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Effect of Mineral (NPK) Rates and Injection with Nano NPK on Growth, Yield and Quality of Onion

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Abstract

This experiment was carried out at the Experimental Farm of Shandaweel Agricultural Research Station, Sohag, (ARC), during 2018/2019 and 2019/2020 seasons, to study the effect of nano fertilizers through injection on growth, yield and quality of onion Giza 6 Mohassan cultivar under Sohag conditions. Four different mineral (NPK) treatments (100% NPK, 75% NPK, 50% NPK and 25% NPK) and four different injections with nano NPK [(control (treatment without injection), 5, 10, and 15 L fed.$^{-1}$ in addation to the control treatment (without injection) were applied. The experiment was conducted in split plot design with three replicates. The different mineral NPK treatments were arranged in the main plot and the different injection with nano NPK treatments were assigned to sub plots. The results showed that both of the mineral NPK rates and the injection onion with nano NPK rates significantly affected most of studied traits, in the both seasons. The interaction between the two studied factors, significantly affected both total and exportable bulb yield traits in two seasons. The injection with the nano NPK rate (10 L fed.$^{-1}$) and the mineral NPK (75% NPK and 100% NPK) achieved the highest values of total bulb yield (21.99 and 21.85) ton fed.$^{-1}$. in the first and second season, respectively. While, the treatment without injection (control treatment) with the lowest mineral NPK (25% NPK) gave the lowest values of total bulb yield (14.06 and 12.75) ton fed.$^{-}$ in the first and second season, respectively. The injection with the nano NPK rate (15 L fed.$^{-1}$ and 10 L fed.$^{-1}$) achieved the highest values of exportable bulb yield (18.51 and 18.56) ton fed.$^{-1}$ in the first and second season, respectively. Therefore, the results of this study recommend the use of mineral NPK combined with nano NPK as soil injection (75% mineral NPK + 10L fed.$^{-1}$ nano NPK), to increase the total and exportale yield of onion, reduce environmental pollution by providing a quarter of the recommended amount of chemical fertilizers and saving hard currency by reducing the import of chemical fertilizers.

Keywords:
Onion ,Dry matter,TSS,Marketable yield, Fertilization, Injection

INTRODUCTION

Onion (*Allium cepa* L.) is considered one of the most important crops in Egypt for local consumption, processing and exportation. onion is one of the most variable species of plants. Onion production in Egypt was approximately 3.08 million tons, produced from the harvested area of 209316.24 fed., in 2019 (FAOSTAT, 2020). In Sohag Governorate the total cultivated area of onion was 19825 fed.$^{-1}$ (Ministry of Agriculture and Land Reclamation, 2021). Because of the importance of the onion crop, farmers have adopted the strategy of increasing crop yields by applying large amounts of chemical fertilizers and pesticides. At present, however, the negative effects of heavy applications of chemical inputs, in terms of production, environment, and quality deterioration are becoming apparent (Nishio, 1996). In addition, the nutrient use efficiencies of conventional fertilizers hardly exceed 30 - 35 %, 18 – 20 %, and 35 - 40 % for N, P and K, respectively which remained constant for the past several decades. (FAO / WHO, 2010). Scenario, Very less concentration reaches the targeted site due to leaching of chemicals, drift, runoff, evaporation hydrolysis by soil moisture, and photolytic and microbial degradation. It has been estimated that around 40–70 % of nitrogen, 80–90 % of phosphorus, and 50–90 % of potassium content of applied fertilizers is lost in the environment and could not reach the plant which causes sustainable and economic losses (Trenkel, 1997) or become unavailable for crops. It is not only causes major economic and resource loss but also is responsible for serious environmental pollution (Guo *et al*., 2005). To overcome the problem of fertilizers and their excessive use and their environomental pollution, a lot of methods have been made. Among them: the use of slow-release nano fertilizer. Nano fertilizer, which is the most important field in agriculture, has attracted the attention of soil scientists as well as ecologists due to its ability to increase yield, improve soil fertility, reduce pollution and create a favorable environment for microorganisms (Ahmed *et al*., 2012) and has been compared to regular chemical fertilizers (Rajonee *et al*., 2017). Nano-fertilizers are intended to improve nutrient use efficiencies by exploiting the unique properties of nanoparticles. (FAO/WHO, 2010) Nano-fertilizers are known to release nutrients slowly and steadily for more than 30 days, which may assist in, improving the nutrient use efficiency without any associated ill effects. Since the nano-fertilizers are designed to deliver slowly over a long period of time (Rahale, 2010). Nano-fertilizers are essential to reduce the use of inorganic fertilizers and reduce their negative effects on the environment. Nano-fertilizers are more reactive and can penetrate the epidermis allowing for gradual release, targeted distribution, and thus reducing nutrients surplus, enhancing nutrient use efficiency, and the function of NPs in alleviating the negative effects of abiotic stress and heavy metal toxicity El-Saadony *et al*., (2021). The impacts of climate change on agriculture are expected to be negative, threatening global food security. also, agriculture and global food security will be severely affected due to the COVID-19 pandemics as its after-effects are yet to be ascertained. The world needs an introduction of a new "Green revolution" in agriculture to increase crop production for food security and biofuel because conventional breeding methods have not brought much of gains not keeping pace with the world population growth Thapa and Bhusal (2020). With the increasing population pressure on land for cultivation, one way to boost production, and increase the area of arable land is to increase per hectare productivity the other alternative is to improve the land productivity plus onion is the most profitable cropping system, but the yield of crops is far below their potential yield. Therefore, there is an urgent need to boost the yields of crops through nutrient management.

In the light of the above, the present study was undertaken to study the Effect of injection with nano NPK to reduce chemical NPK levels and improve yield, yield components and quality of onion.

