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Original Research

Response of Onion Fresh Weight, Nutrients Uptake, Nitrogen Use Efficiency, Yield, and Bulb Quality to Different Nitrogen Fertilization Levels and Plant Density

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Abstract

A field experiment was carried out during the two successive winter seasons of 2020-2021 and 2021-2022, in the private vegetable farm at Diarb Negm District, Sharkia Governorate, Egypt, to study the effect of mineral nitrogen levels and plant density on fresh weight, total N, P, and K uptake, total yield, nitrogen use efficiency, and bulb quality of the onion (cv. Ahmar tantawy). This experiment included 12 treatments, which were combinations between four levels of mineral nitrogen (0, 192, 240, and 288 kg N/ha) and three plant densities (4, 5, and 6 rows per ridge, equalling 33.33, 41.67, and 50 plants per m2, respectively). These treatments were arranged in a split-plot design with three replications. Nitrogen levels were randomly arranged in the main plots, and plant densities were randomly distributed in the subplots. The interaction between nitrogen levels at 288 kg N/ha and plant density (4 rows/ridge) gave the highest values of fresh weight of leaves, bulbs, and total

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fresh weight/plant, percentages of the yield of grade 1, grade 2, and exportable yield from total yield, and increased total N, P, and K uptake by the plant, total carbohydrates, total sugars, and vitamin C contents in bulbs. The interaction between N at 244 kg/ha and high plant density (6 rows/ridge) increased total yield per hectare and nitrogen use efficiency in onion plants.

Keywords: onion, nitrogen levels, yield, bulb quality, nitrogen use efficiency

Introduction

Onion (*Allium cepa* L.) belongs to the family Amaryllidaceae, it is one of the most important vegetable crops. It has a medicinal value, contains carbohydrates, protein, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid [1]. Increasing crop yields is significantly aided by appropriate crop management. The primary causes of the low productivity in vegetable production are the lack of technical knowledge and skill among farmers and development agents [2]. The environment and crop variety may influence the optimal level of agronomic practices like plant population density and fertilizer rate [3]. To optimize onion productivity a full package of information is required for specific growing system. The ideal plant population density makes efficient use of the land resources while, avoiding intense competition between plants for growth factors like light, water, and nutrients. If the plants were grown at the ideal density, they could produce more seeds and have better control over bulbs that were too big or too small. Therefore, controlling plant spacing is a useful method for controlling bulb size, shape, and yield [4-6]. Inadequate fertilization and the cultivation of unsuitable varieties in an area's agroclimatic conditions are to blame for the low onion production. Fertilization is very important technique in the agricultural system to increase the yield and the productivity. Nitrogen is a significant element for increasing bulb size and yield in onions and plays an important role in achieving the highest possible yield. It is an important element for many important substances such protein and nucleic acids [7-10]. An attempt has been made by several workers to find out the optimum plant spacing and nitrogen fertilizer for onion plants to maximize total yield with the best quality and improve storability, especially under old land conditions. The plants grown at a wider spacing received more nutrients, light, and moisture around each plant compared to plants at a closer spacing. This is probably the cause of the better performance and yield of individual onions grown at a wider spacing. Also, these plants with wider spacing produced the highest percentage of multiplier bulbs, which were not better for storing or meeting consumer demand [11-13]. Whereas the plants grown under the closest spacing gave the maximum total yield of onions due to the presence of more plants, resulting in the highest total yield. But the size of the bulbs under the closest spacing was so small that they were not suitable for marketing due to consumers' choices [14]. Therefore, the aim of this study was to estimate the response of onion fresh weight, nutrients uptake, nitrogen use efficiency, yield, and bulb quality to different nitrogen fertilization levels and plant density.

Table 1. The physical and chemical properties of the experimental soil in 2020/2021 and 2021/2022 seasons.

Soil properties	1st season	2nd season
Physical properties		
Sand (%)	90.24	90.69
Silt (%)	7.40	6.18
Clay (%)	2.36	3.13
O.M (%)	0.04	0.06
Texture	Sandy	Sandy
Chemical properties		
pH	8.19	8.16
E.C. (mmhos/cm)	2.08	1.99
Total N (%)	0.02	0.03
Available N (ppm)	4.07	3.98
Available P (ppm)	3.17	3.36
Available K (ppm)	10.24	9.91

Note: O.M: Organic matter and E.C: Electric conductivity. Soil samples were taken from 25 cm soil surface.

