Nano chitosan-N fertilizer affecting the growth and productivity of onion plants under sandy soil conditions

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ABSTRACT

Nano fertilizers have become a very important approach in agriculture research nowadays. In this paper we investigate the effect of chitosan nanoparticles loaded with nitrogen on onion plants using foliar application . Chitosan-N nanoparticles were easily applied to leaf surfaces and absorbed to take pathway to plant organs, avoiding direct interaction with soil systems. The levels of chitosan N 15% (0.5, 0.1 and 1.5 gm / L) were investigated. The results revealed that nano particles. Results showed significant differences among some characters comparing with the control The application of recommended dose of chemical nitrogen surpassed all treatments of chitosan or chitosan with nitrogen in growth characters and yield and its components .It is worth to note that application of chitosan with 15% nano nitrogen gradually increased most of the growth , yield and its attributes and chemical compassion of onion plants , where the maximum dose ChN[1] achieved the maximum values of all characters and recorded the second rank after application of recommended dose of nitrogen.

Key words: Chitosan, nano nitrogen, onion nitrogen fertilizer and growth and yield characters.

ملخص العربى :

أصبحت الأسمدة النانوية نهجًا مهمًا للغاية في البحوث الزراعية في الوقت الحاضر. في هذا البحث قمنا بدراسة تأثير جزيئات الشيتوزان النانوية المحملة بالنيتروجين على نباتات البصل باستخدام الرش الورقي. تم تطبيق جزيئات Chitosan-N النانوية بسهولة على أسطح الأوراق وتم امتصاصها لتأخذ المسار إلى الأعضاء النباتية ، وتجنب التفاعل المباشر مع أنظمة التربة. تم فحص مستويات الكيتوزان 5% N1 بتركيزات (0.5، 0.1، 1.5 جم / لتر

أظهرت النتائج وجود فروق معنوية بين بعض الصفات مقارنة بالمجموعة الضابطة. تفوق استخدام الجرعات الموصى بها من النيتروجين الكيميائي جميع معاملات الشيتوزان أو الشيتوزان بالنيتروجين في صفات النمو والمحصول ومكوناته ، وتجدر الإشارة إلى أن تطبيق الشيتوزان بنسبة 15٪ نانو زاد النيتروجين تدريجياً معظم النمو والمحصول وصفاته والتركيب الكيميائي لنبات البصل ، حيث حققت أقصى جرعة من ChN1 القيم القصوى لجميع الصفات وسجلت المرتبة الثانية بعد تطبيق الجرعة الموصى بها من النيتروجين.

الكلمات الدالة : شيتوسان ، نانو نيتروجين ، سماد نيتروجين ,البصل ، صفات النمو والمحصول.

INTRODUCTION

Chitosan is a natural polymer derived from deacetylation of chitin, which may be obtained from crustaceans, insects, fungi, etc. (Boonsongrit et al., 2006). A positive effect of chitosan has been observed on the growth of roots, shoots and leaves of various plants including gerbera (Wanichpongpan et al., 2001) and several crop plants (Chibu & Shibayama, 2001). However, Walker et al. (2004) conducted some trials on chitosan in organic and

conventional crops with variable results. While chitosan application resulted in yield increases of nearly 20% in two out of three tomato trials, no significant difference in yield of treatments in the organic carrot trial or in average weight of individual carrots was found. Walker et al. (2004) did not find either significant differences among cucumber, capsicum, beet-root or pea plants from any treatment; however, the chitosan foliar treatment had a tendency for greater yield than the other treatments.

Onion (Allium cepa L.) has an economic importance in Egypt. The total area of onion grown in Egypt was 183916 Fed according to The Egyptian Ministry of Agriculture (2014-2015) which produced onion bulb (3115842 ton) (FAO, 2016) with average 16.94 ton / fed and occupies the seventh place in the production of onion in world (FAO, 2016)

Fertilizers play an important role where the ancient chemical fertilizers are replaced with nano and bio fertilizers with their efficiency and environment friendly nature. Primary use of adding is fast uptake of nutrients from the soil and giving better, faster yield. The symbiotic exchange between soil and the plant system is very efficient. When fertilizers are in the form of encapsulated the same is applied in slow and efficient way all the required nutrients is taken up by the plant and restores the required and efficient energy in it for which the yield increases drastically and this can be achieved.

