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Using Nano-Compounds to Increase Growth, Productivity and Quality of Giza 96 Cotton Variety

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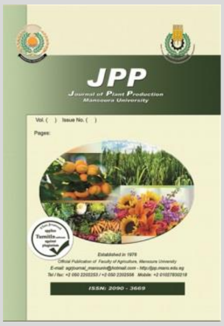

ABSTRACT

Two field experiments were carried out in Sakha Agricultural Research Station at Kafr El-Sheikh Governorate, Egypt, during the growing seasons 2018 and 2019 to study the effect of some Nano-fertilizers and its concentrations on growth, yield and its components and fiber quality of cotton to Giza 96 cotton variety belonging to (*Gossypium barbadense*, L) to increasing productivity and decreasing insect infestation.. The experiment design was a split- plot with four replications. The main plots involved the nano Nano. Compounds (Nano- Silica, Nano- Iron, Nano-Copper and Nano-Zinc) and the sub plots involved three concentration (250, 500 and 1000 ppm). Foliar spraying three times (at squaring, initiation of flowering and two weeks after flowering). The obtained results were as follows: Nano-fertilizers and fertilizer concentrations and their interaction had significant effect on plant height, no. of fruiting branches /plant, first fruiting node, no. of open bolls/plant, boll weight, seed index and seed cotton yield/fed. but gave insignificant effect on lint %, fiber parameters (upper half mean length, uniformity index, fiber strength and micronaire reading). Spring Nano-Si significantly increased plant height, no. of fruiting branches /plant, no.of bolls/plant, boll weight, seed index and seed cotton yield/fed. as compared with the other Nano- fertilizers (Fe, Cu and Zn). The high concentration of Nano-fertilizers 1000 ppm gave the good values of growth and yield and yield components compared with the other concentrations. Spring Nano-Si with the high fertilizer concentration 1000 ppm interaction gave the good values of growth and yield compared with the other interactions. It could be concluded that sparing Nano Si with high concentration 1000 ppm three times at squaring, initiation of flowering and two weeks after flowering gave high productivity of cotton variety Giza 96 under the conditions of Kafr El-Sheikh Governorate.

Keywords: Cotton, Nano- compounds, Growth, Yield, Earliness and Fiber Quality**.**

INTRODUCTION

Nanotechnology is the science of small things less than 100 Nano meter in size. It is the exploration of properties of materials at Nano scale. Nanotechnology is being visualized as a rapidly evolving field that has potential to revolutionize agriculture and food systems and improve the conditions of the poor. It has potential to provide food security by enhancing crop production through precision farming, efficient utilization of water, protection against insects and diseases, providing new tools for molecular and cellular biology, new materials for pathogen detection and protection of the environment (Zheng, *et al.* 2005). Nanotechnology provide efficient means for application of agrochemicals thereby reducing amount of chemicals introduced into the environment. Applications of nanotechnology in agriculture starting from crop production, fertilizer, crop protection and crop improvement for quality and agronomic traits. Nanotechnology-based reorientation of agriculture can boost production of quality food (Razzaq, *et al.* 2016). Nanotechnology opens a large scope of novel application in the fields of biotechnology and agricultural industries, because nanoparticles have unique physicochemical properties, i.e. high surface area, high reactivity, tunable pore size and particle morphology (Siddiqui *et al.*, 2015). Nano-fertilizers are used recently as an alternative to conventional fertilizers for slow release and efficient use by plants. Zhao *et al.* (2003) found that cotton plants grown in elevated CO_2 had greater leaf area and higher leaf photosynthesis, non-structural carbohydrates, and total biomass than plants in ambient CO_2. Silicon (Si) has enhanced the growth development and yield of many plants. Silicon nutrition alleviate many a biotic stresses including physical stress like lodging, drought, radiation, high temperatures, freezing and chemical stress like salt, metal toxicity, nutrient imbalance and many others (Epstein, 1994). Silicon is not traditionally considered as an essential element in plants, it has beneficial effect on plant growth, improves plant resistance to biotic stresses such as disease and various abiotic stressors such as cold, heat, drought, salinity and heavy metals, and enhances photosynthesis. These

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effects have been recognized in a broad variety of plants species for their growth and yield (Liang *et al.*, 2007).