Experimental

Field Experiment

A field experiment was carried out during the two successive winter seasons of 2020/2021 and 2021/2022 on the private farm at Diarb Negm District, Sharkia Governorate, Egypt, to study the effect of mineral nitrogen levels and plant density on dry weight, yield, and its components, as well as bulb quality of onions onion (cv. Ahmar Tanawy).

This experiment included 12 treatments, which were combinations between four levels of mineral nitrogen (0, 192, 240, and 288 kg N/ha), and three plant densities (4, 5, and 6 rows/ridge equal 33.33, 41.67, and 50 plants/m^2, respectively). These treatments were arranged in a split-plot design with three replications. Nitrogen levels were randomly arranged in the main plots, and plant densities were randomly distributed in the subplots. Nitrogen levels were in the form of ammonium sulphate (20.6% N) and added as a soil application (three portions) every month, beginning one month after transplanting. Seeds of onion were sown in the nursery on November 5th and 10th in the 2020/2021 and 2021/2022 seasons,

Table 2. The plant densities and number of plants per m^2 and hectare.

Plant densities	Wide (cm)		Plant spacing (cm)	Area/ plant (m^2)	Number of plants per	
	ridge	row			m^2	ha
4 rows / ridge	120	30	10	0.03	33.33	333300
5 rows / ridge	120	24	10	0.024	41.67	417700
6 rows / ridge	120	20	10	0.02	50	500000

respectively. Onion transplants were transplanted on December 25th and 28th in the first and second seasons, respectively, at 10 cm apart. All experimental units had an area of 21.6 m^2, and they contained three ridges with a length of 6 m and a width of 120 cm. One ridge was used for the samples to measure vegetative growth, and the other two ridges were used for yield determination. Plant densities and the number of plants per m^2 and hectare are presented in Table 2.

Phosphorus and potassium were added at a rate of 144 and 204 kg/ha in the form of calcium superphosphate (16-18% P_2O_5) and potassium sulphate (48-52% K_2O), respectively. All the amounts of phosphorus fertilizer and one fourth of the amounts of K mineral fertilizer were added during soil preparation. The K fertilizer dose was divided into three portions and added to the soil every month, the first dose was added 30 days after transplanting.

Sampling and Measurements

Plant growth: Ten plants from each plot were randomly taken at 100 days after transplanting, and the following data were recorded: Fresh weight of different parts of the onion, i.e., bulb and leaves, as well as total fresh weight (bulb + leaves) per plant.

Nitrogen, phosphorus, and potassium total uptake: The contents of nitrogen, phosphorus, and potassium were assayed in the dry matter from 5 random samples of bulbs and leaves at 100 days after planting in both seasons. The samples were finely ground and wet digested for N, P, and K determinations according to the methods advocated by Jackson [15] and Olsen et al. [16], respectively. N, P, and K uptake in bulbs and leaves and their total uptake were calculated.

Total yield and yield components percentage: At the proper maturity stage of the bulbs, bulbs from each plot were harvested and graded into four categories according to specifications laid down by the Ministry of Economic Affairs for onion exportation (1963) as follows: Grade 1: Bulbs with a diameter above 5.5 cm; grade 2: bulbs with a diameter between 4.5 and 5.5 cm; grade 3: bulbs with a diameter between 3.5 and 4.4 cm; and grade 4: bulbs with a diameter less than 3.5 cm. Each grade was weighed separately on the same day, and the following data was recorded: Total yield (grade 1+ grade 2 + grade 3 + grade 4) tonne/ha.

Nitrogen use efficiency (NUE): It was determined by dividing the bulb yield/ ha by the nitrogen quantity/ ha and expressed as kg bulb/kg N.

Bulbs quality: At harvest time, five bulbs were randomly taken from each treatment and oven dried at 70ºC until constant weight, and the chemical constituents of onion bulbs during the two seasons were determined as follows: Total carbohydrate (%): It was determined calorimetrically as outlined by DuBois et al. [17], and ascorbic acid (Vitamin C) was assayed in juice (mg/100 g FW) using 2,6 dichlorophenol indophenol dye [18].