Main element Nitrogen is needed in abundant and uptake of this itself causes many problems to the plants. A different type of fertilizers for different crop problems is reviewed.

There are ways where N is being lost in the atmosphere, and those processes include volatization, denitrification, leaching, and run off. There is a error in applying this N fertilizer to the crop, in fact continuous applying of these to the pre plants will not benefit in optimum utilization of the entire amount added When the plants are harvested, they take away the nutrients which are present in the soil, therefore it is necessary to replace it by a readily available fertilizer to constantly make the nutrients available to the plants. The element required in abundant, nitrogen (N), is essential for plant growth and animal nutrition and is the nutrient taken up in largest amount by all plants. Source of nitrogen include ammonia, diammonium phosphate, ammonium nitrate, ammonium sulphate, calcium cyanamide, calcium nitrate, sodium nitrate and urea[5] Its widely used because it is easily available,rapid action. This element's role in the environment is complex [6]. When coming to Nitrogen fertilizers, slow release of the same will be plant beneficiary. This is because a farmer can fertilize less often by providing the nutrients slowly and steadily. There was an attempt to increase the uptake of

nitrogen with the application of 25 kg Mg Oha-1which increased the positive uptake [7

Nanotechnology is a science of manipulating materials at nano- scale. Among the latest technological advancements, nanotechnology occupies a central position. It has many applications in all stages of production, processing, storing, packaging and transportation of agricultural products. The term "nanomaterial" is based on the prefix "Nano" which originates from the Greek word meaning "dwarf", the word nano means 10-9 or one – billionths of a meter. A nanometer is only ten atoms across. The world nanomaterial is generally used for materials with a size ranging between 1 and 100 nm.

Most slow release fertilizers (SRF) are chemical compounds that are only slightly soluble in water or are slowly broken down by microbial action (Sartain et al., 2004). On the other hand, controlled-release fertilizers (CRF) are soluble fertilizers coated with materials that limit exposure of the soluble material to water and/or release of the resulting nutrient solution by diffusion. Thus, the rate of nutrient liberation from SRF is related to their water solubility, microbiological degradation, and chemical hydrolysis (Morgan et al., 2009).

Xiao et al. (2008) demonstrated that NO3--N leaching was decreased by applying SRF coated with nano-materials in a rotation of wheat-maize. Liu et al. (2009) indicated increases in grain yields of rice (10.29%), spring maize (10.93%), soybean (16.74%), winter wheat (28.81%) and vegetables (12.34-19.76%) after applying fertilizer together with nano-materials. As reported by Liu et al. (2007), nano-materials could promote germination and rooting early for rice seeds and seedings and the growth of rice at tillering stage was affected obviously by nano-composites. They indicated that the grain yield of rice and nitrogen agronomic utilization efficiency was increased after applying nano-carbon-incorporated SRF.

The objective of the present study was to examine the effects of nano chitosan-NPK application on growth and productivity responses of wheat plants grown on sandy soil.

Material and methods

This study was carried out at the farm of Environmental studies and research institute ,University of Sadat City , Menofiya Governorate, Egypt during the two successive seasons of 2017/2018 and 2018 / 2019.The aim of this study was to investigate the effect of nano particles of chitosan, with Nano nitrogen 15% comparing to the control or the recommended dose of nitrogen on growth, yield and quality of onion

The treatments were Control (without treatments), recommended dose of conventional chemical nitrogen 115 Kg N , chitosan with nano nitrogen 15% in three doses (0.5 g / L , 1.0 g /L and 1.5 g / L). The treatments were arranged in a complete randomized block design with three replications. The characterization of the compounds used in the experiment was carried out using transmission electron microscopy (TEM, JEOL, 100 CX, Japan) for nano chitosan, nano nitrogen as follows in Figs 1.

the effect of nano particles of chitosan and chitosan with 15% nano nitrogen and three levels of nanophosphors on growth , yield, quality and of onion

In November of both seasons, the field was cleaned, ploughed, leveled and divided into plots 10.5 m^2. Planting dates were 6 th and 3 th December in both growing seasons, respectively. One commercial onion cultivar was selected for this study, Allium cepa L. cv. Giza 20 which introduced from Field Crop Institute (A. R. C).