MATERIALS AND METHODS

This experiment was carried out at the Experimental Farm of Shandaweel Agricultural Research Station, Sohag, (ARC), during 2018/2019 and 2019/2020 seasons, to study the effect of mineral NPK and injection with nano NPK on the yield, and quality of onion. The onion cultivar Giza 6 Mohassan was used in the study. Seeds of Giza

6 Mohassan cultivar were sown in the nursery on 1st and 5th September in the first and second seasons, respectively. The nursery was fertilized with 60 kg N fed.$^{-1}$ as ammonium nitrate (33.5% N), 15 kg P_2O_5 fed.$^{-1}$ as a super phosphate (15.5% P_2O_5) and 25 kg K_2O fed.$^{-1}$ as potassium sulphate (50% K_2O). Transplanting took place on 5th November during the two seasons of both experiments. The experimental plot size was 10.5 m^2 (3.5 m length and 3 m in width) included five ridges with 60 cm a part between ridges, ridging directions was north-south (NS). Planting was done on both sides of the ridge at 7 cm between plants. Super-phosphate (15.5% P_2O_5) was applied during the soil preparation, while potassium sulphate (50% K_2O) and ammonium nitrate (33.5% N) were applied at two equal doses, after one and two months from transplanting. The recommended doses of NPK fertilization were 120 kg N + 45 kg P_2O_5 + 50 kg K_2O. Nano NPK fertilizer (20-20-20 NPK) was introduced from nanoway technology company, Egypt. Nano NPK fertilizer was injected with the irrigation water with rates of (0, 5, 10 and 15 L fed.$^{-1}$), after 30 and 60 days from transplanting. The chemical ingredients of nano NPK fertilizer are (20 % Total Nitrogen (N): 20% Available Phosphate (P_2O_5: 20 % Soluble Potash (K_2O). The other normal agricultural practices of onion were applied at the recommended level. The soil of the experiment area was clay loam in texture. The preceding summer crop was sorghum in the two seasons. The mechanical and chemical analyses for the soil of the experimental sites (Table 1) were done according to the procedures described by Piper (1950) and Jackson (1967) at the Soil and Water Lab. of Agricultural Research Center (ARC).

Four different mineral (NPK) treatments (100% NPK, 75% NPK, 50% NPK and 25% NPK) and four different injections with nano NPK treatments As mentioned previoul in abstract 5, 10, 15 L fed.$^{-1}$] were used. The experiment was conducted in split plot design with three replicates. The different mineral NPK treatments were arranged in the main plot and the different injection with nano NPK treatments were assigned to sub plots.

Table 1. The mechanical and chemical analysis for the soil of the experimental sites.

Determination		Season	
		2018/2019	**2019/2020**
Mechanical analysis	**Clay**	30.40	32.06
	Silt	40.53	41.00
	Sand	29.07	26.94
	Textural class	**Clay loam**	**Clay loam**
Chemical analysis	pH	7.8	7.7
	EC (m. mhos/cm.)	0.84	0.73
	Organic matter %	1.53	1.60
	Available N ppm	18.20	20.00
	Available P ppm	9.6	9.00
	Available K ppm	273	257
Cations (meq/100g)	Ca	7.00	6.59
	Mg	2.9	2.38
	Na	1.50	1.58
	K	0.24	0.33
Anion (meq/100g)	Co3	0.00	0.00
	Hco3	2.8	2.5
	So4	5.5	5.3
	Cl	3.3	3.08
Available nutrients (ppm)	Fe	10	9.4
	Cu	0.47	0.45
	Zn	1.77	1.56
	Mn	1.00	1.01

Data recorded
Ten guarded plants were randomly chosen from each plot, two plants from each line at 120 days after transplanting (DAT). The following data were recorded**:**

A. Vegetative growth traits
A.1. Plant height (cm)
It was measured from the base of swelling sheath to the top of the longest tubular blades**.**

A.2. Number.of leaves plant^{-1}
It was calculated as the average number of functioning leaves per plant

A.3. Bulbing ratio

It was calculated according to the following equation according to Mann (1952).

$$\textbf{Bulbing ratio} = \frac{\textbf{Neck diameter}}{\textbf{Bulb diameter}}$$

B. Total bulb yield and its components
At the time of the harvest, all the plants in each plot were harvested then the plants were cured for 15 days under the normal field conditions. For each plot, dried leaves and roots were removed and bulbs having 2 cm length of the dry leaves were considered and assorted into marketable and unmarketable bulbs. The following yield parameters were recorded:
B.1. Bulb weight (g)
It was calculated by dividing weight of single bulbs by its number.

B.2. Total yield (t fed.$^{-1}$)
It was calculated on basis of yield for the experimental plot in tons fed.$^{-1}$.

B.3. Exportable bulbs yield (t fed.$^{-1}$)
It was determined as the weight of single bulbs yield equal or more than 3.5 cm in diameter for each experimental plot.

C. Bulb quality
C.1. Dry matter (D.M.%)
It was determined by estimating the loss in sample of bulbs fresh weight after drying for four hours at 105^{o}C and then at 70^{o}C in a drying oven, according to the following formula:

$$\textbf{D.M.\%} = \frac{\textbf{Sample dry weight}}{\textbf{Sample fresh weight}} \times \textbf{100}$$

C.2. Total soluble solids (TSS%)
It was determined immediately after harvest by a hand refractometer in representative sample of ten bulbs according to A.O.A.C. (1975).

Statistical analysis
All data collected were subjected to analysis of variance according to Snedecor and Cochran (1967). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

A. Vegetative growth characteristics
A. 1. Plant Height (cm)
Data in Table (2 A) clearly showed that the mineral NPK rates significantly affected plant height (cm) in both seasons. The highest mineral NPK rate (100% NPK) gave the highest values (88.58 and 89.86 cm) for this trait in the first and second season, respectivelly. While the lowest mineral NPK rate (25% NPK) recorded the lowest values (83.08 and 85.86 cm) for this trait in the first and second season, respectivelly. Similar results were stated by Bekele (2018); Jilani *et al.,* (2019); Krestini *et al.,* (2020) and Kadam *et al.,* (2020) who cleared that onion plant height significantly increased under addition of 120% recommended dose of NPK. The probable reason for higher plant height could be due to increased rates of nitrogen addition, which is playing a significant role in building block of amino acids, enhancing cell division, cell elongation, chlorophyll synthesis, and protein synthesis which promote the growth of onion plants.
Concerning injection onion with nano NPK, data illustrated in Table (2 A) revealed that injection rates with nano NPK significantly affected plant height in both seasons. The highest values for this trait (88.06 and 92.22 cm) were produced by the highest injection rate with nano NPK (15L fed.$^{-1}$) in the first and second season, respectively. While, the lowest values for this trait (81.30 and 83.86 cm) were obtained from control treatment in the first and second season, respectively. These results were in agreement with that found by Fattahi *et al.,* (2018) and Mahmoud and Swaefy (2020) who reported that onion plant height significantly increased as

nitrogen fertilizer rates increased. The smaller size, the higher specific surface area and the reactivity of nanofertilizers may affect nutrient solubility, diffusion and hence availability to plants (Singh *et al.*, 2013).