Silica nanoparticles (nano-SiO_2) have been used to deliver DNA and chemicals into plant and animal cells and tissues (Torney *et al.,* 2007). Nano-SiO_2 is used to produce effective fertilizers for crops and to minimize the loss of fertilizer through slow and controlled release, allowing for regulated, responsive, and timely delivery (Nair *et al.,* 2010). Nano-SiO_2 significantly enhances seed germination and seedling root growth (Bao-Shan *et al.,* 2004). Hamoda *et al.,* (2016) found that foliar spraying Lithovit- Nano fertilizer at the rate of 7.5 g/l in two times at 45 and 60 days after planting the cotton significantly increased No. of open bolls/plant, boll weight, seed cotton yield/plant, lint% and seed cotton yield/fed. Shallan, et *al.* (2016) showed that pretreatment of cotton plants under drought stress with nano-TiO_2 or nano-SiO_2 caused increasing of pigments content, total soluble sugars, total phenolics, total soluble proteins, total free amino acids, proline content, total reducing power, total antioxidant capacity and antioxidant enzyme activities and enhancement of yield characteristics. The optimum concentration of nano-TiO_2 and nano-SiO_2 to alleviate the drought stress in cotton plant was 50 ppm and 3200 ppm, respectively. Foliar application of nano-TiO_2 or nano-SiO_2 could improve the drought tolerance and productivity of cotton. Mattson and Leatherwood (2010) observed the formation of a coating on the leaves after spraying potassium silicate, suggesting that the formation of this “film” would strengthen the cuticle activity as a mechanical barrier to pathogen penetration. Almeida *et al.,* (2005) found that silicon fertilizer increased the no. of cotton bolls and weight of bolls. The accumulation of silicon in transpiration organs causes the formation of a circular silica layer which, due to its thickness, is believed to promote the reduction in transpiration and result in a decrease in water demand by the plant. Kumar (2011) reported that Nano fertilizers have emerged as an alternative to conventional fertilizers for slow release and efficient use of water and fertilizers by plants. Micronutrients (Fe, Cu, Zn ,…) have positive environmental impacts through increasing the use efficiency of macronutrients, Malakouti, (2006). Thus, micronutrients are a critical component of balanced plant fertilization management necessary for increasing and sustaining future crop production, Dell *et al*. (2006). Among micronutrients, boron and zinc are of particular importance for cotton, and adequate supply of both to cotton can be of significant economic importance, Alloway (2008). Several workers documented favorable responses of cotton growth and productivity to foliar feeding with Zn, El-Menshawi and El-sayed (2007). Therefore, the main purpose of this study was to investigate the effect of some Nano-fertilizers and its concentrations on growth, yield and its components and fiber quality of cotton to Giza 96 cotton variety.

MATERIALS AND METHODS

Two field experiments were carried out in Sakha Agricultural Research Station at Kafr El-Sheikh Governorate, Egypt, during the growing seasons 2018 and 2019 to study the response of cotton plant to application of some nano-compounds to increasing growth, yield and yield components and fiber quality of Giza 96 cotton cultivar belonging to (*Gossypium barbadense*, L). Characterized Giza 96 variety showed in Table (1). The experimental design was a split- plot with four replications. The main plots involved the Nano- fertilizers (Silica (Si), Iron (Fe), Copper (Cu) and Zinc (Zn)) and the sub plots included three concentrations (250 ppm, 500 ppm and 1000 ppm for every compound). Foliar spraying three times (at squaring, initiation of flowering and two weeks after flowering).

Table 1. Characterized the Giza 96 variety.

Genotype name	**Giza 96**
Species	Barbadense.
Category	Extra long staple and extra fine.
Pedigree	{Giza 84 x (Giza70 x Giza 51B)} x C62
Characteristics	Extra long staple variety characterized by high yielding, earliness, resistance to Fusarium wilt, high lint percentage (%) about 38%.
Botanical distinguishing characters	The stem has a length with resistance to lodging and also has a green color mixed by dim red with internodes length ranged from short to medium. The leaves have navicular shape; medium size with medium lobes and leather feel. The node of the first fruiting branch ranged from 7-8, the axillaries buds will activate to give a fruiting branch which ended with one or two bolls. Flower petals has shape like a tubular, the petals is rolling. The boll shape is conical shape with shoulder and many glands. Seed is medium-sized and the fuzz cover about 1/4 to 1/2 from the whole size and fuzz color is gray-greenish.
Hybrid bred by	Breeding Res. Section, Cotton Res. Inst., Agric. Res. Center, Giza, Egypt.

