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Onion Production and Nitrogen Uptake in Response to Different Doses of Urea Fertilizer at Two Different Plant Populations

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Abstract. Two field experiments were conducted during the 2000-2001 and 2001-2002 growing seasons in the Agriculture Research Station of Jordan University, to study the response of 3 onion cultivars from Texas Early Grano 502 (lot No. 222181 from Royal Sluis, lot No. 7A9062/1 from Bakker Brothers and lot No. 96367-73100 from Amsa Seed.moss. main selection) to 6 nitrogen doses and 2 different plant populations in terms of dry qualified yield and nitrogen absorption (kg/ha). The impact of nitrogen waste (kg/ha) in relation to each dose on the environment was also examined. The two plant populations (i.e., 67 and 83 plants/m^2) were interacted with the 6 nitrogen doses (i.e., 100, 120, 140, 160, 180 and 200 kg/ha) and with the 3 onion cultivars. Both plant densities produced almost comparable results for almost all dry production components. But, for ecological considerations, the 67 plants/m^2 showed better nitrogen absorption and, consequently, showed less impact on the environment as nitrogen waste quantity. This could be also beneficial in reducing the production cost. The 140 kg N/ha showed the highest potential in producing dry yield especially the marketable (1^{st} + 2^{nd} categories) in both seasons. Also, it showed the lowest waste global nitrogen quantity (51 kg/ha). The 150 kg N/ha dose was found to be the closest one to the optimum dose, since the 140 kg N/ha dose gave the best results, but the onion plants still needed 11 kg N/ha, while at 160 kg N/ha about 25 kg N/ha were wasted. For higher doses, the wasted nitrogen space increased as more nitrogen is added and the impact on the environment became heavier.

Introduction

Onion plant (*Alliuum cepa*, L.), a member of Alliaceae family, is cultivated in more than 125 countries worldwide [1]. It is characterized by having shallow, fibrous, little branched and sparse root system, with no root hairs [2, p. 35]. Some researchers found that 90% of the root length was concentrated in the top 18 cm of the soil throughout the season [3]. With these two characteristics, plants show low competition among themselves and with the weeds to the sun light and low efficiency in absorbing the distributed fertilizers (especially the nitrogen forms), which are of great readiness to leach downward with the use of sprinklers or furrow irrigation systems [2, p. 94]. Also, these characteristics and accordingly enable the farmers to increase the plant density (plants/m^2).

Nitrogen loading to the ground water was found to be correlated to the factors of fertilizer application rate and form, irrigation rate and system, soil draining capacity, type of plant cover and its nitrogen uptake rate and degree of tillage [4].

Increasing plant population, improving root absorbing efficiency and managing the distributed quantity of fertilizer by using the proper system of water irrigation are needed to increase the uptake rate of added fertilizer quantity.

Fifty to one hundred plants/m^2 were found to produce high commercial yield with the highest number of bulbs of 5-7 cm diameters which are preferred by most consumers as well as the lowest number of colossal bulbs [2, p. 68, 5, 6].

In my doctorate research theses (unpublished work), 67 and 83 plants/m^2, among the 6 used plant densities of 17, 33, 50, 67, 83 and 100 plants/m^2, gave the better results of onion yield and nitrogen recovery percent.

It has been documented that the quantity of macro nutritive elements to be mixed in the cultivated soil layer are sufficient at 150 kg/ha of P_2O_5 and of K_2O [6, 7]. Many authors indicated that the range of 150-200 kg/ha of nitrogen is recommended, especially to the poor soil, to substitute for the poor absorbing rate effectuated by the shallow root system of the onion plant [2, p. 94, 8, 9]. It was also clear from previous studies that the percentage of nitrogen recovery decreased as the added quantity increased. It did not normally exceed 40%, therefore, the wasted quantity increased [2, p. 94, 8].

In addition to being a loss to the farmer's budget, the wasted nitrogen may become involved in forming complex environmentally unsafe byproducts in the soil. Nitrogen fertilizers have high salt index which increases the soil osmotic pressure and favors the plasmolysis phenomena which may result in plant death [10, p. 404]. The wasted nitrogen may also induce plant lodging or exposure to the leaching process [5]. Leaching to the ground water in the form of NO_2^- or NO_3^- increases water pollution and, therefore, risks to human health [11]. Another pathway of the wasted nitrogen would be volatilization in the form of Nitrogen gas (N_2) [9].

Nitrate$^-$ and nitrite$^-$ nitrogen constitute a public health concern, related primarily to Methemoglobinemia (infantile cyanosis) and carcinogenesis. Methemoglobinemia is a disease primarily affecting infants and is often described by the term, blue babies [12-14]. Carcinogenesis (gastric cancer, in particular) has been associated with the ingestion of N-nitroso compounds. Nitrites (indirectly from nitrates) can react with amines and amides to form nitrosamines and nitrosamides. The epidemiological evidence suggests that high nitrate ingestion may be a contributing factor to gastric cancer [13-15].