Regarding the interaction between the two studied factors, data in Table (2 A) showed that the interaction significantly affected this trait in both seasons. Injection with the highest Nano NPK at rate (15L fed.$^{-1}$) with the highest (100% NPK) or the lowest (25% NPK) mineral NPK rates achieved the highest values (92.45 and 92.78 cm) in the first and second season, respectively. While the control treatment (without injection) combined with either the mineral NPK 75% or NPK 25%, gave the lowest values (77.44 and 79.33 cm) in the first and second season, respectively.

A. 2. No. of leaves plant^{-1}

Data in Table (2 B) clearly showed that the mineral NPK rates significantly affected No. of leaves plant^{-1} in both seasons. The highest mineral NPK rate (100% NPK) gave the highest values (10.00 and 9.778 cm) for this trait in the first and second season, respectively. While the lowest mineral NPK rate (25% NPK) recorded the lowest values (8.889 and 8.883 cm), in the first and second season, respectively. Similar results were reported by Kore *et al.*, (2006) who reported maximum number of leaves with increasing N, P and K. Nasreen *et al.*, (2007), Jilani *et al.*, (2009) and Bekele *et al.*, (2018) stated that, the main effect of N, P and K had shown significant difference on the mean number of leaves per plant at physiological maturity. Injection rates with nano NPK significantly affected No. of leaves plant^{-1} in both seasons Table (2 B). The highest values for this trait (9.862 and 9.941) were produced by the highest injection rate with nano NPK (15L fed.$^{-1}$) in the first and second season, respectively. While, the lowest values for this trait (9.056 and 8.873) were obtained from control treatment (without injection) in the first and second season, respectively. These results were in agreement with that found by Liu and Lal (2014); Aryanpour *et al.*, (2017); Gosavi *et al.*, (2017); and Merghany *et al.*, (2019) who stated that the positive effect of foliar applied nitrogen, phosphorus, and potassium to sustain proper leaf nutrition as well as carbon balance, and improving photosynthetic capacity is well established.

Regarding the interaction between the two studied factors, data in Table (2 B) showed that the interaction significantly affected this trait in both seasons. Injection with the highest Nano NPK (15L fed.$^{-1}$) in combination with the mineral NPK rate (75% NPK or 100% NPK) achieved the highest values (10.55 and 10.67) in the first and second season, respectively. While the combination of control treatment (without injection) with the lowest mineral NPK (25% NPK) gave the lowest values (8.55 and 8.577) in the first and second season, respectively. The importance of these NPK fertilizers lies in their role to supply the necessary nutrients for plant growth (Mokrani *et al.*, 2018).

A. 3. Bulbing Ratio (%)

Data presented in Table (3 A) clearly showed that the mineral NPK rates did not significantly affect the bulbing ratio (%) in both seasons. Similar results were reported by Miah *et al.*, (2005); Islam *et al.*, (2007); Kandil *et al.*, (2013-a); and Mohamed *et al.*, (2019) who found that foliar spraying with calcium and potassium compounds individually and/or mixing together decreased the number of days to maturity as compared to 100% NPK alone.

Concerning injection rates with nano NPK, data illustrated in (Table 3 A) revealed that injection rates with nano NPK significantly affected bulbing ratio only in the second season. The highest value for this trait (0.2808 %) were produced by the injection with nano NPK at rate 10L fed.$^{-1}$ in the second season. While, the lowest value for this trait (0.2567 %) were obtained from control treatment in the first and second season, respectivelly. These results were in agreement with that found by Subramanian and Tarafdar 2011; Ekinci *et al.*, (2014); and Valadkhan *et al.*, 2015 who found that nano-technology liquid fertilizers ferbanat significantly affected the yield plant^{-1} and fruit length of cucumber statistically. These increases can be attributed to the roles of chelated nano-fertilizer applied by spray solutions in many physiological processes such as increasing the chlorophyll content in the leaves, which is necessary to increase the efficiency of photosynthesis and the formation of the amino acid (Tryptophan) that is necessary for cell elongation,

Regarding the interaction between the two studied factors, data in Table (3 A) showed that the interaction did not significantly affect this trait in both seasons. These results were in agreement with that obtained by Bansiwal, *et al.*, (2006), Manikandan and Subramanian, (2016) who reported that nano fertilizer is easily absorbed by the epidermis of leaves and a translocated to stems which facilitated the uptake of active molecules and enhanced growth of wheat Abdel-Aziz *et al.*, (2018).

Table2: Effect of mineral NPK fertilization and injection with nano NPK on plant height (cm) and Number of leaves plant^{-1} at 120 days during seasons of 2018/2019 and 2019/2020.

