**	**1.850**	**1.710**	**1.290**	**1.62**
Mean		**25.93**	**20.89**	**16.99**	**21.27**	**2.38**	**2.06**	**1.92**	**2.12**	**1.78**	**1.56**	**1.23**	**1.53**
LSD. 5 % methods		**2.00**	**1.55**	**1.38**		**0.24**	**ns**	**0.035**		**0.035**	**ns**	**ns**	
LSD. 5 % N Rates		**1.22**	**2.49**	**3.48**		**0.20**	**0.19**	**0.08**		**0.05**	**ns**	**ns**	
Interaction		*******	*******	*******		**ns**	**ns**	*******		*******	**ns**	**ns**	

The significant increase of weight 100 seeds (g) was affected different methods alone or mineral N fertilizer different rates and interaction under interval irrigation period. The methods application on yield of weight pods (ton/fed) was significant increase under interval irrigation water 10 and 20 days, while the effect of mineral N different rates on pod yield (ton/fed) was significant under irrigation water different periods. As well as, the interaction between all treatments were significant increase of pods yield (ton/fed) at 10 days period. The methods application or mineral N fertilizer different rates and interaction were significant increase of weight seeds yield (ton/fed) as affect interval irrigation water at 10 days while the interval at 15 and 20 days was no significant. On the other hand, the relative increases of mean values were 30.57 % for weight of 100 seeds (g), 7.21 % for weight of pods (ton/fed) and 13.83 % seeds yield (ton/fed) respectively, treated with chitosan soaking method combined by mineral N fertilizer different rates under different period irrigation water compared to mineral N different rates fertilizer. the relative increases of mean values were 71.84 % for weight of 100 seeds (g), 11.71 % for weight of pods (ton/fed) and 15.96 % seeds yield (ton/fed) respectively, treated with chitosan foliar application method combined by mineral N fertilizer different rates under different period irrigation water compared to mineral N different rates fertilizer. Also, the relative increases of mean values were 83.99, 77.48 and 50.00 % for weight of 100 seeds (g), weight of pods (ton/fed) and seeds yield (ton/fed) as affected with potassium silicate soaking method combined by mineral N different rates and irrigation periods compared with mineral N fertilizer different rates. As well as, the relative increases of mean values were 105.11, 90.99 and 6.77 % for weight 100 seeds, weight of pods (ton/fed) and weight seeds yield (ton/fed) respectively, treated by potassium silicate foliar application method combined by mineral N different rates and irrigation periods compared with mineral N fertilizer different rates. **Merwad (2018)** indicated that foliar potassium silicate was increase of values of 1000 seed weight (g), biological yield (kg/ha) and seed yield (kg/ha). **Farouk and Ramadaa (2012)** found that the foliar application of chitosan led to increased plant growth, yield and its quality as well as physiological constituents in plant shoot under stressed or non-stressed conditions as compared to untreated plants. **Geries et al 2020)** reported that the foliar application of chitosan was reduced the effects of abiotic stress on plants (like drought stress), by increase the key enzymes related to the closure of the plants stomata resulting in reduction of water loss.

Macronutrients concentration on seeds.

Data presented in Table (7) show that the increase of values N, P and K concentrations in seed were 4.16, 0.67 and 2.98 % respectively, treated with potassium silicate foliar application method combined by mineral N different rates under irrigation water at 10 days compared to other treatments. The significant increase of N concentration in seeds as effect of methods application and irrigation at 15 days while, the mineral N fertilizer different rates applied was significant increase of concentration for N in seed cowpea under interval irrigation water at 10- and 15-days periods. As well as, the interaction all treatments on N concentration in seeds were significant at 15 days interval irrigation water while the other treatments were no significant. Effect of all treatments and interaction on P concentration was significant. The methods application and mineral N different rates combined with on K concentration in seeds was significant for irrigation water at 15 and 20 days compared with 10 days. The relative increases of mean values N, P and K concentrations in seeds were 6.51, 25.71 and 20.45 % respectively for soaking chitosan method and 16.10, 46.71 and 27.84 % respectively for chitosan foliar application method combined with mineral N fertilizer different rats under irrigation water periods compared with mineral N different rates.

Table (7). Macronutrients concentrations in seeds of cowpea.