The sub-plot size was 19.5 m^2 including six rows (5 m long and 0.65 m width). Cottonseeds were sown after two cuts of Egyptian clover Barseem (*Trifolium alexandrinum* L.,) in 2018 and 2019 seasons. Soil samples was taken in the two seasons before planting cotton to estimate the soil characters using the standard methods as described by Chapman and Parker (1981). The results are shown in Table (3).

Table 3. Mechanical and chemical analysis of the experiment soil in 2015 and 2016 seasons.

Season	Texture	pH	Organic Matter (%)	EC (m mhos/cm)	Bicarbonate (%)	Available elements (ppm)		
						N	P	K
2018	**Clay loam**	8.11	1.69	0.69	2.21	25.62	17.61	232.0
2019	**Clay loam**	8.21	1.78	0.80	2.02	27.25	16.42	226.0

In both seasons, the soil texture was clay loam, low content of organic matter, low calcium carbonate and non-saline. The soils of the two seasons were low in total N, Extractable-P, and low to medium in available K. Hills were spaced at 30 cm within rows and seedlings were thinned at 2 plants/hill after 35 day from planting. Phosphorus fertilizer as ordinary superphosphate (15.5% P_2O_5) at the rate of 22.5 kg P2O5/fed. was incorporated during seed bed preparation. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) at the rate of 60 kg N/fed. was applied in two equal doses, immediately before the first and the second irrigations. Potassium fertilizer in the form of potassium sulphate (48% K2O) at the rate of 24 kg K2O/fed. was side-dressed in a single dose before the second irrigation. The other standard agricultural practices were followed throughout the two growing seasons. At harvesting, five representative hills (10 plants/sub-main plot) were taken at random from the inner ridges in order to study the following traits in both seasons; plant height at harvest (cm), number of fruiting branches/ plant, first fruiting node, number of open bolls/plant, boll weight (g), seed cotton yield /fed., lint percentage and seed index (g). The yield of seed cotton in kentars/fed. was estimated from the three inner ridges, (One kentar = 157.5 kg.). Samples of lint cotton under different treatments were tested at the laboratories of the Cotton Technology Research Division, Cotton Research Institute at Giza to determine fiber properties, under controlled conditions of 65% ± 2 of relative humidity and 21º ± 2 Cº temperature. Fiber length and uniformity index, fiber strength and Micronaire reading were determined on digital Fibrograph instrument 630, Pressley instrument and Micronaire instrument 675 respectively, according to A.S.T.M. (2012) at the C.R.I. laboratories. Analysis of variance of the obtained data of each season was performed. The measured variables were analysed by ANOVA using M Stat-C statistical package (Freed, 1991). Mean comparisons were done using least significant differences (L.S.D) method at 5% level ($P \leq 0.05$) of probability to compare differences between the means (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

1- Effect of Nano-fertilizers, fertilizer concentrations and its interactions on growth traits and first fruiting node of cotton.

The results of growth traits (plant height at harvest and no. of fruiting branches /plant) and first fruiting node as affected Nano-fertilizers, fertilizer concentrations and its interactions during 2018 and 2019 seasons are shown in Table (3).

Table 3. Cotton growth traits and first fruiting node as affected by Nano-fertilizers, fertilizer concentrations and its interactions during 2018 and 2019 seasons.