A- Plant height (cm)										
Mineral NPK	2018/2019 seasons					2019/2020 seasons				
	Injection rates				Mean	Injection rates				Mean
	Control (WI)	5 L/fed	10 L/fed	15 L/fed		Control (WI)	5 L/fed	10 L/fed	15 L/fed	
100% NPK	83.75 defg	87.45 abcde	90.67 abc	92.45 a	**88.58 A**	6.78 bcdef	89.89 abcde	90.78 abcd	92.00 abc	**89.86 A**
75% NPK	77.44 h	89.55 abcd	91.22 ab	88.00 abcde	**86.56 AB**	84.11 fg	88.22 abcdef	90.89 abcd	91.89 abc	**88.78 AB**
50% NPK	85.00 cdef	83.44 efg	87.56 abcde	85.11 cdef	**85.28 AB**	85.22 def	88.67 abcdef	84.33 efg	92.22 ab	**87.61 AB**
25% NPK	79.00 gh	85.89 bcdef	80.78 fgh	86.67 abcde	**83.08 B**	79.33 g	86.44 cdef	84.89 ef	92.78 a	**85.86 B**
Mean	**81.30 B**	**86.58 A**	**87.56 A**	**88.06 A**		**83.86 C**	**88.31 B**	**87.72 B**		

B- No of leaves plant^{-1}										
Mineral NPK	2018/2019 seasons					2019/2020 seasons				
	Injection rates				Mean	Injection rates				Mean
	Control	5 L/fed	10 L/fed	15 L/fed		Control	5 L/fed	10 L/fed	15 L/fed	
100% NPK	9.670 abcd	10.11 ab	10.33 a	9.890 abc	**10.00 A**	9.00 bc	9.56 abc	9.89 abc	10.67 a	**9.778 A**
75% NPK	8.777 de	9.667 abcd	10.44 a	10.55 a	**9.860 A**	9.28 bc	9.55 abc	9.833 abc	10.22 ab	**9.721 A**
50% NPK	9.22 bcde	9.11 bcde	9.00 cde	9.89 abc	**9.306 B**	8.637 c	9.690 abc	9.690 abc	9.800 abc	**9.454 A**
25% NPK	8.55 e	9.11 bcde	8.78 de	9.11 bcde	**8.889 B**	8.577 c	8.970 bc	8.910 bc	9.077 bc	**8.883 B**
Mean	**9.056 B**	**9.500 AB**	**9.638 A**	**9.862 A**		**8.873 B**	**9.443 AB**	**9.581 A**	**9.941 A**	

WI (Without injection), Means followed by the same letter or letters are not significantly different of the 5% significance level.

Table 3. Effect of mineral NPK fertilization and injection with nano NPK on bulbing ratio (cm) and plant fresh weight (g) at 120 days during seasons of 2018/2019 and 2019/2020.

A- Bulbing ratio (%)										
Mineral NPK	2018/2019 seasons					2019/2020 seasons				
	Injection rates				Mean	Injection rates				Mean
	Control	5 L/fed	10 L/fed	15 L/fed		Control	5 L/fed	10 L/fed	15 L/fed	
100% NPK	0.2667 a	0.2600 a	0.2633 a	0.2600 a	**0.2625 A**	0.2367 a	0.2500 a	0.2867 a	0.2700 a	**0.2608 A**
75% NPK	0.2500 a	0.2500 a	0.2567 a	0.2633 a	**0.2550 A**	0.2700 a	0.2800 a	0.2633 a	0.2633 a	**0.2692 A**
50% NPK	0.2267 a	0.2367 a	0.3000 a	0.2867 a	**0.2625 A**	0.2533 a	0.2533 a	0.2767 a	0.2867 a	**0.2675 A**
25% NPK	0.2500 a	0.2867 a	0.2267 a	0.2933 a	**0.2642 A**	0.2667 a	0.2533 a	0.2967 a	0.2533 a	**0.2675 A**
Mean	**0.2483 A**	**0.2583 A**	**0.2617 A**	**0.2758 A**		**0.2567 C**	**0.2592 C**	**0.2808 A**	**0.2683 B**	

Means followed by the same letter or letters are not significantly different of the 5% significance level.

B. Total bulb yield and its components

B. 1. Bulb weight (g)

Data presented in Table 4A clearly show that bulb weight (g) was significantly affected by mineral NPK fertilization in both seasons. The highest mineral NPK treatment (100% NPK) gave the highest values (115.30 and 118.20 g) for this trait in the first and second seasons, respectively. While the lowest mineral NPK (25% NPK) recorded the lowest values (68.42 and 89.08 g) for this trait in the first and second seasons, respectively. Similar results were reported by Jawadagi *et al.*, (2012), Sultana *et al*, (2014) and Messele (2016) who reported that Nitrogen had significantly increased the average bulb weight of onion. There was 46.2 % average bulb weight increment in response to the N treatments, regardless of the rates.

Concerning injection onion with nano NPK rates, data illustrated in (Table 4 A) revealed that injection rates significantly affected bulb weight (g) in both seasons. The highest values for this trait (102.80 and 115.4 g) were produced by the highest injection rate (15L fed.$^{-1}$) in the first and second season, respectively. While, the lowest values for this trait (82.33 and 91.92 g) were obtained from treatment without injection (control treatment) in the first and second season, respectively. These results were in agreement with that found by Ekinci *et al.*, (2012) and Ekinci *et al.*, (2014) who observed the highest average fruit weight of cucumber and fruit length from Nano at 4.0 L ha^{-1}.

Regarding the interaction between the two studied factors, data in Table (4 A) show that the interactions significantly affected this trait in both seasons. The combination between the highest Nano NPK (15L fed.$^{-1}$) injections with the highest mineral NPK (100% NPK) achieved the highest values (122.30 and 133.70 g) in the first and second season, respectively. While the treatment without injection (control treatment) with the lowest mineral NPK (25% NPK), gave the lowest values (52.67 and 73.67 g) in the first and second season, respectively. These results were agreed with Ferbanat (2013) obtained results Ferbanat addition with a sprinkler and drip irrigation system have increased development root of the plant and the number of buds and weight of cucumber plant. Also, these results may be due to the role of nitrogen in promotion of phytophormone formation and translocation to the plant that increased dry weight of bulb. These results agreed with those of (Mohd-Mostakim *et al.*, 2000; Rather *et al.*, and Hamuda, 2006). In line with this finding, nitrogen at the concentration up to 5,000 mg·L^{-1} increased bulb fresh and dry weights Charbaji *et al.*, (2008).