Statistical analysis: Collected data were subjected to proper statistical analysis of variance and the differences among treatments were compared using Duncan's multiple range test [19].

Results

Fresh Weight of Leaves/Plant, Fresh Weight of Bulb, and Fresh Weight of Plant

The effect of nitrogen levels, plant density and their interaction on fresh weight of leaves/plant (g), fresh weight of bulb (g), and fresh weight of plant (g) at 100 days from transplanting of onion plants during 2020/2021 and 2021/2022 seasons are presented in Table 3. At 100 days after transplanting, the fresh weight of the leaves per plant, the fresh weight of the bulb, and the fresh weight of the plant were significantly affected by the nitrogen fertilizer levels (192, 240, and 288 Kg/ha). From 192 to 240 and 288 kg N/ha, all the examined growth characteristics rose significantly, and the variations were noticeable throughout both growing seasons. In both growing seasons, the best results were seen 100 days after transplanting when the greatest nitrogen fertilizer application (288 kg N/ha) was used. The low plant density (4 rows/ridge) produced the highest growth parameters at 100 days from transplanting in both seasons, followed by 5 rows/ridge and 6 rows/ridge. Plant densities of up to 6 rows per ridge at 100 days in both seasons resulted in a decrease in the fresh weight of the leaves per plant, the fresh weight of the bulb, and the fresh weight of the plant (Table 2). Maximum values for leaf, bulb, and total fresh weight per plant were found at 100 DAT in both seasons when nitrogen levels were 288 kg N/ha and plant density was 4 rows/ridge (Table 3).

Table 3. Effect of nitrogen levels, plant density and their interaction on fresh weight of leaves/plant (g), fresh weight of bulb (g), and fresh weight of plant (g) at 100 days from transplanting of onion plants during 2020/2021 and 2021/2022 seasons.

Nitrogen levels kg /ha. (NL)	Plant density (PD)			Mean (NL)
	4 rows/ridge	5 rows/ridge	6 rows/ridge	
Fresh weight of leaves/plant (g)				
	2020/2021 season			
0	33.40fg	28.31h	26.16i	29.29d
192	44.77b	34.10ef	32.07g	36.98b
240	39.32c	35.59de	32.27g	35.72c
288	48.53a	43.09b	37.12d	42.91a
Mean (PD)	41.50a	35.27b	31.90c	
	2021/2022 season			
0	17.96f	16.27g	15.43h	16.55d
192	21.12c	20.25d	18.28f	19.88c
240	24.45b	19.52e	18.11f	21.15b
288	25.84a	20.84cd	20.27d	21.85a
Mean (PD)	22.34a	19.22b	18.02c	
Fresh weight of bulb (g)				
	2020/2021 season			
0	17.85de	17.06ef	15.82g	16.91c
192	19.47c	18.55cd	16.69fg	18.23b
240	22.10b	17.05ef	17.60def	18.91b
288	25.47a	19.24c	17.78de	20.83a
Mean (PD)	21.22a	17.97b	16.97c	
	2021/2022 season			
0	24.12d	19.07f	15.65g	19.61d
192	26.44b	25.56bc	21.59e	24.53c
240	29.01a	25.09cd	22.40e	25.50b
288	30.09a	26.26b	22.41e	26.25a
Mean (PD)	27.41a	23.99b	20.51c	
Total fresh weight of plant (g)				
	2020/2021 season			
0	51.25ef	45.36h	41.98i	46.19c
192	64.24b	52.65e	48.76g	55.21b
240	61.42c	52.64e	49.86fg	54.64b
288	73.99a	62.32c	54.90d	63.73a
Mean (PD)	62.72a	53.24b	48.87c	
	2021/2022 season			
0	53.38e	45.49g	42.77h	47.21c
192	57.32cd	55.85d	49.96f	54.37b
240	63.90b	55.49de	47.87f	55.75b
288	72.12a	65.72b	59.56c	65.80a
Mean (PD)	61.68a	55.63b	50.04c	

Note: Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

Table 4. Effect of nitrogen levels, plant density and their interaction on N, P, and K-uptake (mg) of onion plants at 100 days from transplanting of onion plants during 2020/2021 and 2021/2022 seasons.

