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Obiadalla-Ali H A
El-Shaikh K A A
Boktor Amal Z S
Vegetable Crops Department
Faculty of Agriculture
Sohag University
Sohag
Egypt
82524

Marey R A
Onion Research Department
Field Crops Research Institute
Agricultural Research Center
Giza
Egypt
12619

Effect of Fertilization with Mineral NPK and Spraying with Nano NPK on Growth, Yield and Quality of Onion

Obiadalla-Ali H A, El-Shaikh K A A, Marey R A and Boktor Amal Z S

Abstract

Two field experiments were conducted during 2018/2019 and 2019/2020 seasons at Shandaweel Agriculture Research Station, Sohag Governorate, to study the effect of different rates of mineral NPK fertilization under foliar application with Nano NPK, on vegetative growth, yield and quality of onion. Split plot design with three replicates was used. Mineral NPK fertilization rates occupied the main plots (100% NPK, 75% NPK, 50% NPK and 25% NPK), whereas Nano NPK spraying rates (control, 2 L/fed, 4 L/fed and 6 L/fed) occupied the sub plots. The obtained results could be summarized as follow: (i) Application of 100% NPK gave the highest values of plant height while, application of 25% of NPK gave the lowest values, in the two seasons; (ii) Spraying with Nano NPK at rate of 6 L /fed appeared the highest values of plant height, whilst, spraying with water (control treatment) appeared the lowest values; (iii) Application of 100% of mineral NPK gave the highest values of total yield, while, application of 25% of NPK gave lowest values in both seasons; (iv) Spraying with Nano NPK at rate of 6 L /fed appeared the highest values of total yield/fed, whilst, spraying with water (control treatment) appeared the lowest values, in the two seasons; (v) The highest values of total yield/fed were obtained by using 75% mineral fertilization and spraying with Nano NPK at rate of 6 L/fed, in both seasons; and (vi) The highest values of exportable bulbs yield were obtained by using 75% mineral fertilization and spraying with Nano NPK at rate of 6 L/fed., while, the lowest values were obtained by application of 25% of mineral NPK and spraying with water (control treatment), in both seasons.

Keywords:
Onion – fertilization - NPK.

INTRODUCTION

Onion (*Allium cepa L*.) is one of the main vegetable crops in the world. It is one of the oldest bulb vegetables in continuous cultivation dating back to at least 4000 B.C. (Ahmad *et al.,* 2008). The cultivated area in the world is about 5,201,591 hectares (about 12,853,651 Feddans). The annual world production of onion is 97,862,928 tons of dry bulbs of land with an average yield of 18.8 t ha-1(FAO, 2017). The total cultivated area of onion in Sohag was 17538fed. Which produced 326.998 tons with average of 18.64 ton/fed (Ministry of Agriculture, 2020). Onion (*Allium cepa L*.) is amongst the main vegetable crops in Egypt for consumption processing and exportation. It is one of the most important sources for hard currency (El-Hadidi *et al.,* 2016).

Onion bulb is a rich source of minerals like phosphorus and calcium. It also contains protein and vitamin C, quercetin and flavonoids. Quercetin helps to eliminate free radicals in the human body, to inhibit low density lipoprotein oxidation (an important reaction in the atherosclerosis and coronary heart disease), to protect and regenerate vitamin E and to inactivate the harmful effects of chelate metal ions (Scott, 2007).

The primary macro elements, e.g. nitrogen, phosphorus and potassium (NPK) are necessary for plant growth, maturity, bulb yield, bulb quality and storability. The application of NPK fertilization in a balance ratio is prerequisite for producing high yield of onion bulbs with a good keeping quality. Nitrogen is an integral part of chlorophyll. It is essential for synthesis of proteins and enzymes. Phosphorus and potassium play a vital role in several keys of physiological processes viz. photosynthesis, respiration, energy storage (ATP, ADP formation), and enhancing the translocation of assimilates and protein synthesis (Marschner 1995, El-Desuki *et al.,* 2006 a & b). Onion plant is sensitive to nutritional balance, this might be due to shallow root system and high productivity, besides, it is a long term crop (Yaso and Abdel-Razzak, 2007).

Nitrogen plays an important role for optimum yield of onion and is found to be essential to increase the bulb size and yield. Increasing nitrogen application rates significantly enhances plant height, number of green leaves per plant and weight of bulb, marketable yield and also total soluble solids (Nasreen *et al.,* 2007 and Al-Fraihat, 2009). Phosphorus is essential for root development and when the availability is limited, plant growth is usually reduced. In onions, P deficiencies reduce root and leaf growth, bulb size, and yield and can also delay maturation (Greenwood *et al.,* 2001). Potassium integrates different biochemical functions in the physiological processes, whether in translocation of sugars (translocation and storage of photosynthesis assimilates), in the respiration, in the opening and closing of stomata in osmotic regulation (maintaining the osmotic potential and ionic balance) or as activator of more than 60 enzymes related to these processes (Malavolta, 2006 and Epstein and Bloom, 2006).