B. 2. Total bulb yield (t fed^{-1})

Data presented in Table 4B clearly showed that total yield (t fed.$^{-1}$) was significantly affected by mineral NPK fertilization in both seasons. The highest mineral NPK treatment (100% NPK) gave the highest values (20.81 and 20.29 t) for this trait in the first and second seasons, respectively. While the lowest mineral NPK (25% NPK) recorded the lowest values (14.84 and 13.93 t) for this trait in the first and second seasons, respectively. Similar results were reported by, (El-Tantawy and El-Beik, 2009; Soleymani and Shahrajabian, 2012; Esawy *et al.*, 2015 and Messele, 2016) reported that addition of nitrogen at the rate of 50 kg ha^{-1} gave optimum total and marketable bulb yields without significantly influencing the quality of onion.

Concerning injection onion with nano NPK rates, data illustrated in (Table 4 B) revealed that injection rates significantly affected total yield (t fed.$^{-1}$) in both seasons. The highest values for this trait (19.63 and 18.85 t) were produced by the highest injection rate (15L fed.$^{-1}$) in the first and second season, respectively. While, the lowest values for this trait (16.60 and 16.59 t) were obtained from the control treatment in the first and second season, respectively. These results were in agreement with that found by (DeRosa *et al.*, 2010; Monreal *et al.*, (2016) and Rajonee *et al.*, 2017) and who stated that nitrogen, might be given only very few parts to plant and soil need, although it has been reported that the use of very small nanofertilizer particles is more effective than this rate. The effects of foliar addition with nano-NPK levels had significant difference on vegetative parameter compared with control treatment. The best values of plant height number of leaves plant^{-1}, number of branches plant^{-1}, chlorophyll content in leaves, dry matter of leaves and TSS, this finding is agreed with results mentioned previously by Merghany *et al.*, (2019). Regarding the interaction between the two studied factors, data in

Table (4 B) show that the interactions significantly affected this trait in both seasons. The injection with the Nano NPK rate (10L fed.$^{-1}$) with either the mineral 75% NPK or 100% NPK) achieved the highest values (21.99 and 21.85 t) in the first and second season, respectively. While the treatment without injection (control treatment) with the lowest mineral NPK (25% NPK) gave the lowest values (14.06 and 12.75 t), in the first and second season, respectively. These results were agreed with that obtained by Abdel-Aziz *et al.,* (2018) who stated that foliar addition of different levels of conventional fertilizer and nanofertilizers to wheat plants could significantly increase all yield parameters determined. The magnitude of increased yield parameters was most pronounced with 10% nano-chitosan-NPK fertilizer.

B. 3. Exportable bulbs yield (t fed.$^{-1}$)

Data presented in Table 5A clearly showed that exportable yield (t fed.$^{-1}$) was significantly affected by mineral NPK fertilization in both seasons. The mineral NPK treatment (100% NPK and 75% NPK) gave the highest values (17.81 and 17.56 t) for this trait in the first and second seasons, respectively. While the lowest mineral NPK treatment (25% NPK) recorded the lowest values (12.58 and 11.58 t) for this trait in the first and second seasons, respectively. Similar results were reported by Mohamed *et al.,* (2019) who stated that fertilizing onion plants with Potassin + Calfruit + Humic acid + 75% NPK produced the highest total bulbs yield fed.$^{-1}$ (15.84 and 16.69 t fed.$^{-1}$.) and the highest exportable bulbs yield fed.$^{-1}$ (13.62 and 14.28 t fed.$^{-1}$). Concerning injection onion with nano NPK rates, data illustrated in (Table 5 A) revealed that injection rates significantly affected exportable yield (t fed.$^{-1}$) in both seasons. The highest values for this trait (16.73 and 16.25 t) were produced by the highest injection rate (15L fed.$^{-1}$) in the first and second season, respectively. While, the lowest values for this trait (14.65 and 14.12 t) were obtained from the control treatment in the first and second season, respectively. These results were in agreement with that found by Manikandan and Subramaian (2016), Gomaa *et al.,* (2017), Kandil and Marie (2017), Burhan and AL-Hassan (2019), who confirmed a significant increase in traits vegetative growth effect of nanofertilizer used, The significant role of the fertilizer components in the increase in plant height, is the effect of nitrogen levels that stimulate the production of auxins that encourage cell division and elongation of cells of the total vegetative plant also it has a direct impact on the plant height as it is the necessary element to build the amino acid (Tryptophan), which is the main hormone and building indol acetic acid (IAA), in the plant (Al-Asady and Al-Kikkhani, 2019). Regarding the interaction between the two studied factors, data in Table (5 A) show that the interactions significantly affected this trait in both seasons. The combination between injection with the Nano NPK either at rate of 15L fed.-1 or 10L fed.-1 and the mineral NPK (75% NPK) treatment, achieved the highest values (18.51 and 18.56 t) in the first and second season, respectively. While the combination between control treatment (without injection) with the lowest mineral NPK (25% NPK), gave the lowest values (11.76 and 10.89 t) in the first and second season, respectively. These results were agreed with obtained results Bekele et al., (2018) who stated that combined addition of N-P-K acted to be superior for total and marketable bulb yield.

C. Bulb Quality

C. 1. Dry matter (%)

Data presented in Table 6A clearly showed that dry matter (%) was significantly affected by mineral NPK fertilization in both seasons. The highest mineral NPK treatment (100% NPK) gave the highest value (17.72 and 17.29%) for this trait in the first and second season, respectively. While the lowest mineral NPK treatment (25% NPK) recorded the lowest value (15.98 and 16.01 %) for this trait in in the first and second season, respectively. Similar results were reported by Tekeste *et al.,* (2018) and Bekele (2018) who reported that with the increase of doses of the main fertilizer N, P and K 70, 45, 70 kg ha-1 to N, P and K 110, 75, 110 kg ha^{-1} caused the increase of dry matter content in bulbs from 14.6% to 15,5%.Valadkhan *et al.,* (2015) reported that improvement in the yield components was due to the enhanced photosynthetic and other metabolic activities, which resulted in the production of more dry matter and greater nutrient uptake. Abd El-Gawad *et al.,* (2016) found that encouraging potassium on enzymes activity stimulate the translocation of assimilates and protein synthesis. Bala *et al.,* (2014) and Messele (2016) reported that Nitrogen had significantly increased the average bulb weight of onion. There was 46.2 % average bulb weight increment in response to the N treatments, regardless of the rates. This may be attributed to the increase in plant height, number of leaves per plant and leaf length, which have direct effects on dry matter production. The lower bulb dry matter yield of onion observed at addition of the nil rate of nitrogen might be due stiffer to competition among plants for the limited growth resources, which may have resulted in reduced vegetative growth like leaf number, leaf diameter, leaf length and plant height (Khan *et al.,* 2002). Thus, finally the weight of bulb and diameter becomes small, leading to lower value of bulb dry matter of onion. These results are in conformity with the findings of (Sikder *et al.,* 2010; Ademe *et al.,* 2012; Tekle, 2015 and Bojtor *et al.,* 2021).