Soil application of 115 kg nitrogen (recommended dose), foliar spray with, chitosan with 15% nano nitrogen at 0.5 gm /L , 1.0 gm / L and 1.5 gm / L . Onion plants were sprayed three times during the growth period, after and 4 , 7 and 10 weeks for chitosan .

In both seasons, all cultural practices i.e., cultivations irrigation, fertilization and pest and diseases control were done according to the recommendations of the Egyptian Ministry of Agriculture.

Data recorded:

1. Vegetative growth characters: Random samples of five plants from each experimental sub plot were taken at flower initiation 90 day after transplanting and the following measurements were recorded:

1- Plant height: It was measured in cm from the highest point of the plant down to the soil surface.

2- Number of leaves / plant: All leaves were counted.

3- Plant fresh and dry weight: five plants were weighed and dried in an oven at 70°C for 48 to 72 hour until constant weight then the dry weight was calculated.

2 Total bulbs yield 1. Bulb yield (kg/plot): All bulbs of plot was harvested individually and then weighed after curing

2. Marketable bulb yield (%): It was calculated after exclusion of infected, double and injured bulbs from total yield than weighed.

3. Bulb yield (ton. /fed): It was calculated from bulb yield per plot.

4. Marketable bulb yield (ton. /fed.) : It was calculated fro Marketable bulb yield per plot.

5. Bulb dry matter content (%): Five bulbs were weighed and dried in an oven at 70°C for 48 to 72 hour until constant weight then the dry weight was calculated as:

Dry matter % = Dry weight X 100 / fresh weight

3. Physical characteristics of bulbs:

Harvesting was done on 8th, 5 th May in both seasons, respectively and the curing was done for two weeks.

1. Bulb length: It was measured in cm from the highest point of the bulb to the less point.

2. Bulb diameter: It was measured using Vernier caliber.

3. Bulb length/diameter ratio: It was calculated from the bulb length and diameter values.

4. Neck thickness: It was measured using Vernier caliber. III.1.3.4. Chemical Components:

1. Mineral content:- Mineral contents, i.e., nitrogen, phosphorus, potassium , calcium and copper were determined in dry matter of the leaves and bulbs. Potassium was determined by using Flam photometer, total nitrogen was determined according to Jackson, 1967. In addition Phosphorus contents of bulb onion and leaves were determined by Watanabe and Olsen (1965). .

2. Total carbohydrates: Total carbohydrates were determined calorimetrically according to enthrone method by Sadasivam and Manickam q

3. Protein content: - protein was determined according to the method described in A.O.A.C. (2007).

. Statistical analysis:

The data were subjected to proper statistical analysis of variance. The treatments means were compared by using the least significant differences (L.S.D.) test at 5% level of probability, F test was also followed to differentiate among means of studied characters as recommended by Snedecor and Cochran (1967) and by SAS 2006 Statistical analysis program, SAS User´s Guide: Statistics. SAS Institute Inc Editor, cary, NC.

Results and Discussion

Growth characters of onion: -

The data in Table (2) indicated that were significant differences among the the applied treatments for all studied characters. Application of chemical nitrogen at 115 k /fed achieved the maximum values for most growth traits i.e plant height , no. of leaves , total chlorophyll content , plant fresh weight , plant dry weight and bulb diameter while the maximum value of bulb length was obtained with control treatment and application of chitosan 15 % N produced the maximum neck thickness of onion , In the same time , increasing chitosan 15% nitrogen led to increase all growth characters , where gradually increasing were resulted by using 1.5 g chitosan 15% nano N / L in all studied traits except bulb length and neck thickness and took the second rank after application of recommended N 115 gk N/ fed

These result may be due to the application of a nano-engineered composite consisting of N which enhance the uptake and use of nutrients by grain crops (Jinghua, 2004). In addition, nano fertilizers will combine nano devices in order to synchronize the release of fertilizer-N with their uptake by crops, so preventing undesirable nutrient losses to soil, water and air via direct internalization by crops, and avoiding the interaction of nutrients with soil, microorganisms, water, and air (De Rosa et al., 2010).