Nowadays, application of fertilizers containing NPK is vital for the development of crop production and plays important roles in food safety. The importance of these NPK fertilizers lies in their role to supply the necessary nutrients for plant growth (Mokrani *et al.,* 2018 a,b). The ultimate goal of sustainable agriculture is to develop farming systems that are productive, profitable, energy-conserving, environmentally-sound, conserving of natural resources such as soil and water, and that ensure food safety and quality (Fawzy *et al*, 2012).

To overcome the problem of fertilizer use and increase economical use, lots of approaches have been made. Among them: use of slow release Nano fertilizer. Nano fertilizer, the most important field of agriculture, has drawn the attention of the soil scientists as well as the environmentalists due to its capability to increase yield, improve soil fertility, reduce pollution and make a favorable environment. 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 (Sharmila and Subramanian 2013).

Properties of Nanoparticles (NPs), i.e., high surface area, high reactivity, tunable pore size, and particle morphology. The key role of Nanoparticles in soil systems: effective means for the smart delivery of fertilizers that has a strong bearing on the growth and yield of plants. Nano-based slow-release or controlled-release (CR) fertilizers have the potential to increase the efficiency of nutrient uptake; Hence, it had utilized of Nanoparticles for delivery of fertilizers in an agricultural production Nanoparticles may be treated as “magic bullets,” Mani and Mondal (2016)

With the increasing population pressure on land for cultivation, one way to boost production, Increase the area of arable land ,is increase per hectare productivity and the other alternative is to improve the land productivity. Plus onion is the most profitable cropping system, but yield of crops are 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 with the following objectives.

This investigation was conducted to study growth, yield, yield components and quality of onion bulbs grown under different rate of mineral NPK fertilization, under foliar spraying with Nano NPK.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm of Shandaweel Agricultural Research Station, Sohag, (ARC), during 2017/2018 and 2018/2019 seasons, to study the effect of foliar spraying with Nano NPK on the yield, quality and storability of onion under different rates of mineral NPK fertilization.

The onion variety used in this experiment:

Onion seeds of Giza 6 Mohassan variety in the two experiments 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 as ammonium nitrate (33.5% N), 15 kg P_2O_5/fed as a super phosphate (15.5% P_2O_5) and 25 kg K_2O/fed 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 m2 (3.5 m length and 3 m in width) included fife 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 planting date. The recommended dose of NPK fertilization was 120 kg N + 45 kg P_20_5 + 50 kg K_2O. Nano NPK fertilizer (20-20-20 NPK) was introduced from Nano way technology company, Egypt. Nano NPK fertilizer was sprayed as a foliar fertilizer, by using 200 liter water per fed, after 30 and 60 days from transplanting. The chemical compositions of Nano NPK fertilizer was presented in Table 2. 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).

A split plot design with three replicates was used in this experiment. The main plots were devoted to the rates of mineral NPK fertilizer, while, the sub plots were devoted to the rates of the sprayed Nano NPK.

The treatments of this experiment were arranged as follows:

Main plots: Mineral NPK fertilization rates:

1- 100% of recommended NPK rate.
2- 75% of recommended NPK rate.
3- 50% of recommended NPK rate.
4- 25% of recommended NPK rate.

The Sub plots: Nano NPK spraying rates:

1- Control (spraying with water).
2- Spraying with 2 L/fed Nano NPK.
3- Spraying with 4 L/fed Nano NPK.
4- Spraying with 6 L/fed Nano NPK.

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

Determination		Season 2018/2019	Season 2019/2020
Mechanical analysis	Textural class	Clay loam	Clay loam
Chemical analysis	pH	7.8	7.7
	EC ($ds.m^{-1}$)	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
Anions (meq/100g)	CO_3	0.00	0.00
	HCO_3	2.8	2.5
	SO_4	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

Table (2) The chemical compositions of Nano NPK fertilizer.

Chemical ingredients	Percentage by weight
Total Nitrogen (N)	20%
Available Phosphate (P2O5)	20%
Soluble Potash (K2O)	20%
Magnesium (Mg)	Zero
Iron	Zero
Sulfur (S)	Zero
Inert ingredients	40%

Data recorded

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

A. Vegetative growth characteristics

A.1. Plant height (cm)

It was measured from the base of swelling sheath to the top of the longest tubular blades**.**

A.2. Bulbing ratio

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

Bulbing ratio=Neck diameter/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 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. Average bulb weight (g)

It was calculated by dividing weight of single bulbs by its number.

B.2. Total yield (ton/fed)

It was calculated on basis of yield for the experimental plot in tons/fed.

B.3. Exportable bulbs yield (ton/fed)

It was determined as the weight of single bulbs yield equal or more than 3.5 cm in diameter for each experimental plot.

B.4. Local marketable yield (ton/fed)

It includes bulbs of less than 3.5 cm diameter, doubles, and bolters.

C. Bulb quality

C.1. Dry matter percentage (D.M. %)

It was determined by estimating the loss in sample of bulbs fresh weight after drying for four hours at 105°C and then at 70°C in a drying oven, according to the following formula:

D.M. %=

(Sample dry weight/sample fresh weight) x100

C.2. Total soluble solids percentage (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)

1. Mineral NPK

Data in Table 3 revealed that mineral NPK rates significantly affected plant height in the second season only. Application of 100% NPK gave the highest values of plant height, while, application of 25% of NPK gave lowest values, in the two seasons. Similar results were reported by (El-Shaikh (2005), Abdissa *et al.*, (2011); Bekele (2018), and Jilani *et al* (2019). The probable reason for higher plant height could be due to increased rates of nitrogen application, 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.