Treatments		Growth traits				First fruiting node	
		Plant height at harvest (cm)		No. of fruiting branches /plant			
Nano-Fertilizers (A)	**Fertilizer Concentrations(B)**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
	250ppm	139.33	140.00	12.93	12.93	6.80	7.07
Nano- Si	500ppm	142.33	143.33	13.90	13.56	6.50	6.70
	1000ppm	146.33	147.00	14.43	14.37	6.07	6.10
Mean		142.67	143.44	13.75	13.62	6.46	6.62
	250ppm	132.00	135.67	11.93	11.63	7.20	7.37
Nano- Fe	500ppm	136.00	138.00	12.43	12.13	6.97	7.13
	1000ppm	139.33	141.00	12.97	13.10	6.67	6.70
Mean		135.78	138.22	12.44	12.29	6.94	7.07
	250ppm	124.00	130.00	10.63	10.73	7.80	7.80
Nano- Cu	500ppm	128.00	132.00	11.10	11.07	7.33	7.43
	1000ppm	132.67	137.00	11.93	11.93	6.93	7.07
Mean		128.22	133.00	11.22	11.24	7.36	7.43
	250ppm	120.00	123.33	8.80	9.20	8.03	7.90
Nano- Zn	500ppm	122.00	127.00	9.73	9.63	7.40	7.70
	1000ppm	126.67	130.00	10.43	10.63	7.17	7.40
Mean		122.89	126.78	9.66	9.82	7.53	7.67
	250ppm	128.83	132.25	11.08	11.13	7.46	7.53
General mean of Fertilizer conc. (B)	500ppm	132.08	135.08	11.79	11.60	7.05	7.24
	1000ppm	136.25	138.75	12.44	12.51	6.70	6.80
	A	1.67	1.53	0.19	0.14	0.11	0.09
L.S.D. at 5%	B	1.03	1.10	0.13	0.15	0.12	0.10
	A x B	2.06	2.16	0.26	0.30	0.21	0.18

The data showed that Nano-fertilizers and fertilizer concentrations and its interaction had significant effect on plant height at harvest, number of fruiting branches /plant and first fruiting node in both seasons. Spring Nano-Si significantly increased plant height at harvest and number of fruiting branches /plant while decreasing first fruiting node in 2018 and 2019 seasons as compared with the other Nano- fertilizers (Fe, Cu and Zn). Similar results were obtained by Mattson and Leatherwood (2010) and Almeida *et al.,* (2005).

The high concentration of Nano-fertilizers 1000 ppm gave the good values of plant height at harvest at harvest, number of fruiting branches /plant and first fruiting node as compared with the other concentrations. Spring Nano-Si with the high concentration 1000 ppm gave the high values of plant height and number of fruiting branches /plant while decreasing first fruiting node in 2018 and 2019 seasons as compared with the other interactions

2- Effect of Nano-fertilizers, fertilizer concentrations and its interactions on yield and yield components of cotton.

The results of yield and its components as affected Nano-fertilizers, fertilizer concentrations and its interactions during 2018 and 2019 seasons are shown in Table (4). The data showed that Nano-fertilizers had significant effect on no. of open bolls/plant, boll weight, seed index and seed cotton yield/fed. but, insignificant effect on lint % in both seasons. Spring Nano-Si significantly increased number of bolls/plant, boll weight, seed index and seed cotton yield/fed. in 2018 and 2019 seasons as compared with the other Nano-fertilizers (Fe, Cu and Zn). While the lowest values of no. of bolls/plant, boll weight, seed index and seed cotton yield/fed. were obtained from sparing with Nano -Zn. Similar results were obtained by Almeida *et al.,* (2005). Madeiros *et al.,* (2005) found that the accumulation of silicon in transpiration organs causes the formation of a circular silica layer which, due to its thickness, is believed to promote the reduction in transpiration and result in a decrease in water demand by the plant and increasing growth and yield. Attia *et al*. (2016) and Hamoda *et al*. (2016) reported that using foliar CO_2 as a Nano fertilizer enhanced cotton leaves chemical composition and lead to increasing growth and yield in cotton.

Table 4. Cotton yield and yield components as affected by Nano-fertilizers, fertilizer concentrations and its interactions during 2018 and 2019 seasons.