The drip irrigation system proved to have a lower leaching rate. It keeps the water and the nutrient solutions around the roots located in the upper soil zone for longer period of time than the other systems. Therefore, it has been used more for shallow rooted plants [16]. Nitrogen fertilizers that are added frequently through the drip lines have the potential to be more efficient than if applied by a broadcast, side dressed or with running water in a furrow irrigated field [17].

It is documented that the drip irrigation system has higher irrigation efficiency (IF) than other systems [18, 19]. Consequently, the system was used in field trials involving intensive crop cultivation, frequent application of fertilizer doses, were conducted to improve the efficiency of the fertilizer's uptake and minimize the impact on the environment.

Materials and Methods

Field experiments were conducted during two growing seasons of 2000/2001 and 2001/2002, at the Agriculture Research Station, Jordan University Farm, located in the Jordan Valley. This location lies between 35° and 35.2° longitude, and has an average annual rainfall of about 100 to 350 mm.

The soil in that location is of sandy loam texture, low to medium fertility and sub-alkaline reaction. Soil samples were collected randomly from the experimental site up to 20 cm depth by auger. Phosphorous and potassium contents were measured using the Champan and Pratt [20] method. The Kjeldahl nitrogen procedure [21] was used to measure the total nitrogen content. Inorganic nitrogen components (NO_3^-) were measured according to Keeney and Nilson [22] method. Approximately 92 kg/ha of K_2O (and no P_2O_5) were introduced to the experimental land during its preparation in order to achieve the suggested doses of 150 kg/ha each. Sullivan, *et al.* [23] and Brewester, [2, p. 95] indicated that the total amounts of applied nitrogen was adjusted to account for the nitrate residue from previous crops.

A split–split plot design with four replicates was used where the main plot was devoted to plant densities (67 and 83 plants/m^2) and sub plot to onion cultivars and sub-sub plot to nitrogen doses. In each plot, a grid of 18 treatments (2 m x 1.2 m each) derived from the factorial combination of 3 onion short day cultivars.

Six nitrogen doses (i.e. 100, 120, 140, 160, 180 and 200 kg/ha) were arranged randomly. Over each plot, two drip lines of (GR type with : inside diameter of 12.5 mm, outside one of 16 mm, emitters at 40 cm space and discharge rate of 4 liter/hr at 1 bar pressure) were installed at 60 cm center to the center.

Consequently, the modest quantities of N-NO_3 (3.1 kg/ha) found in the soil, are the reasons to incorporate the quantity of each nitrogen dose completely in three stages; one-third of the quantities during soil preparation; the second-third at bulb swelling (i.e. about 55 days after transplanting) and the last third after about 105 days. They were distributed using the urea form of 46 N %.

With seeds produced in the same year, seeding was effectuated on October 2000 and 2001 for the 1st and 2nd growing seasons, respectively. Four or five seeds were planted in each eye of trays filled with peat-moss. All seeded trays were placed, until emergence, in closed dark conditions of heated greenhouse with a room temperature of approximately 25°C. As the plants emerge, all trays were spread over the beds and the room temperature was adjusted to 18-20°C. During this pre-transplanting period, the seedlings were irrigated, as necessary, and fertilized with leaf neutral material every 10 days at a rate of 25 g/L.

Seedlings of 4 to 5 green true leaves were transplanted, in all treatments, on December 2000 and 2001 for the first and second growing seasons, respectively. At 30 cm between lines and 20 cm between plants within line, 40 holes were planted with 4 or 5 seedlings in each treatment. The four and five plants/hole is equal to 67 and 83 plants/m^2, respectively.

Onion brown rot caused by the fungus *Botrytis allii* was controlled by the application of Remaltin (Cymoxanil 4% and Mancozeb 46%) at 225 g/100 liters, then two weeks later with Sumisclex (Procemidone 50%) at 100g/100 liters. Herbicides of Focus Ultra (cycloxydim 10% active ingredient) was applied at 0.2 kg/ha. One week later Ronstar (oxadiazon 25% active ingredient) was applied at 1.25 kg/ha. The following data were recorded:

i) Thirty-five bulbs/treatment were collected randomly. The horizontal and vertical diameters of each bulb were measured using a caliber (± 0.1 cm) and classified according to the following grades based on the diameter of the bulb (θ): 1) first category (θ >6.5cm); 2) second category (θ = 3.5 to 6.5cm); and 3) third category (θ < 3.5 cm).

ii) Five representative bulbs and canopy sample were collected from each treatment. They were weighed using an analytical balance (± 0.001g), and cut into pieces and dried in ashel oven at 65ºC until a constant weight was recorded.

iii) To obtain fine homogeneous samples, the dried samples were crushed. Micro Kjeldahl nitrogen procedure [21] was used to measure total nitrogen in these samples. Total absorbed and wasted nitrogen quantity in relation to each dose were then calculated.

iv) The samples were dried at 105ºC to eliminate the moisture. The dry matter (%), dry yield (g/bulb and g/plant) and dry production (ton/ha) in each of the three categories, marketable (1st+2nd categories), total bulbs, canopy and total production were calculated and recorded.