2. Nono NPK L/fed

Spraying onion with Nano NPK significantly affected plant height in the first and second seasons. Spraying with Nano NPK at rate of 6L /fed appeared the highest values of plant height it was (88.39 and 87.17) respectively, whilst, spraying with water (control treatment) appeared the lowest values (84.17 and 82.56) in the first and second seasons respectively. These results were in agreement with that found by 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).

3. Interaction

The effect of the interaction between the two studied factors on plant height was significant in the first and second seasons. In the first season, the highest values (91.67cm.) were obtained by using 100% mineral fertilization and spraying with Nano NPK at rate of 4L/fed, while in the second season, the highest values (91.44) were obtained by using 100% mineral NPK and spraying with Nano NPK at rate of 6L/fed, while the lowest values were obtained by application of 25% of mineral NPK under control treatments (spraying with water), in both seasons.

A.2. Number of leaves per plant

1. Mineral NPK

Data in Table 3 revealed that mineral NPK rates significantly affected No. of leaves/plant in the first and second seasons. Application of 100% NPK gave the highest values of No. of leaves/plant, while, application of 25% of NPK gave lowest values, in both seasons. 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 (2018) who revealed that, the main effect of N, P and K had shown significant difference on the mean number of leaves per plant at physiological maturity. The highest mean value (11.62) was obtained from the combined application of 150:92 kg of N-P ha-1, application gave highly significant effect on number of leaves per plants.

2. Nono NPK L/fed

Spraying onion with Nano NPK significantly affected of No. of leaves/plant in the first and second seasons. Spraying with Nano NPK at rate of 6L /fed appeared the highest values of No. of leaves/plant (11.06 and 10.50) respectively, whilst, spraying with water (control treatment) appeared the lowest values in the first season only. These results were true in the first and second seasons. These results were in agreement with that found by Ni *et al.*, (2009), Ekinci *et al.*, (2014), Liu and Lal (2014), Aryanpour *et al.*, (2017); Merghany *et al.*, (2019) and Gosavi *et al.*, (2017) 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.

3. Interaction

The effect of the interaction between the two studied factors was significant in the first and second seasons. the highest values of No. of leaves/plant (12.44 and 12.11) were obtained by using 100% mineral fertilization and spraying with Nano NPK at rate of 4,6 L/fed, or by using of 100% mineral fertilization NPK and spraying with control treatment (spraying with water), in the first and second seasons, respectively. On the other hand the lowest values of No. of leaves/plant (7.66 and 7.00) were obtained by application of 25% of mineral NPK and spraying with Nano NPK at rate of 6L/fed and by application of 25% of mineral NPK and spraying with control treatment (spraying with water), in the in the first and second seasons, respectively.

A.3. Bulbing ratio

1. Mineral NPK

Data in Table 3 revealed that mineral NPK rates significantly affected bulbing ratio in the second season only. Application of 75 and100% NPK gave the highest values of bulbing ratio (0.287 and 0.288) in the first and second seasons, respectively. Application of 100% of NPK gave lowest values (0.279) in the first season, while application of 50 or 75% of NPK gave the lowest value (0.228) in the second season.

2. **Nano NPK L/fed**

Spraying onion with Nano NPK significantly affected bulbing ratio in the first and second seasons. Spraying with water (control treatment) appeared the highest values of bulbing ratio (0.293 and 0.295) in the first and second seasons respectively, whilst, spraying with Nano NPK at rate of 4 and 6L/fed appeared the lowest values (0.269 and 0.223) in the first and second seasons respectively. These results were in agreement with that found by Ekinci *et al.,* (2014); and Al-juthery and Al-Maamouri (2020) who found that Nanotechnology liquid fertilizers Ferbanat significantly affected the yield per plant 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,

3. Interaction

The interaction between the two studied factors had significant effect on bulbing ratio in the first and second seasons. The highest values (0.313 and 0.347cm) were obtained by using 50 or 25% mineral NPK fertilization and spraying with water, in the first and second seasons, respectively, while, using 50 or 25% NPK mineral fertilization and spraying with Nano NPK at rate of 4 or 6 L/fed., gave the lowest values (0.257 and 0.200), in the first and second seasons, respectively. Similar results were in coincidence with those stated by Tekalign *et al.,* (2012) and Sangakkara *et al.,* (2000) demonstrated that the increase in plant growth due to the role of potassium in biochemical pathways of the cells enlarge the photosynthetic rates, CO_2 assimilation and supports carbon movements

A.4. Fresh weight

1. Nano NPK L/fed

Spraying onion with Nano NPK significantly affected plant fresh weight in the first and second seasons. Spraying with Nano NPK at rate of 2 and 6 L /fed appeared the highest values of Plant fresh weight (209.7 and 212.6 g) in the first and second seasons respectively, whilst, spraying without Nano NPK (control treatment) appeared the lowest values (182.5 and 169.0 g) in the first and second seasons respectively.