Nitrogen levels kg /ha. (NL)	Plant density (PD)			Mean (NL)
	4 rows/ridge	5 rows/ridge	6 rows/ridge	
N-uptake (mg)				
	2020/2021 season			
	2021/2022 season			
0	307.65gh	267.62hi	246.42i	273.90c
192	438.92bcd	402.32cde	344.30fg	395.18b
240	441.73bc	390.69def	359.91efg	397.44b
288	632.89a	486.78b	396.04c-f	505.24a
Mean (PD)	455.30a	386.85b	336.67c	
	2021/2022 season			
0	332.26g	311.63h	266.53i	303.47d
192	445.01c	401.96de	386.09ef	411.02b
240	407.52d	376.22f	373.53f	385.76c
288	545.33a	481.71b	455.10c	494.05a
Mean (PD)	432.53a	392.88b	370.31c	
P-uptake (mg)				
	2020/2021 season			
0	47.89ef	44.21f	38.21g	43.43d
192	72.38c	66.10d	50.67e	63.05c
240	74.06bc	73.31bc	63.99d	70.45b
288	95.50a	78.40b	66.73d	80.21a
Mean (PD)	72.45a	65.50b	54.90c	
	2021/2022 season			
0	50.98g	48.43g	37.48h	45.63d
192	81.18b	73.76cd	70.82d	75.25b
240	76.08c	64.92e	57.67f	66.22c
288	88.49a	76.70c	71.16d	78.78a
Mean (PD)	74.18a	65.95b	59.28c	
K-uptake (mg)				
	2020/2021 season			
0	240.13fg	208.76gh	186.48h	211.79d
192	344.75bc	302.75de	247.69f	298.40c
240	361.25bc	330.28cd	293.52e	328.35b
288	464.03a	367.20b	311.20de	380.81a
Mean (PD)	352.54a	302.25b	259.72c	
	2021/2022 season			
0	246.76g	244.76g	198.65h	230.06d
192	363.90bc	310.45f	292.28f	322.21c
240	370.73bc	337.87de	315.92ef	341.51b
288	462.85a	379.18b	355.44cd	399.16a
Mean (PD)	361.06a	318.06b	290.57c	

Note: Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

Table 5. Effect of nitrogen levels, plant density and their interaction between them on total yield (ton/ha.) of onion plants during 2020/2021 and 2021/2022 seasons.

Nitrogen levels kg/ha. (NL)	Plant density (PD)			Mean (NL)
	4 rows/ridge	5 rows/ridge	6 rows/ridge	
	2020/2021 season			
0	14.470f	16.109f	16.548f	15.710c
192	27.358e	28.289e	33.038d	29.561b
240	38.86 8c	40.951abc	42.014ab	40.610a
288	39.571bc	40.798abc	42.742a	41.038a
Mean (PD)	30.067c	31.536b	33.586a	
	2021/2022 season			
0	15.144f	16.207f	16.949f	16.099c
192	28.010e	28.178de	30.804d	28.997b
240	35.906c	37.781bc	39.708ab	37.798a
288	37.109bc	38.878ab	40.831a	38.940a
Mean (PD)	29.042b	30.262b	32.074a	

Note: Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

Table 6. Effect of nitrogen levels, plant density, and their interaction between them on nitrogen use effectiveness (kg bulb per kg nitrogen) of onion plants during the 2020/2021 and 2021/2022 seasons under clay soil conditions.

Nitrogen levels kg /ha. (NL)	Plant density (PD)			Mean (NL)
	4 rows/ridge	5 rows/ridge	6 rows/ridge	
	2020/2021 season			
0	0.000h	0.000h	0.000h	00.00d
192	67.13f	63.44g	85.89e	72.15c
240	101.6c	103.5b	106.1a	103.76a
288	87.16e	85.73e	90.95d	87.95b
Mean (PD)	85.32b	84.23b	94.32a	
	2021/2022 season			
0	0.000j	0.000j	0.000j	00.00d
192	67.01h	62.35i	72.16g	67.17c
240	86.51c	89.89b	118.5a	98.31a
288	76.27f	78.72e	82.93d	79.31b
Mean (PD)	76.60b	76.99b	91.21b	