Concerning injection onion with nano NPK rates, data illustrated in (Table 6 A) revealed that injection rates significantly affected dry matter (%) in both seasons. The highest values (17.54 and 17.28 %) for this trait were recorded by the injection with the highest nano NPK rate (15L fed.$^{-1}$) in the first and second season, respectively. While, the lowest values (15.89 and 16.15 %) for this trait were obtained the control treatment in the first and second season, respectively. These results are corresponded with that report by Kobraee *et al.,* (2011). The raising in vegetative growth parameter thus raise the photosynthesis process efficiency by high utilization of nano particles then lead to increasing the productivity in the source then increasing the accumulation of dry substance in sinks, and increasing of yield parameters. Similar results were obtained by Liu and Lal, (2015). Also, this finding is in agreement with results reported previously by (Abdel-Aziz *et al.,* 2016) who suggested that, these effects may due to the presence foliar spray of macronutrients fertilizers that may be mediated via the enzymatic systems responsible for biosynthetic apparatus, and thus rising sugars and nitrogen in intact plants. This means that foliar application of fertilizers induced increases in mineral and increased the dry matter. These results are similar to those obtained by Al-Juthery and Al-Maamouri (2020) who found that nano-fertilizers increase the availability of ready-made nutrients to the plant, longer and by suitable release in line with plant growth that increases the formation of chlorophyll, the rate of photosynthesis, dry matter production, consequently, the overall plant growth. Also, Shami and Murad (2019) when studying the effect of nano-nitrogen on potato yield,who found that a significant increas in dry matter of vegetative under fertigation and foliar application which may due to the good processing of nitrogen during the application. Regarding the interaction between the two studied factors, data in Table (6 A) show that the interactions significantly affected this trait in both seasons. The injection with the Nano NPK either at rate of 15L fed.$^{-1}$ or 10L fed.$^{-1}$ with the highest mineral NPK (100% NPK) gave the highest values (19.18 and 18.26 %) in the first and second season, respectively. While the treatment without injection (control treatment) gave the lowest values (15.38 and 15.62 %) when combined with the mineral NPK either at rate of 50% NPK or 25% NPK), in the first and second season These results were agreed with obtained results by Emadian (2017) and Morales-Díaz *et al.,* (2017) who found that the usage of nanofertilizers to transport nutrient elements to the plant at the needed time and the required amount and balances the release of nitrogen and phosphorus fertilizer with the absorption by the plant, thereby preventing the nutrient losses and avoiding unwanted nutrients interaction with microorganisms, water and air. Improvement in bulb dry weight as well as total dry biomass yield could be attributed to increased photosynthetic area in response to N fertilization that may have enhanced assimilate production and partitioning to the bulbs Anwar *et al.,* (2001). Chitosan nanoparticles (prepared using sodium tripolyphosphate and loaded with Cu) act as an efficient photocatalyst by improving the photosynthetic complexes and nitrogen metabolism which can enhance cell growth as well as dry mass of treated maize plants (Choudhary *et al.,* 2017).

C. 2. Total soluble solids "T.S.S." (%)

Data presented in Table 6B clearly showed that TSS (%) was significantly affected by mineral NPK fertilization in both seasons. The highest mineral NPK treatment (100% NPK) gave the highest value (15.27 and 15.15%) for this trait in the first and second season, respectively. While the lowest mineral NPK treatment (25% NPK) recorded the lowest values (14.07 %) for this trait in in the first and second season. Moursy *et al.*, (2007) indicated that increasing the level of N fertilizer to 80 kg N ha^{-1} resulted in about 8.5% increase in the TSS as compared to the level of 40 kg N ha^{-1}. Al-Fraihat (2009) stated that with increasing addition of nitrogen fertilizer from 100 kg N ha^{-1} to 200 kg N ha^{-1} in the first and second growing seasons, the TSS value increased from 13.75% to 14.70% and 13.90% to 15.07% during the first and second growing seasons, respectively. Morsy *et al.,* (2012) also showed addition of 120 kg N ha^{-1} led to the highest values of TSS whereas, addition of 90 kg N ha^{-1} resulted in the lowermost values of TSS in both seasons. Mohamed and El-Tokhy (2018). Concerning injection onion with nano NPK rates, data illustrated in (Table 6 B) revealed that injection rates significantly affected TSS (%) in both seasons. The highest values (15.18 and 15.02 %) for this trait were recorded by the injection with the highest Nano NPK rate (15L fed.$^{-1}$) in the first and second season, respectively. While, the lowest values (14.15 and 14.30 %) for this trait were obtained from the control treatment in the first and second season, respectively.These results were in agreement with that found by (Dimkpa *et al.*, 2015 and Qureshi *et al.*, 2018). It seems that when foliarnutritionals were used, the photosynthetic activity was stimulated, leading to enhancement of chemical constituents as crude protein, starch, carbohydrate, L-ascorbic acid and T.S.S in shoots, Eleiwa *et al*., (2012). The smaller size, the higher specific surface area and the reactivity of nanofertilizers may affect nutrient solubility, diffusion and hence availability to plants (Singh *et al.*, 2013). These results are consistent with Shareef *et al.*, (2020) who stated that nano-fertilizers NPK (1g L $^{-1}$) on date palm (Hillawi cv.) led to an increase in fruit ripening rate, dry mass, and total soluble solids. Regarding the interaction between the two studied factors, data in Table (6 B) show that the interactions significantly affected this trait in both seasons. The combination between injection with the highest Nano NPK rate (15L fed.$^{-1}$) and the mineral NPK (75% NPK) gave the highest values (16.20 and 15.73 %) in the first and second season, respectively. While the treatment without injection (control treatment) gave the lowest values (13.47 and 13.50 %) when combined with the lowest mineral NPK (25% NPK), in the first and second season, respectively. These results were agreed with obtained results by Jinghua (2004), nutrients uptake by grain crops can be boosted when a nano-composite contains N, P and K was applied El-Shamy *et al.*, (2019) reported that foliar addition of macronutrients fertilizers induced increases in mineral status of plants and increased the dry matter in potato.also Mohamed and El-Tokhy (2018) reborted that the interaction from mineral nitrogen at the uppermost rate (535.71 kg N ha^{-1}) and hand weeding method on onion cv. Giza 6, significantly increased the percentages of bulbs in diameter, doubles, bulb fresh weight, bulb diameter and length , bulb dry matter , bulb quality such as vitamin C concentration, percentages of sulfur volatile oil, total soluble solids (TSS), crude protein and total carbohydrates in onion bulb.