2. Interaction

The interaction between the two studied factors had significant effect on plant fresh weight in the first and second seasons, the highest values of plant fresh weight (248.3 and 226.7 g) were obtained by using 100 and 75% mineral fertilization and spraying with water or Nano NPK at rate of 4 L/fed in the first and second seasons respectively, while using 50, 100% mineral NPK fertilization and spraying with Nano NPK at rate of 6 L/fed (59.2 and146.7 g) appeared the lowest values in the first and second seasons respectively.

B.Total bulb yield and its components

B.1 Bulb weight (g)

1. Mineral NPK rates

Data in Table 4 revealed that mineral NPK rates significantly affected bulb weight in the first and second seasons. Application of 100% NPK gave the highest values of bulb weight, while, application of 25% of NPK gave lowest values, in both seasons. Similar results were reported by 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. This may be attributed to the increase in plant height, number of leaves per plant and leaf length.

2. Nano NPK L/fed

Spraying onion with Nano NPK significantly affected of bulb weight in the first and second seasons. Spraying with Nano NPK at rate of 6 L/fed appeared the highest values of bulb weight (112.9 and 77.33 g), whilst, spraying with water (control treatment) appeared the lowest values (95.67 and 56.83 g) in the first and second seasons, respectively. These results were in agreement with that found by Ekinci *et al.,* (2014) who observed the highest average fruit weight of cucumber and fruit length from Nanonat 4.0 L ha-1. On the same line, El-Hefnawy (2020) used Nano NPK as a foliar spray for improving pea growth irrigated

3. Interaction

The effect of the interaction between the two studied factors was significant in the first and second seasons. the highest values of bulb weight (123.7 and 96.33 g.) were obtained by using 50% NPK mineral fertilization and spraying with Nano NPK at rate of 6 L/fed, or by using 100% mineral fertilization NPK and spraying with Nano NPK at rate of 6 L/fed, in the first and second season respectively. On the other hand, the lowest values of bulb weight (g.) (78.33 and 26.00g) were obtained by application of 50% or 25% mineral NPK and spraying with water (control treatment) in the first and second season, respectively.

B.2 Total yield (ton/fed.)

1. Mineral NPK rates

Data in Table 4 revealed that mineral NPK rates significantly affected of total yield (ton/fed.) in the first and second seasons. Application of 100% of mineral NPK gave the highest values of total yield, while, application of 25% of NPK gave lowest values in both seasons. Similar results were reported by, El-Tantawy and El-Beik (2009); Soleymani and Shahrajabian (2012); Esawy *et al.,* (2015) and Messele (2016) who reported that application of nitrogen at the rate of 50 kg ha-1 gave optimum total and marketable bulb yields without significantly influencing the quality of onion. El- Metwaly *et al.,* (2021) revealed that application of 120% NK-from recommended rate on garlic resulted in significant increases in most parameters, yield and its components. Such favorable effect of mineral nitrogen on total bulbs yield might be resulted from quickly providing nitrogen uptake in roots zone which resulted in more vegetative growth.

2. Nano NPK L/fed

Spraying onion with Nano NPK significantly affected total yield (ton/fed.) in the first and second seasons. Spraying with Nano NPK at rate of 6 L/fed appeared the highest values of total yield (18.17 and 19.71 ton/fed.) respectively, whilst, spraying with water (control treatment) appeared the lowest values (17.20 and 15.26 ton/fed.), these results were true in the first and second seasons respectively. These results were in agreement with that found by Monreal *et al.,* (2016) ; Rajonee *et al.,* (2017) and DeRosa *et al.,* (2010) who stated that nitrogen, which is one of the most important nutrients in agricultural production, might be given only very few parts to plant and soil need, although it has been reported that the use of very small Nano fertilizer particles is more effective than this rate. The effects of foliar application 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. The obtained results could be due to the physiological role of nitrogen in bimolecular compound such porphyrin that exist in metabolism process such as cytochrome and chlorophyll pigent, which the necessary in respiration and photosynthesis and coenzymes that promote by phosphorus and essential for most of enzyme and amino acid production that usage for production of protein (Espinosa *et al.,* 1999). However, potassium are responsible on enzyme activity and stable of protein (Hänsch and Mendel, 2009).

3. Interaction

The effect of the interaction between the two studied factors was significant in the first and second seasons. The highest values were obtained by using 75% and spraying with Nano NPK at rate of 6L/fed, in both seasons. On the other hand total yield (ton/fed.) appeared the lowest values of total yield (ton/fed.) by application of 25% of mineral NPK and spraying with 6 L/fed. or by water (control treatment) in the first and second seasons, respectively.

Table (3) Response of bulbing ratio and plant fresh weight (g) to mineral NPK fertilization and spraying with Nano NPK at 120 days during seasons of 2018/2019 and 2019/2020.