Treatments	N rates (kg/fed)	N (%)				P (%)				K (%)			
		Irrigation water period (day)											
		10	15	20	Mean	10	15	20	Mean	10	15	20	Mean
Mineral	**15**	**2.85**	**2.77**	**2.65**	**2.76**	**0.35**	**0.29**	**0.25**	**0.30**	**1.88**	**1.69**	**1.55**	**1.17**

	30	**3.04**	**2.95**	**2.83**	**2.94**	**0.42**	**0.34**	**0.33**	**0.36**	**1.88**	**1.75**	**1.60**	**1.74**
	45	**3.15**	**3.04**	**2.98**	**3.06**	**0.44**	**0.39**	**0.36**	**0.40**	**1.95**	**1.83**	**1.69**	**1.82**
Mean		**3.01**	**2.92**	**2.82**	**2.92**	**0.40**	**0.34**	**0.31**	**0.35**	**1.90**	**1.76**	**1.61**	**1.76**
Soaking chitosan	**15**	**3.05**	**2.95**	**2.80**	**2.93**	**0.40**	**0.38**	**0.33**	**0.37**	**2.13**	**1.98**	**1.95**	**2.02**
	30	**3.22**	**3.14**	**2.99**	**3.12**	**0.49**	**0.46**	**0.39**	**0.45**	**2.22**	**2.10**	**2.05**	**2.12**
	45	**3.48**	**3.25**	**3.15**	**3.29**	**0.55**	**0.52**	**0.46**	**0.51**	**2.35**	**2.18**	**2.14**	**2.22**
Mean		**3.25**	**3.11**	**2.98**	**3.11**	**0.48**	**0.45**	**0.39**	**0.44**	**2.23**	**2.09**	**2.05**	**2.12**
Chitosan foliar	**15**	**3.25**	**3.14**	**3.10**	**3.16**	**0.52**	**0.44**	**0.39**	**0.45**	**2.25**	**2.15**	**2.07**	**2.16**
	30	**3.55**	**3.35**	**3.24**	**3.38**	**0.58**	**0.51**	**0.45**	**0.51**	**2.38**	**2.27**	**2.15**	**2.27**
	45	**3.84**	**3.55**	**3.46**	**3.62**	**0.63**	**0.58**	**0.53**	**0.58**	**2.43**	**2.35**	**2.23**	**2.34**
Mean		**3.55**	**3.35**	**3.27**	**3.39**	**0.58**	**0.51**	**0.46**	**0.51**	**2.35**	**2.26**	**2.15**	**2.25**
Soaking of Silicate potassium	**15**	**3.65**	**3.29**	**3.14**	**3.36**	**0.56**	**0.48**	**0.44**	**0.49**	**2.50**	**2.29**	**2.18**	**2.32**
	30	**3.89**	**3.48**	**3.26**	**3.54**	**0.62**	**0.53**	**0.47**	**0.54**	**2.56**	**2.37**	**2.26**	**2.40**
	45	**3.95**	**3.56**	**3.42**	**3.64**	**0.64**	**0.58**	**0.51**	**0.58**	**2.59**	**2.42**	**2.33**	**2.45**
Mean		**3.83**	**3.44**	**3.27**	**3.52**	**0.61**	**0.53**	**0.47**	**0.54**	**2.55**	**2.36**	**2.26**	**2.39**
Foliar silicate potassium	**15**	**3.88**	**3.38**	**3.22**	**3.49**	**0.60**	**0.52**	**0.48**	**0.53**	**2.84**	**2.46**	**2.40**	**2.57**
	30	**4.12**	**3.55**	**3.40**	**3.69**	**0.65**	**0.58**	**0.51**	**0.58**	**2.93**	**2.64**	**2.55**	**2.71**
	45	**4.16**	**3.61**	**3.57**	**3.78**	**0.67**	**0.62**	**0.55**	**0.61**	**2.98**	**2.66**	**2.59**	**2.74**
Mean		**4.05**	**3.51**	**3.40**	**3.65**	**0.64**	**0.57**	**0.51**	**0.58**	**2.92**	**2.59**	**2.51**	**2.67**
LSD. 5 % methods		**ns**	**0.14**	**ns**		**0.0015**	**0.009**	**0.015**		**ns**	**0.035**	**0.098**	
LSD. 5 % N Rates		**0.02**	**0.15**	**ns**		**0.009**	**0.020**	**0.011**		**ns**	**0.031**	**0.066**	
Interaction		**ns**	*****	**ns**		*******	*******	*******		**ns**	*******	*****	

The relative increases of mean values were 20.55 , 54.29 and 35.80 % for N, P and K concentrations in seeds of treated by potassium silicate soaking method and 25.00 , 65.71 and 51.70 % for N, P and K concentration in seeds for foliar application potassium silicate combined with mineral N fertilizer different rates under irrigation water periods compared with mineral N different rates. **Fouda et al (2022)** found that the potassium silicate (100 ppm) foliar application led to increase in the contents and uptake of macronutrients (N, P, and K), and their absorption in faba bean plants.

Micronutrients concentrations in seeds cowpea plant.

Data presented in Table (8) found that the increase of micronutrients (Fe, Mn and Zn (mg/kg) concentrations in seeds cowpea for plant treated with potassium silicate foliar application method combined with mineral N at rate 40 kg/fed as irrigated at 10 days than other treatments. The all treatments and interaction were significant increase for Mn and Zn concentrations in seeds, while the Fe was significant increase at irrigation water at 15 and 20 days and different rates mineral N fertilizer and periods irrigation water.