Table 5. Effect of mineral NPK fertilization and injection with Nano NPK on Exportable yield (t fed.$^{-1}$) and local marketable yield (t fed.$^{-1}$) during seasons of 2018/2019 and 2019/2020.

A- Exportable yield (t fed.$^{-1}$)										
Mineral NPK	**2018/2019 seasons**					**2019/2020 seasons**				
	Injection rates				**Mean**	**Injection rates**				**Mean**
	Control	**5 L/fed**	**10 L/fed**	**15 L/fed**		**Control**	**5 L/fed**	**10 L/fed**	**15 L/fed**	
100% NPK	**16.83 abcd**	**17.65 ab**	**18.40 a**	**18.37 ab**	**17.81 A**	**14.71 bcd**	**16.86 abc**	**17.91 ab**	**17.40 abc**	**16.72 A**
75% NPK	**15.28 de**	**17.12 abc**	**17.48 ab**	**18.51 a**	**17.10 A**	**16.47 abc**	**16.71 abc**	**18.56 a**	**18.49 a**	**17.56 A**
50% NPK	**14.74 ef**	**14.62 ef**	**15.51 cde**	**16.68 bcd**	**15.39 B**	**14.40 cd**	**14.78 bcd**	**16.25 abc**	**16.59 abc**	**15.51 A**
25% NPK	**11.76 g**	**12.76 g**	**12.47 g**	**13.34 fg**	**12.58 C**	**10.89 e**	**11.75 de**	**11.17 e**	**12.50 de**	**11.58 B**
Mean	**14.65 C**	**15.54 B**	**15.97 B**	**16.73 A**		**14.12 B**	**15.03 AB**	**15.97 A**	**16.25 A**	

Means followed by the same letter or letters are not significantly different of the 5% significance level.

Table 4. Effect of mineral NPK fertilization and injection with Nano NPK on bulb weight (g) and total yield (t fed.$^{-1}$) during seasons of 2018/2019 and 2019/2020.

A- Bulb weight (g)										
Mineral NPK	2018/2019 seasons					2019/2020 seasons				
	Injection rates				Mean	Injection rates				Mean
	Control	5 L/fed	10 L/fed	15 L/fed		Control	5 L/fed	10 L/fed	15 L/fed	
100% NPK	110.30 ab	111.00 ab	117.70 a	122.30 a	**115.30 A**	102.30 bcd	118.30 ab	118.30 ab	133.70 a	**118.20 A**
75% NPK	95.00 bc	112.10 ab	119.30 a	119.00 a	**111.30 B**	101.00 bcd	107.00 bcd	112.70 bc	117.00 ab	**109.40 B**
50% NPK	71.33 de	79.33 cde	82.67 cd	84.33 cd	**79.42 C**	90.67 def	100.30 bcd	108.70 bcd	103.70 bcd	**100.80 C**
25% NPK	52.67 f	73.00 de	62.67 ef	85.33 cd	**68.42 D**	73.67 f	79.33 ef	96.00 cde	107.30 bcd	**89.08 D**
Mean	**82.33 C**	**93.85 B**	**95.58 AB**	**102.80 A**		**91.92 C**	**101.30 B**	**108.9 AB**	**115.4 A**	
B- Total yield (t fed.$^{-1}$)										
Mineral NPK	2018/2019 seasons					2019/2020 seasons				
	Injection rates				Mean	Injection rates				Mean
	Control	5 L/fed	10 L/fed	15 L/fed		Control	5 L/fed	10 L/fed	15 L/fed	
100% NPK	19.10 cd	20.59 abc	21.72 ab	21.82 ab	**20.81 A**	18.50 de	19.94 abcd	21.85 a	20.88 ab	**20.29 A**
75% NPK	16.81 ef	18.99 cd	21.99 a	21.25 ab	**19.76 A**	19.11 bcde	19.75 abcde	20.89 ab	20.68 abc	**20.11 A**
50% NPK	16.44 ef	17.00 ef	17.48 de	19.83 bc	**17.69 B**	16.01 fgh	16.51 fg	17.69 ef	18.63 cde	**17.21 B**
25% NPK	14.06 g	15.36 fg	14.33 g	15.62 efg	**14.84 C**	12.75 j	14.06 hij	13.72 ij	15.19 ghi	**13.93 C**
Mean	**16.60 C**	**17.99 B**	**18.88 AB**	**19.63 A**		**16.59 C**	**17.57 B**	**18.54 A**	**18.85 A**	

Means followed by the same letter or letters are not significantly different of the 5% significance level.

Table 6. Effect of mineral NPK fertilization and injection with nano NPK on dry matter % and T.S.S % during seasons of 2018/2019 and 2019/2020.