Treatments		2018/2019		2019/2020	
		Plant height (cm)	Bulbing ratio	Plant height (cm)	Bulbing ratio
NPK rates (A)					
100% NPK		88.42 A	0.279 A	88.31 A	0.288 A
75% NPK		86.89 A	0.286 A	86.92 B	0.228 B
50% NPK		86.53 A	0.283 A	85.44 C	0.228 B
25% NPK		85.22 A	0.281 A	80.44 D	0.280 A
Spraying rate (B)					
Control		84.17 B	0.293 A	82.56 B	0.295 A
Nono NPK 2 L/fed		86.94 AB	0.280 B	85.42 AB	0.254 B
Nono NPK 4 L/fed		87.56 AB	0.269 C	85.97 A	0.252 B
Nono NPK 6 L/fed		88.39 A	0.289 A	87.17 A	0.223 C
Interaction (A X B)					
100% NPK	**Control**	87.67 ab	0.283 abcd	88.56 abcd	0.317 b
	Nano 2 L/fed	84.33 ab	0.263 cd	87.22 abcd	0.287 c
	Nano 4 L/fed	91.67 a	0.273 bcd	86.00 abcd	0.293 bc
	Nano 6 L/fed	90.00 a	0.297 abc	91.44 a	0.257 de
75% NPK	**Control**	83.33 ab	0.293abcd	86.56 abcd	0.257 de
	Nano 2 L/fed	89.78 a	0.307 ab	89.78 abc	0.233 ef
	Nano 4 L/fed	86.78 ab	0.270 bcd	83.67 bcde	0.220 fgh
	Nano 6 L/fed	87.67 ab	0.280 abcd	87.66 abcd	0.200 h
50% NPK	**Control**	85.89 ab	0.313 a	81.89 de	0.260 d
	Nano 2 L/fed	87.56 ab	0.273 bcd	86.33 abcd	0.227 fg
	Nano 4 L/fed	85.22 ab	0.257 d	90.78 ab	0.220 fgh
	Nano 6 L/fed	87.44 ab	0.287 bcd	82.78 cde	0.203 gh
25% NPK	**Control**	79.78 b	0.280 abcd	73.22 f	0.347 a
	Nano 2 L/fed	86.11 ab	0.2733 bcd	78.33 ef	0.270 cd
	Nano 4 L/fed	86.56 ab	0.277 abcd	83.44 bcde	0.273 cd
	Nano 6 L/fed	88.44 ab	0.293 abcd	86.78 abcd	0.230 f

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

Table (4) Response of bulb weight (g) and total yield (t/fed) to mineral NPK fertilization and spraying with Nano NPK during seasons of 2018/2019 and 2019/2020.

Treatments		2018/2019		2019/2020	
		Bulb weight (g)	Total yield (ton/fed.)	Bulb weight (g)	Total yield (ton/fed.)
NPK rates (A)					
100% NPK		115.6 A	19.26 A	82.33 A	18.98 A
75% NPK		109.5B	18.97 A	72.08 B	17.72 B
50% NPK		99.50C	17.58 B	66.25 B	17.38 B
25% NPK		89.50D	15.39 C	48.17 C	15.04 C
Spraying rate (B)					
Control		95.67 C	17.20 B	56.83 D	15.26 D
Nono NPK 2 L/fed		99.83 C	17.74 AB	64.00 C	16.49 C
Nono NPK 4 L/fed		105.7B	18.09 A	70.67 B	17.66 B
Nono NPK 6 L/fed		112.9 A	18.17 A	77.33 A	19.71 A
Interaction (A X B)					
100% NPK	**Control**	113.7 abc	17.15 fgh	74.00 bcde	16.79 def
	Nano 2 L/fed	113.0 abc	19.98 ab	75.67 bcd	18.93 bc
	Nano 4 L/fed	115.3 abc	19.89 abc	83.33 b	19.82 ab
	Nano 6 L/fed	120.3 ab	20.02 ab	96.33 a	20.36 a
75% NPK	**Control**	101.3 def	17.90 efg	80.33 bc	15.43 g
	Nano 2 L/fed	105.0 cde	18.12 defg	74.33 bcde	16.63defg
	Nano 4 L/fed	120.3 ab	19.45 abcde	61.67 e	17.93 cd
	Nano 6 L/fed	111.3 bcd	20.41a	72.00 bcde	20.88 a
50% NPK	**Control**	78.33 i	15.44 ij	47.00 f	16.47 efg
	Nano 2 L/fed	101.7 def	16.83 ghi	73.67 bcde	16.90 def
	Nano 4 L/fed	94.33 efg	18.47 bcdef	68.00 cde	17.23 de
	Nano 6 L/fed	123.7 a	19.60 abcd	76.33 bcd	18.93 bc
25% NPK	**Control**	89.33 gh	18.31 cdefg	26.00 g	12.34 H
	Nano 2 L/fed	79.67 hi	16.02 hij	32.33 g	13.49 H
	Nano 4 L/fed	92.67 fg	14.55 j	69.67 bcde	15.67 FG
	Nano 6 L/fed	96.33 efg	12.66 k	64.67 de	18.67 BC

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

B.2. Exportable Bulbs yield (ton/fed.)

1. Mineral NPK rates

Data in Table 5 revealed that mineral NPK rates significantly affected exportable bulbs yield (ton/fed.) in the first and second seasons. Application of 100% NPK gave the highest values of exportable bulbs yield (ton/fed.) (16.00 and 16.46 t/fed), while application of 25% of mineral NPK gave lowest values (12.68 and 13.64 ton/fed), in the first and second seasons respectively. Similar results were reported by Tekeste *et al.,(*2018) and Nigatu *et al.*,(2018) who reported that onion plants supplied with 105:119.6:22 kg ha-1 N:P2O5:S fertilizer rate gave the highest mean marketable yield (20.8ton ha-1).