Table (8). Micronutrients concentrations in seeds of cowpea.

Treatments	N rates (kg/fed)	Fe (mg/kg)				Mn(mg/kg)				Zn (mg/kg)			
		Irrigation water period (day)											
		10	15	20	Mean	10	15	20	Mean	10	15	20	Mean
Mineral	15	63.52	55.96	52.63	57.37	35.21	27.62	22.19	28.34	25.96	22.69	20.99	23.21
	30	66.75	58.30	55.63	60.23	39.63	30.82	27.59	32.68	27.63	25.75	23.65	25.68
	45	72.32	63.40	60.41	65.23	41.30	34.69	32.31	36.10	35.41	34.15	28.10	32.55
Mean		67.53	59.22	56.22	60.99	38.71	31.04	27.36	32.37	29.67	27.53	24.25	27.15
Soaking chitosan	15	66.95	60.63	57.63	61.74	45.98	40.12	37.25	41.12	33.45	30.10	27.88	30.48
	30	73.24	65.77	62.85	67.29	52.43	43.49	40.10	45.34	36.85	34.12	30.69	33.89
	45	75.20	69.85	67.32	70.79	57.52	48.41	43.21	49.71	39.78	36.89	34.80	37.16
Mean		71.80	65.42	62.60	66.60	51.98	44.01	40.19	45.39	39.59	33.70	31.12	33.84
Chitosan foliar	15	72.95	70.14	65.89	69.66	55.85	50.20	41.63	49.23	36.95	33.90	30.84	33.90
	30	77.85	74.63	69.12	73.87	63.62	56.20	46.32	55.38	39.55	37.55	35.62	37.57
	45	83.65	79.63	73.24	78.84	65.32	58.63	51.88	58.61	45.21	41.20	39.75	42.05
Mean		78.15	74.80	69.42	74.12	61.60	55.01	46.61	54.41	40.57	37.55	35.40	37.84
Soaking of Silicate potassium	15	76.32	72.41	68.10	72.28	62.16	53.48	46.75	54.13	39.85	36.52	34.16	36.84
	30	79.61	74.23	70.36	74.73	64.21	56.89	50.14	57.08	42.16	39.82	36.52	39.50
	45	85.63	82.14	77.10	81.62	71.32	65.46	54.89	63.89	49.32	42.15	39.85	43.77
Mean		80.52	76.26	71.85	76.21	65.90	58.61	50.59	58.57	43.78	39.50	36.84	40.04
Foliar	15	78.32	74.12	70.32	74.25	65.98	55.12	48.21	56.44	41.30	38.49	36.66	38.82

silicate potassium	**30**	**83.45**	**75.36**	**72.19**	**77.00**	**66.84**	**58.47**	**50.41**	**58.57**	**44.55**	**42.10**	**38.59**	**41.75**
	45	**88.62**	**77.15**	**74.36**	**80.04**	**68.49**	**60.75**	**53.73**	**60.99**	**51.63**	**44.62**	**40.12**	**45.46**
Mean		**83.46**	**75.54**	**72.29**	**77.10**	**67.10**	**58.11**	**50.78**	**58.67**	**45.83**	**41.74**	**38.46**	**42.01**
LSD. 5 % treatments		**ns**	**1.34**	**1.76**		**1.98**	**1.31**	**1.69**		**1.32**	**1.67**	**1.35**	
LSD. 5 % N Rates		**ns**	**0.59**	**0.95**		**1.36**	**0.43**	**1.60**		**2.64**	**1.83**	**0.94**	
Interaction		**ns**	*******	*******		*******	*******	*******		*******	*******	*******	

On the other hand, the relative increases of mean values were 9.20, 40.22 and 24.64 % for Fe , Mn and Zn respectively concentrations in seeds treated with chitosan soaking method and 21.53 , 68.09 and 39.37 % for Fe , Mn and Zn in seeds treated with foliar application chitosan method combined with mineral N fertilizer different rates under irrigation periods. Also, the relative increases of mean values Fe, Mn and Zn concentrations in seeds as affected with potassium silicate soaking method were 24.95, 80.94 and 47.48 % respectively and 16.41, 81.25 and 54.73 % for Fe, Mn and Zn concentrations in seeds treated with potassium silicate foliar application combined with mineral N different rates fertilizer under irrigation water periods. These result are in agreement by **Fouda et al (2022)** found that the potassium silicate foliar application led to increase in the contents and uptake of micronutrients (Fe, Mn, Zn) and their absorption infaba bean plants.

Conclusion

The study recommends foliar application of potassium silicate combined with mineral N fertilizer at rate 40 kg/fed under irrigation water interval 10 days was improve soil pH, soil salinity and increase of macro-micronutrients available contents in soil as well as, increase macro-micronutrients concentrations in seeds and growth and yield cowpea compared other treatments.

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