A- Dry matter %										
Mineral NPK	2018/2019 seasons					2019/2020 seasons				
	Injection rates				Mean	Injection rates				Mean
	Control	5 L/fed	10 L/fed	15 L/fed		Control	5 L/fed	10 L/fed	15 L/fed	
100% NPK	16.44 bcd	16.62 bcd	18.62 ab	19.18 a	**17.72 A**	16.25 def	16.90 bcde	18.26 a	17.74 ab	**17.29 A**
75% NPK	16.20 cd	16.49 bcd	16.98 bcd	18.03 abc	**16.92 AB**	16.57 bcdef	16.95 bcde	17.00 bcde	17.50 abc	**17.00 B**
50% NPK	15.38 d	16.56 bcd	17.37 abcd	17.31 abcd	**16.65 BC**	16.17 def	16.96 bcde	17.21 abcd	17.46 abc	**16.95 B**
25% NPK	15.54 d	16.82 bcd	15.93 cd	15.64 d	**15.98 C**	15.62 f	16.10 def	15.91 ef	16.42 cdef	**16.01 C**
Mean	**15.89 B**	**16.62 AB**	**17.23 A**	**17.54 A**		**16.15 C**	**16.73 B**	**17.09 AB**	**17.28 A**	
B- T.S.S %										
Mineral NPK	2018/2019 seasons					2019/2020 seasons				
	Injection rates				Mean	Injection rates				Mean
	Control	5 L/fed	10 L/fed	15 L/fed		Control	5 L/fed	10 L/fed	15 L/fed	
100% NPK	14.73 abcdef	15.47 abc	15.07 abcde	15.80 ab	**15.27 A**	14.53 bcde	15.40 abc	15.47 ab	15.20 abcd	**15.15 A**
75% NPK	13.93 cdef	14.60 bcdef	14.93 abcdef	16.20 a	**14.92 AB**	14.40 cdef	14.53 bcde	15.47 ab	15.73 a	**15.03 A**
50% NPK	14.47 bcdef	13.53 ef	15.33 abcd	14.47 bcdef	**14.45 BC**	14.77 abcd	14.90 abcd	15.07 abcd	14.80 abcd	**14.88 A**
25% NPK	13.47 f	14.73 abcdef	13.80 def	14.27 bcdef	**14.07 C**	13.50 f	14.70 bcd	13.70 ef	14.37 def	**14.07 B**
Mean	**14.15 B**	**14.58 AB**	**14.78 AB**	**15.18 A**		**14.30 B**	**14.88 A**	**14.93 A**	**15.02 A**	

Means followed by the same letter or letters are not significantly different of the 5% significance level.

CONCLUSION

This experiment was carried out at Shandaweel Agriculture Research Station, Sohag Governorate during the growing seasons of 2018/2019 and 2019/2020, to study the effect of different mineral NPK rates and injection with Nano NPK rates on vegetative growth, yield and quality of onion. According to the results obtained from this study, the following can be concluded:

Using mineral NPK (75%) combined with Nano NPK as soil injection (10 L fed.$^{-1}$) significantly achieved the following advantages:

1- The highest total and exportable yield t fed.$^{-1}$
2- Reduce the environmental pollution through minimizing the recommended doses of chemical NPK by 25%
3- Save the hard currency through reducing importing chemical fertilizers.

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الملخص العربى

تأثير التسميد بالأسمدة المعدنية والحقن بأسمدة النانو على النمو والمحصول والجودة في البصل

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اجريت هذه التجربة فى مزرعة التجارب الزراعية بمحطة بحوث جزيرة شندويل – مركز البحوث الزراعية – محافظة سوهاج، وذلك فى الموسم الشتوى للاعوام 2018/ 2019، 2020/2019م، لدراسة تاثير المعدلات المختلفة من التسميد المعدنى (نيتروجين-فوسفور-بوتاسيوم) مع الحقن باسمدة النانو (نيتروجين-فوسفور-بوتاسيوم)، على النمو الخضرى والمحصول والجودة فى صنف البصل. جيزة 6 محسن. تمت الزراعة فى تجربة مصممة بنظام القطع المنشقة مرة واحدة مع استخدام ثلاث مكررات. تم وضع معدلات التسميد المعدنى فى القطع الرئيسية (100%، 75%، 50%، 25% نيتروجين-فوسفور-بوتاسيوم)، بينما تم وضع معدلات الحقن بسماد النانو فى القطع الشقية (كنترول، 5 لتر، 10 لتر، 15 لتر للفدان).أظهرت النتائج أن معاملات الحقن باسمدة النانو Nana NPK ومعاملات الأسمدة المعدنية NPK المعدنية أثر كل منهما معنوياً على معظم الصفات المدروسة في كلا الموسمين. وأثر التفاعل بينهما معنوياً على كل من المحصول الكلى والمحصول القابل للتصدير في كلا الموسمين. الحقن باسمدة النانو بمعدل (10 لتر/فدان) اعطى أعلى محصول كلى للأبصال (21.99، 21.85 طن) وذلك مع استخدام التسميد المعدنى NPK (75٪، 100٪ NPK) في الموسم الأول والثاني على التوالي. بينما أعطت معاملة الكنترول (المعاملة بدون الحقن باسمدة النانو) اقل محصول كلي للابصال (14.06، 12.75 طن) وذلك مع اقل معاملة تسميد معدنى NPK(25%NPK) في الموسم الأول والثاني على التوالي. حقق الحقن باسمدة النانو Nano NPK بمعدل (15، 10 لتر/فدان) -أعلى القيم لمحصول الأبصال القابل للتصدير (18.51، 18.56 طناً) وذلك مع معاملة التسميد المعدنى (75%NPK)، في الموسم الأول والثانى على التوالي. لذلك، توصى نتائج هذه الدراسة باستخدام التسميد المعدنى NPK بمعدل 75%جنبًا إلى جنب مع اسمدة الـ Nano NPK كحقن للتربة بمعدل 10 لتر/فدان، لزيادة المحصول الكلى والقابل للتصدير، وللحد من التلوث البيئي من خلال توفير ربع الكمية الموصى بها من الأسمدة الكيماوية وتوفير العملة الصعبة عن طريق تقليل استيراد الأسمدة الكيماوية.