2. Nano NPK L/fed

Spraying onion with Nano NPK significantly affected exportable bulbs yield (ton/fed.) in the first and second seasons. Spraying with Nano NPK at rate of 6L /fed appeared the highest values of exportable bulbs yield (16.49 and 16.93 ton/fed.) in the first and second seasons respectively, whilst, spraying with water (control treatment) appeared the lowest values (12.87 and 13.45 ton/fed), in the first and second seasons respectively. These results were in agreement with that found by Gosavi *et al.,* (2017) who reported 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. The results of this experiment agreed with that obtained by Manikandan and Subramaian (2016); Gomaa *et al.,* (2017); Kandil and Marie (2017); and 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, which is the result of 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 has a direct impact on the plant height as it is the necessary element to build the amino acid Tryptophan It is the main building material for building indol acetic acid (IAA), which is the main hormone in the plant (Wareaing, 1983; AL-Asady and AL-Kikkhani, 2019). Nitrogen also has an important role in the molecular structure of essential biomolecules in photosynthesis and respiration, as well as the role of phosphorus in the construction and activation of coenzymes necessary for the work of many enzymes and the production of amino acids that contribute to the construction of protein (Espinosa, 1999). Potassium is mainly responsible for the enzymatic activity and stability of proteins (Hänsch and Mendel, 2009), and the regulatory role in the mechanism of closing and opening stomata, which is positively reflected in increasing the efficiency of photosynthesis process and thus increase its growth due to the good balance between the elements of nitrogen, phosphorus and potassium (Shabala, 2003)

3. Interaction

The effect of the interaction between the two studied factors was significant in the first and second seasons. The highest values of exportable bulbs yield (17.25 and 18.00 ton/fed.) were obtained by using 75% of mineral fertilization and spraying with Nano NPK at rate of 6 L/fed, in the first and second seasons respectively. On the other hand the lowest values of exportable bulbs yield (11.10 and 11.89 ton/fed) were obtained by application of 25% of mineral NPK and spraying with water (control treatment), in the first and second seasons respectively.

B.3. Local Marketable yield (ton/fed)

1. Mineral NPK rates

Data in Table 5 revealed that mineral NPK rates significantly affected local bulbs yield (ton/fed.) in the second seasons only, where, application of 25% NPK gave the highest value (2.783 ton/fed.), while, application of 75% of NPK gave the lowest value, (1.720 ton/fed) these results were true in the second seasons. Similar results were reported by Aregay *et al.,* (2009); Eldardiry *et al.*, (2015), and Hafez and Geries (2018).

2. Nano NPK L/fed

Spraying onion with Nano NPK significantly affected local bulbs yield in the second season only, where, spraying with Nano NPK at rate of 6 L/fed appeared the highest values of local bulbs yield (2.783 ton/fed) in the second seasons. On the other hand, the lowest value (1.720 ton/fed) was obtained by spraying with Nano NPK at rate of 2 L/fed. These results were in agreement with that found by Liu *et al.,* (2009); Kole *et al.,* (2013), Sirisena *et al.,* (2013), who study the significance of Nanofertilizers to improve plant characteristics, the application of Nano-K fertilizer increased rice grain yield.

3. Interaction

The effect of the interaction between the two studied factors was significant of local bulbs yield (ton/fed.) in the first and second seasons. The highest values of local bulbs yield were obtained by using 100% mineral fertilization and spraying with Nano NPK at rate of 2 or 4 L/fed, in the first and second seasons, respectively. On the other hand the lowest values of local bulbs yield were obtained by application of 25% of mineral NPK and spraying with Nano NPK at rate of 4 L/fed in the first season and by application of 25% of mineral NPK and spraying with water (control treatment) in the second season.

C. Bulb quality

C1.Dry matter Percentage (%)

1. Mineral NPK rates

Data in Table 6 revealed that mineral NPK rates significantly affected dry matter% in the first and second seasons. Application of 100% NPK gave the highest values (17.11 and 16.75%) of dry matter % in the first and second seasons respectively. while, application of 25% of NPK gave the lowest values (15.62 and 15.29%), in the first and second seasons 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.

2. Nono NPK L/fed

Spraying onion with Nano NPK significantly affected dry matter% in the first and second seasons. Spraying with Nano NPK at rate of 6L /fed appeared the highest values of dry matter % (16.51 and 16.83%) in the first and second season respectively, whilst, spraying with water (control treatment) appeared the lowest values (15.66 and 15.13%), 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. 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, by Shami (2019) who studied the effect of Nano-nitrogen fertigation on potato yield.

3. Interaction

The effect of the interaction between the two studied factors was significant on dry matter % in the first and second seasons. The highest values (17.47 and 17.70%) were obtained by using 100% mineral fertilization and spraying with Nano NPK at rate of 6 or 4 L/fed, in the first and second seasons respectively, while using 50 or 25% mineral NPK, and spraying with water appeared the lowest values (14.77 and 14.37%) of dry matter% in the first and second seasons respectively.