Treatments		No. of open bolls/plant		Boll weight (g)		Seed index (g)		Lint percentage (%)		Seed cotton yield (Kentar/fed.)	
Nano-Fertilizers (A)	Fertilizer Concentrations (B)	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
	250ppm	15.40	16.80	2.10	2.00	9.85	9.91	38.30	38.45	7.07	7.30
Nano- Si	500ppm	16.90	17.30	2.26	2.30	9.96	9.95	38.50	38.54	8.47	8.30
	1000ppm	18.00	18.70	2.35	2.31	10.20	10.10	38.65	38.82	9.40	9.20
Mean		16.77	17.60	2.24	2.20	10.00	9.99	38.48	38.60	8.31	8.27
	250ppm	14.50	15.70	2.00	1.90	9.83	9.90	38.55	38.45	6.40	6.30
Nano- Fe	500ppm	15.00	16.30	2.10	2.01	9.90	9.95	38.62	38.71	6.80	7.06
	1000ppm	15.80	17.00	2.30	2.15	10.00	9.98	38.70	38.89	7.10	7.87
Mean		15.10	16.33	2.13	2.02	9.91	9.94	38.62	38.68	6.77	7.08
	250ppm	14.20	14.00	1.60	1.72	9.63	9.71	38.58	38.65	4.86	5.20
Nano- Cu	500ppm	14.70	14.70	1.70	1.80	9.75	9.75	38.61	38.76	5.30	5.93
	1000ppm	15.10	15.20	1.90	2.10	9.85	9.87	38.80	38.88	6.07	6.60
Mean		14.67	14.63	1.73	1.87	9.74	9.78	38.66	38.76	5.41	5.91
	250ppm	12.90	13.20	1.40	1.52	9.60	9.65	38.80	38.61	3.93	4.06
Nano- Zn	500ppm	13.10	13.40	1.60	1.57	9.68	9.73	38.90	38.79	4.23	4.60
	1000ppm	13.70	14.10	1.70	1.72	9.76	9.90	38.91	38.96	5.10	5.30
Mean		13.23	13.57	1.57	1.60	9.68	9.76	38.87	38.79	4.42	4.65
General mean	250ppm	14.25	14.93	1.78	1.79	9.73	9.79	38.56	38.54	5.57	5.72
of Fertilizer	500ppm	14.93	15.43	1.92	1.92	9.82	9.85	38.66	38.70	6.20	6.47
conc. (B)	1000ppm	15.65	16.25	2.06	2.10	10.00	9.96	38.77	38.89	6.90	7.20
	A	0.62	0.27	0.025	0.011	0.19	0.13	N.S	N.S	0.23	0.20
L.S.D. at 5%	B	0.25	0.36	0.012	0.010	0.13	0.14	N.S	N.S	0.17	0.13
	A x B	0.50	0.63	0.024	0.022	0.27	0.31	N.S	N.S	0.23	0.21

3-Effect of Nano-fertilizers, fertilizer concentrations and its interactions on fiber parameters of cotton.

The results of fiber parameters as affected by as affected Nano-fertilizers, concentrations and their interactions during 2018 and 2019 seasons are shown in Table (5). The data showed that Nano-fertilizers and concentrations and their interaction gave insignificant effect on fiber parameters under study (upper half mean length, uniformity index, fiber strength (Presley units) and micronaire reading) during 2018 and 2019 seasons.

Table 5. Cotton fiber parameters as affected by Nano - fertilizers, fertilizer concentrations and its interactions during 2018 and 2019 seasons.