Note: Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

N, P and K-uptake of Onion Plants

The effect of nitrogen levels, plant density and their interaction on N, P, and K-uptake (mg) of onion plants at 100 days from transplanting of onion plants during 2020/2021 and 2021/2022 seasons are presented in Table 4. Data in Table 4 show the effect of nitrogen fertilizer levels on N, P, and K total uptake. Application of the highest level of nitrogen fertilizer at 288 kg/ha gave the highest values for total N, P, and K uptake by the onion plant at 100 days in both seasons. Planting onion plants with low plant density (4 rows per ridge) gave the plant's highest values of total N, P, and K uptake at 100 days in both seasons. The interaction between the N rate at

Table 7. Effect of nitrogen levels, plant density, and their interaction between them on total carbohydrates (%) and vitamin C (mg/100 g FW) in bulbs at harvesting time of onion plants during the 2020/2021 and 2021/2022 seasons under clay soil conditions.

Nitrogen levels kg /ha. (NL)	Plant density (PD)			Mean (NL)
	4 rows/ridge	5 rows/ridge	6 rows/ridge	
Total carbohydrates (%)				
	2020/2021 season			
0	48.91f	49.30f	44.64g	47.61d
192	65.27bc	63.71cd	57.40e	62.12c
240	66.37b	63.51d	63.60cd	64.49b
288	71.61a	66.46b	65.21bc	67.76a
Mean (PD)	63.04a	60.74b	57.71c	
	2021/2022 season			
0	51.54e	49.46f	42.06g	47.68d
192	49.75f	50.31f	64.29d	54.78c
240	65.85c	65.87c	64.20d	65.30b
288	72.43a	67.37b	67.46b	69.08a
Mean (PD)	59.89a	58.25b	59.50a	
Vitamin C (mg /100 g FW)				
	2020/2021 season			
0	12.94g	11.87hi	11.48i	12.09c
192	13.71f	12.44gh	12.83g	12.99b
240	17.06b	16.19c	14.37de	15.87a
288	18.37a	14.69d	13.89ef	15.65a
Mean (PD)	15.52a	13.79b	13.14c	
	2021/2022 season			
0	12.96gh	11.89i	12.58h	12.47d
192	13.68f	14.34de	12.85h	13.62c
240	14.73d	13.88ef	13.59fg	14.06b
288	16.21c	17.04b	18.34a	17.19a
Mean (PD)	14.39a	14.28a	14.34a	

Note: Values having the same alphabetical letter(s) did not significantly difference at the 0.05 level of significance, according to Duncan's multiple range test.

288 kg /ha and plant density at 4 rows/ridge increased N, P, and K total uptake by plants at 100 days in both seasons (Table 4). In general, under low plant density (4 rows/ridge), all N levels (192, 244, and 288 kg/ha) as well as control increased total N, P, and K uptake by plants compared to high plant density (5 and 6 rows/ridge) with all N levels.

Total Yield

The effect of nitrogen levels, plant density and their interaction on total yield (ton/ha.) of onion plants during 2020/2021 and 2021/2022 seasons are presented in Table 5. Results in Table 4 showed that the total yield was significantly affected by nitrogen fertilizer levels. Application of 288 kg N/ha produced the highest total yield in both seasons. High plant density (6 rows per ridge) increased total yield in both seasons (Table 5). The interaction between N at 244 kg/ha and high plant density (6 rows/ridge) increased total yield/ha with no significant differences with the interaction between N at 288 kg/ha and plant density (5 and 6 rows/ridge), as shown in Table 5.

Nitrogen Use Efficiency (NUE)

Data in Table 6 illustrate that N at 244 kg /ha gave the highest NUE by onion plant (103.76 and 98.31 kg bulb/kg N), followed by N at 288 kg/ha (87.95 and 79.31 kg bulb/kg N) in the 1st and 2nd seasons, respectively. Nitrogen use efficiency increased with increasing plant density up to 6 rows per ridge (Table 6). This means that high plant density (6 rows per ridge) gave the highest NUE by onion plant (94.32 and 91.21 kg bulb per kg N) in the 1st and 2nd seasons, respectively. The interaction between N at 244 kg/ha and plant density at 6 rows/ridge increased NUE by onion plants (106.1 and 118.5 kg bulb/kg N), followed by the interaction between N at 244 kg/ha and plant density at 5 rows/ridge (103.5 and 89.89 kg bulb/kg N) in the 1st and 2nd seasons, respectively.