C2.Total Soluble Solids Percentage (T.S.S. %)

1. Mineral NPK rates

Data in Table 6 revealed that mineral NPK rates significantly affected T.S.S % in the first and second seasons. Application of 100% NPK gave the highest values (14.67 and 14.74%) of T.S.S%, while, application of 25% of NPK gave lowest values (13.53 and 13.41%), in the first and second seasons respectively. Similar results were reported by Moursy *et al.,* (2007) and Mousa *et al.,* (2009) who 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 application 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 application of 120 kg N ha-1 led to the highest values of TSS whereas, application of 90 kg N ha-1 resulted in the lowest values of TSS in both seasons.

2. Nano NPK L/fed

Spraying onion with Nano NPK significantly affected of T.S.S% in the first and second seasons. Spraying with Nano NPK at rate of 6 L/fed appeared the highest values of T.S.S% (14.86 and 14.53%) in the first and second seasons respectively, whilst, spraying with water (control treatment) and spraying with Nano NPK at rate of 2 L/fed appeared the lowest values (13.64 and 13.55%), in the first and second seasons, respectively. It seems that when foliar nutritionals 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 (Ibrahim and Mohamed, 2012b). 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 revealed 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.

3. Interaction

The effect of the interaction between the two studied factors was significant of T.S.S. % in the first and second seasons. The highest values (15.37 and 15.40%) were obtained by using 75% or 100% mineral fertilization and spraying with Nano NPK at rate of 6 or 4 L/fed, in the first and second seasons respectively. While, using 25% mineral NPK and spraying with water or spraying Nano NPK at rate of 2 L/fed appeared the lowest values of T.S.S. % (12.83 and 13.00%) in the first and second seasons respectively.

Table (5) Response of exportable yield (t/fed) and local yield (ton/fed) to mineral NPK fertilization and spraying with Nano NPK during seasons of 2018/2019 and 2019/2020.

Treatments		2018/2019		2019/2020	
		Export. yield (t/fed.)	Local yield (t/fed.)	Export. yield (t/fed.)	Local yield (t/fed.)
NPK rates (A)					
100% NPK		16.00 A	3.256 A	16.46 A	1.803 B
75% NPK		15.89 A	3.077 A	15.58 B	1.720 B
50% NPK		13.96 B	3.629 A	15.15 B	1.989 B
25% NPK		12.68 C	2.704 A	13.64 C	2.783 A
Spraying rate (B)					
Control		12.87 D	2.918 A	13.45 D	1.803 B
Nono NPK 2 L/fed		14.03 C	3.712 A	14.77 C	1.720 B
Nono NPK 4 L/fed		15.14 B	2.947 A	15.68 B	1.989 B
Nono NPK 6 L/fed		16.49 A	3.088 A	16.93 A	2.783 A
Interaction (A X B)					
100% NPK	Control	14.91 cd	2.230 ab	14.80 efgh	1.993 abcd
	Nano 2 L/fed	15.49 bc	4.500 a	16.62 abc	2.317 abc
	Nano 4 L/fed	16.54 ab	3.347 ab	16.64 abc	3.180 a
	Nano 6 L/fed	17.07 a	2.947 ab	17.77 ab	2.590 ab
75% NPK	Control	13.83 de	4.073 a	13.46 hi	1.970 abcd
	Nano 2 L/fed	15.56 bc	2.557 ab	14.80 efgh	1.827 abcd
	Nano 4 L/fed	16.93 a	2.523 ab	16.09 cde	1.843 abcd
	Nano 6 L/fed	17.25 a	3.153 ab	18.00 a	2.887 a
50% NPK	Control	11.64 g	3.803 ab	13.68 ghi	2.800 a
	Nano 2 L/fed	13.14 ef	3.690 ab	15.04 defg	1.860 abcd
	Nano 4 L/fed	14.07 de	4.403 a	15.48 cdef	1.760 abcd
	Nano 6 L/fed	16.98 a	2.620 ab	16.39 bcd	2.540 ab
25% NPK	Control	11.10 g	1.567 b	11.89 j	0.4467 d
	Nano 2 L/fed	11.92 fg	4.100 a	12.61 ij	0.8767 cd
	Nano 4 L/fed	13.04 ef	1.517 b	14.49 fgh	1.173 bcd
	Nano 6 L/fed	14.67 cd	3.633 ab	15.56 cdef	3.113 a

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

Table (6) Response of dry matter% and T.S.S% to mineral NPK fertilization and spraying with Nano NPK during seasons of 2018/2019 and 2019/2020.