Treatments		Upper half mean		Uniformity index		Fiber strength (Presley units)		Micronaire reading	
Nano-Fertilizers (A)	Fertilizer Concentrations (B)	2018	2019	2018	2019	2018	2019	2018	2019
	250ppm	36.36	36.21	87.57	87.81	12.15	11.70	4.20	4.10
Nano- Si	500ppm	36.55	36.62	87.68	87.96	12.23	11.92	4.13	4.23
	1000ppm	36.87	36.81	88.22	88.54	12.27	11.99	3.98	3.87
Mean		36.59	36.55	87.82	88.10	12.22	11.87	4.10	4.07
	250ppm	36.00	35.78	87.11	86.93	11.80	11.78	4.16	4.17
Nano- Fe	500ppm	36.42	36.30	88.24	87.91	11.88	11.96	4.12	4.07
	1000ppm	36.49	36.45	87.91	87.72	12.02	11.99	4.12	4.10
Mean		36.30	36.18	87.75	87.52	11.90	11.91	4.13	4.11
	250ppm	35.91	35.70	87.44	87.24	11.55	11.90	4.25	4.25
Nano- Cu	500ppm	36.21	35.53	87.11	86.90	11.63	11.91	4.22	4.27
	1000ppm	36.89	37.20	88.60	88.70	12.68	12.04	4.10	4.07
Mean		36.34	36.14	87.72	87.61	11.95	11.95	4.19	4.20
	250ppm	35.57	35.37	86.54	86.31	11.51	11.32	4.15	4.33
Nano- Zn	500ppm	35.52	34.65	86.10	86.65	11.47	11.52	4.13	4.27
	1000ppm	35.78	35.30	86.56	87.00	11.86	11.61	4.10	4.17
Mean		35.62	35.11	86.40	86.65	11.61	11.48	4.13	4.26
General mean of	250ppm	35.96	35.77	87.17	87.07	11.75	11.68	4.19	4.21
fertilizer conc.	500ppm	36.18	35.78	87.28	87.36	11.80	11.83	4.15	4.21
(B)	1000ppm	36.51	36.44	87.82	87.99	12.21	11.91	4.08	4.05
	A	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
L.S.D. at 5%	B	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	A x B	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

CONCLUSION

The results obtained in this study could lead us to a package of recommendations, which seemed to be useful for increasing the cotton yield production and the best fiber quality. It could be concluded the sparing Nano Si with high concentration 1000 ppm three times at squaring, initiation of flowering and two weeks after flowering gave high productivity of cotton variety Giza 96 under the conditions of Kafr El-Sheikh Governorate.

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استخدام مركبات النانو لزيادة نمو وانتاجية وجودة صنف القطن جيزه 96

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا، محافظة كفر الشيخ خلال موسمي النمو 2018 و 2019 وذلك بهدف دراسة تأثير أستخدام الأسمدة الحديثة النانو رشاً بتركيزات مختلفه علي النمو والمحصول ومكوناته وبعض صفات جودة التيلة لصنف القطن جيزه 96 حيث أجريت التجربة تحت تصميم القطع المنشقة مرة واحدة فى أربع مكررات حيث وضعت اسمدة النانو في القطع الرئيسية (نانو سليكات، نانو حديد، نانو نحاس و نانو ذنك) ووضعت تركيزات اسمدة النانو في القطع المنشقة (250 ، 500 و 1000جزء فى المليون). تم رش اسمدة النانو ثلاث مرات خلالى الموسم (عند الوسواس، بداية التزهير وبعد التزهير بأسبوعين) وتتلخص أهم النتائج المتحصل عليها فيما يلى: اثرت اسمدة النانو وتركيزات السماد والتفاعل بينهم على طول النبات، عدد الافرع الثمريه/النبات، عدد اللوز/النبات، وزن اللوزه، معامل البذرة ومحصول القطن الزهربالقنطار/الفدان بينما لم توثر معنويا على تصافى الحليج وصفات التيلة (الطول، معدل الانتظام، المتانه والنعومة) في كلا الموسمين.رش سماد النانو سليكات أدى لزيادة طول النبات، عدد الافرع الثمريه/النبات، عدد اللوز/النبات، وزن اللوزه، معامل البذرة ومحصول القطن الزهربالقنطار/الفدان في كلا الموسمين بالمقارنه ببقية اسمدة النانو (حديد – نحاس - زنك)أعطى التركيز العالى 1000 جزء فى المليون افضل القيم لصفات النمو والمحصول ومكوناته بالمقارنه ببقية التركيزات اعطى تفاعل رش النانو سليكات بالتركيز العالى 1000 جزء فى المليون اقضل القيم لصفات النمو والمحصول بالمقارنه ببقية التفاعلات من النتائج المتحصل عليها في هذه الدراسة فأنه يمكننا التوصية برش النانو سليكات بالتركيز العالى ثلاث مرات (عند ظهور الوسواس، بداية التزهير وبعد التزهير بأسبوعين) لزيادة إنتاجية وجودة محصول القطن للصنف جيزه 96 تحت ظروف منطقة كفر الشيخ.