Table (2): Effect of nano particles of chitosan, calcium and copper on

Characters / Treatment	plant height (cm)	No. of leaves/plant	Total Chlorophyll content (SPAD)	Plant fresh weight (g)	Plant dry weight (g)	Bulb lenghth(cm)	Bulb diameter (mm)	Bulb length / diameter ratio)	Neck thickness (mm)
Control.	55.33	7.37	73.77	101.10	10.63	6.82	7.27	0.94	1.17
Recommended N	73.33	7.33	86.43	110.03	14.33	7.13	8.60	0.85	1.19
Nano chitosan1	62.00	7.60	78.40	104.00	11.53	7.35	7.53	0.90	1.28
Nano chitosan2	68.67	7.83	82.47	106.40	11.63	7.09	7.73	0.90	1.18
Nano chitosan3 .	71.87	8.47	84.57	105.63	12.67	7.30	8.30	0.88	1.15
LSD at 0.05	1.02	NS	2.17	2.41	1.16	NS	0.86	0.03	NS

vegetative characters of onion and bulb physical characteristics during 2017/2018 and 2016/2017 seasons::

Results in Table (3) showed that for some characters, the treatments showed significant differences compared with control or application of conventional N fertilizer as a recommended dose except both of K% in bulb and total carbohydrate content in bulb . The application of nitrogen at 115 kg / fed followed by (nano chitosan with 15% nano N at the concentration 1.5 g/ L achieved the maximum values of all traits. While the control recorded the minimum values of the most characters of yield and its attributes as well as quality characters

Table (3): Effect of nano particles of chitosan on yield N,P,K in leaves, Carbohydrate and protein of onion during 2017/2018 and 2018/2019

Characters Treatment	Marketable bulb yield (%)	Bulb yield(Ton/fed.)	N leaves (%)	N bulb (%)	P leave (%)	P bulb(%)	K leaves (%)	K bulbs(%)	Total carbohydrates (bulbs) ppm q	Protein content (bulbs) ppm
Control.	96.13	12.61	1.85	1.37	0.35	0.27	2.34	1.24	0.42	9.53
Recommended N	98.27	18.89	2.98	1.92	2.58	0.30	1.41	1.16	0.41	11.27
Nano chitosan1	95.07	16.93	2.08	1.47	0.40	0.27	2.13	1.33	0.46	9.75
Nano chitosan2	94.50	17.30	2.42	1.52	0.40	0.29	2.04	1.33	0.41	19.83
Nano chitosan3 .	96.17	17..44	2.81	1.57	0.40	0.31	1.52	1.09	0.40	10.43
LSD at 0.05	2.53	1.06	0.05	0.04	0.42	NS	0.12	NS	NS	0.63

Yield and its attributes and quality characters of onion plants:-

Treatment of onion plants with either N normal fertilizer or nano composite N fertilizer led to significant progressive increase in all growth variables (marketable

bulb yield % , bulb yield ton / fed , bulb or leaves N% , bulb or leaves P% and protein bulb content), determined throughout the adult and reproductive growth and developmental stages.

At all experimental stages, the values of the different growth variables were higher in nanofertilizer-treated plants than in control , while the application of normal recommended N surpassed the other treatments , followed by the higher dose of nano 15 % N with chitosan (1.5 g /L) . It was very obvious that application of nano nitrogen achieved a very marketable increases comparing with control and reached a very closed values of most characters near the recommended nitrogen .

The present results concerning the increased growth variables of onion plants as influenced by foliar application of nano N nanoparticles, in particular at low concentration (1.5 g/ L), and grown on sandy soil can be explained on the basis that the sprayed nano composite-N nanoparticles may got absorbed through the stomata of onion leaves and be trans located in the plant. The selective uptake, biotransformation, and translocation of various nanoparticles by a model plant have been schematically represented (Dhoke *et al*., 2013). Nanoparticles have high reactivity because of more specific surface area, more density of reactive areas, or increased reactivity of these areas on the particle surfaces. These features in nano-scale simplify their absorption in plants (Dhoke *et al*., 2013). Mahmoodzadeh *et al*. (2013) reported that direct exposure of onion plants to specific types of nanoparticles cause significant increase in all growth variables determined at optimum concentrations of nano solution.

Lu *et al*. (2002), Lei *et al*. (2008) and Feizi *et al*. (2012) concluded that nanoparticles increased water absorption by the seeds; increased nitrate reeducates enzyme concentration; promoted seed antioxidant system; reduced antioxidant stress by reducing H_2O_2, superoxide radicals, and malonyldialdehyde content; and increased some enzymes such as superoxide dismutase, ascorbate peroxidase, guaiacol peroxidase and catalase activities, which improved seed germination in some plant species.

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