Treatments		2018/2019		2019/2020	
		Dry matter %	T.S.S %	Dry matter %	T.S.S %
NPK rates (A)					
100% NPK		17.11 A	14.67 A	16.75 A	14.74 A
75% NPK		16.09 B	14.56 A	16.26 AB	14.02 B
50% NPK		15.88 BC	14.21 A	15.78 BC	13.77 B
25% NPK		15.62 C	13.53 B	15.29 C	13.41 B
Spraying rate (B)					
Control		15.66 B	13.46 B	15.13 D	13.85 BC
Nono NPK 2 L/fed		16.10 A	13.91 B	15.82 C	13.55 C
Nono NPK 4 L/fed		16.42 A	14.75 A	16.30 B	14.02 B
Nono NPK 6 L/fed		16.51 A	14.86 A	16.83 A	14.53 A
Interaction (A X B)					
100% NPK	Control	16.75 abc	14.12 abcdef	15.47 ef	14.33 bc
	Nano 2 L/fed	17.02 ab	14.35 abcde	16.33 cd	14.13 cde
	Nano 4 L/fed	17.21 ab	15.01 abc	17.70 a	15.40 a
	Nano 6 L/fed	17.47 a	15.20 ab	17.50 ab	15.10 ab
75% NPK	Control	15.37 efg	13.50 defg	15.33 ef	13.87 cdef
	Nano 2 L/fed	16.42 bcd	14.69 abcd	16.37 cd	13.87 cdef
	Nano 4 L/fed	16.00 cdef	14.67 abcd	16.37 cd	13.87 cdef
	Nano 6 L/fed	16.57 abcd	15.37 a	16.97 bc	14.50 abc
50% NPK	Control	14.77 g	12.97 fg	15.33 ef	13.93 cdef
	Nano 2 L/fed	15.67 def	13.77 cdefg	15.50 ef	13.20 ef
	Nano 4 L/fed	16.80 abc	15.33 a	15.87 de	13.67 cdef
	Nano 6 L/fed	16.29 bcde	14.79 abc	16.43 cd	14.30 bc
25% NPK	Control	15.75 def	13.25 efg	14.37 g	13.27 def
	Nano 2 L/fed	15.30 fg	12.83 g	15.10 f	13.00 f
	Nano 4 L/fed	15.69 def	13.99 bcdefg	15.27 ef	13.13 f
	Nano 6 L/fed	15.73 def	14.07 bcdefg	16.43 cd	14.23 bcd

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

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

حازم عبدالرحمن عبيد الله على، خالد احمد امين الشيخ، رفعت علام مرعى، امل زكى سدره بقطر

اجريت هذه الدراسة فى مزرعة التجارب الزراعية بمحطة بحوث جزيرة شندويل – مركز البحوث الزراعية – محافظة سوهاج، وذلك فى الموسم الشتوى للاعوام 2018/ 2019 و 2019/2020، لدراسة تاثير المعدلات المختلفة من التسميد المعدنى (نيتروجين-فوسفور-بوتاسيوم) مع الرش باسمدة النانو (نيتروجين-فوسفور-بوتاسيوم)، على النمو الخضرى والمحصول والجودة فى البصل. تمت الزراعة فى تجربة مصممة على نظام القطع المنشقة مرة واحدة مستخدما ثلاث مكررات. حيث تم وضع معدلات التسميد المعدنى فى القطع الرئيسية (100%، 75%، 50% و25% نيتروجين-فوسفور-بوتاسيوم)، بينما تم وضع معدلات الرش بسماد النانو فى القطع الشقية (كنترول، 2 لتر ، 4 لتر، و6 لتر للفدان). ويمكن تلخيص اهم النتائج المتحصل عليها فيما يلى: (أ) ادت اضافة 100% سماد معدنى (نيتروجين – فوسفور –بوتاسيوم) الى تحقيق اعلى القيم من طول النبات بينما ادت اضافة 25% الى تحقيق اقل القيم، فى كلا الموسمين، (ب) ادى الرش بسماد النانو (نيتروجين – فوسفور –بوتاسيوم) بمعدل 6 لتر للفدان الى تحقيق اعلى القيم من طول النبات، بينما ادى الرش بالماء (الكنترول) الى تحقيق اقل القيم، فى كلا الموسمين. (ج) اظهرت معاملة اضافة التسميد المعدنى بمعدل 100% (نيتروجين – فوسفور –بوتاسيوم) اعلى القيم من المحصول الكلى من الابصال، بينما اظهرت معاملة 25% اقل القيم، فى كلا الموسمين.

(د) اعطت معاملة الرش بأسمدة النانو (نيتروجين – فوسفور – بوتاسيوم) بمعدل 6 لتر للفدان اعلى قيمة من المحصول الكلى للفدان، بينما اعطت معاملة الرش بالماء (معاملة الكونترول) اقل القيم، فى كلا الموسمين. (ه) تم الحصول على اعلى قيمة من المحصول الكلى للفدان من خلال التسميد بمعدل 75% (نيتروجين – فوسفور –بوتاسيوم)، مع الرش الورقى بسماد النانو بمعدل 6 لتر للفدان، فى كلا الموسمين. (و) تم الحصول على اعلى قيمة من المحصول التصديرى للبصل من خلال المعاملات 75% من التسميد المعدنى (نيتروجين – فوسفور –بوتاسيوم)، مع الرش الورقى بمعدل 6 لتر للفدان من سماد النانو (نيتروجين – فوسفور –بوتاسيوم)، فى كلا الموسمين، فى حين تم الحصول على اقل القيم من خلال التسميد بمعدل 25% من التسميد المعدنى ، مع الرش بالماء (معاملة الكونترول)، فى كلا الموسمين.