Bulb Quality

Total carbohydrates and vitamin C in the bulb significantly increased with increasing N up to 288 kg N/ha (Table 7). Planting at low plant density (4 rows per ridge) significantly increased total carbohydrates and vitamin C in bulbs, except for vitamin C content in the 2nd season. Data in Table 6 show that the interaction between N at 288 kg/ha and planting at 4 rows/ridge increased total carbohydrates and vitamin C contents, except vitamin C content in the 2nd season.

Discussion

Onion is a very important crop in Egypt, it is highly sought after both domestically and abroad. After rice and citrus, it is third in this category [20]. Selecting the optimal level of mineral nitrogen and plant density are just two of the many agricultural practices that determine the productivity of onions. Nitrogen fertilizer is very important element for all living processes in enhancing the productivity in the plant [7]. It is the limiting nutrient and very important element in agricultural production. The excess of nitrogen hindered the bulbs from ripening properly and made them of poor storage quality, despite the fact that nitrogen is required for increasing bulb size and productivity [21, 22].

In the present study, at 100 days after transplanting, the fresh weight of the leaves per plant, the fresh weight of the bulb, and the fresh weight of the plant were significantly affected by the nitrogen fertilizer levels (192, 240, and 288 Kg/ha). The important role of nitrogen fertilizer was recorded in many plants such as onion [1], rice [23], sugar beet [24], wheat [25] and cowpea plants [26]. Nitrogen may play a significant role in increasing an onion's vegetative growth by enhancing its color, vigor of the leaf canopy, and meristematic activity, which contributes to the increase in cell number and cell elongation, and ultimately, its overall size [27]. These results are in harmony with those recorded by Barrales et al. [28]. At 100 days after transplanting, the present study found that the lowest plant density (4 rows/ridge) yielded the best growth metrics in both growing seasons. This was followed by densities of 5 rows/ridge and 6 rows/ridge. Results improved with increased distance between plants, perhaps because there was less competition for resources such as water, nutrients, and light. Plant spacing within onion seedlings, as measured by El-Fakharany et al. [29].

The essential role of nitrogen fertilizer in the formation of proteins, protoplasm, and chlorophyll can be attributed to the observed gradual increase in N, P, and K uptake with increasing nitrogen fertilizer levels. This in turn can be attributed to the observed increase in cell size, leaf area, photosynthetic activity, and growth characters, consistent findings with those reported by [22,30]. Increasing nitrogen fertilizer rates up to 288 kg N/ha led to increase total yield because nitrogen stimulates plant growth, which in turn increased yield components and yield per unit area for bulbs [31]. High plant density (6 rows per ridge) increased total yield may be due to those six rows or ridges increasing yields in grades 2, 3, and 4. Khan et al. [32] found that 12 cm plant spacing with 100 kg N/ha gave the best results for size of bulb, weight of bulb, and bulb yield. Effect of nitrogen concentration, plant density and their interaction on N, P, and K-uptake using of the maximum level of nitrogen fertilizer at 288 kg/ha gave the highest values for N, P, and K total uptake by the onion plant the same way found amaranth [33]. Planting onion plants with low plant density gave the plant's highest values of N, P, and K total previous study on onion showed that low density increase yield [34]. Carbohydrates and vitamin C in the bulb significantly increased with increasing N fertilizer. The vitamin C value obtained falls within range of vitamin C in onion. Using the low plant density pointedly increased total carbohydrates and vitamin C in bulbs [34].

Conclusions

Our findings indicated that, the interaction between nitrogen at 288 kg N/ha and plant density (4 rows/ridge) gave the best results of fresh bulbs, total fresh weight/plant and percentages of the yield of grade 1, grade 2, and exportable yield from total yield. Also, total N, P, and K uptake by the plant, total carbohydrates, total sugars, and vitamin C contents were increased in bulbs. The interaction between N at 244 kg /ha and high plant density (6 rows/ridge) increased total yield per hectare and nitrogen use efficiency in onion plants (cv. Ahmar Tanawy).

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Conflicts of Interest

The authors declare no conflict of interest

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