The analysis of variance (ANOVA) method was used to determine the significant differences related to separate and interactive effects of various studied factors. For the variables that showed significant variation to separate and/or interactive effects of the factors, the means were separated at 0.05 level of probability using the least significant differences (LSD) test [24]. The regression analysis was applied for the variables that varied significantly by nitrogen doses in order to indicate their group type. Values of the correlation coefficient (r) and the significant levels of the regressions were also recorded.

Results and Discussion

Dry matter production at the mature stage

Interactive effects of “plant population x nitrogen doses” on some components of dry production in the second and for both growing seasons were of significant differences. These components were: marketable (1st and 2nd) category and total bulbs (1st, 2nd and 3rd categories) in tons per hectare. Indicators of either component suggested that the best production results from the combination of 83 plants/m^2 and 140 kg N/ha, while the results of either “67 plants/m^2 x 200 kg N/ha” or “83 plants/m^2 x 200 kg N/h” were not significantly varied from other combinations (Table 1). This could be explained by the fact that excess of nitrogen availability (higher dose) might enhance more vegetative growth and, therefore, delay shifting to bulbs formation [2].

Table 1. Interactive effects of “plant population x nitrogen doses” on some components of dry onion production in the second (2001/2002) and for both growing seasons (2000/2001 +2001/2002)

Plant population (plants/m^2)	Nitrogen doses (kg/ha)	Marketable (1st + 2nd) 2nd season (Ton/ha)	Total bulbs (1st+2nd+3rd) 2ndseason (Ton/ha)	Marketable (1st+2nd) both seasons (Ton/ha)	Total bulbs (1st+2nd+3rd) both seasons (Ton/ha)
67	100	3.9 b	3.9 b	6.6 b	6.7 b
	120	4.6 ab	4.7 ab	7.7 ab	7.9 ab
	140	4.2 b	4.3 ab	7.3 ab	7.4 b
	160	4.3 ab	4.3 ab	7.7 ab	7.8 ab
	180	4.7 ab	4.7 ab	7.7 ab	7.9 ab
	200	4.5 ab	4.5 ab	7.3 ab	7.5 b
83	100	4.2 b	4.3 b	7.0 b	7.4 b
	120	4.2 b	4.3 b	7.3 ab	7.7 ab
	140	5.9 a	5.9 a	9.4 a	9.7 a
	160	4.0 b	4.1 b	7.2 b	7.6 ab
	180	4.5 ab	4.5 ab	7.7 ab	8.0 a
	200	3.4 b	3.4 b	6.5 b	6.8 b
LSD $_{0.05}$		1.6	1.7	2.2	2.2

*Within each column, interactive means for each variable having different letters are significantly different at the 5% level according to LSD test.

Table 2 showed that lower plant density of 67 plants/m^2 significantly improved the average dry bulb weight per plant in the second growing season; it was increased from 5.3 to 6.6 g/bulb. The lower plant density clearly produced higher yield than the higher plant density. In the first season, cultivar of lot No. 96367-73100 produced, statistically, lower dry matter accumulation of marketable bulbs while cultivar of lot No. 7A9062/1 produced the highest results, it was ranged from 2.7 to 3.1 to 3.6 ton/ha for cultivar of lot No. 96367-73100, 222181 and 7A9062/1, respectively. During the second season, variations among cultivars, in the marketable yield, were minimized recording values of 4.2, 4.3 and 4.6 ton/ha for cultivar of lot No. 96367-73100, 222181 and 7A9062/1, respectively. On the other hand, cultivar of lot No. 96367-73100 produced the highest dry yield for the 3rd category of small bulbs in the first season (0.21, 0.18 and 0.12 tons/ha for cultivar of lot No. 96367-73100, 222181 and 7A9062/1, respectively). In the second season, the results of the 3rd category dry bulbs production showed neglected variations (0.08, 0.05 and 0.06 tons/ha for cultivar of lot No. 96367-73100, 222181 and 7A9062/1, respectively). This variation could be due to better adaptability of cultivar of lot No. 222181 and 7A9062/1 than cultivar of lot No. 96367-73100. Nitrogen doses did not create any significant differences among values of various dry production parameters in the first growing seasons. Dry marketable and total bulb production of the second growing season, were the only variables to respond with significant differences to the nitrogen doses. The dose of 140 kg N/ha produced the highest quantities for both parameters, and the values of marketable yield were: 4.0, 4.4, 5.0, 4.1, 4.6 and 3.9 ton/ha, and of total bulb production were: 4.1, 4.5, 5.1, 4.2, 4.6 and 4.0 tons/ha for the doses of 100, 120, 140, 160, 180 and 200 kg N/ha, respectively. These results suggested that the requirement of nitrogen fertilizer is the best if it is around 140 kg N/ha. This will avoid the negative effects of excessive nitrogen application on the plant productivity as well as on the environmental media such as soil and groundwater. Besides, it helps the farmers avoid unnecessary expenditure and control their production costs.

Table 2. Effect of plant population and nitrogen doses on some components of dry onion yield of three onion cultivars at the mature harvesting stage in the first and the second growing seasons

Treatments	Average dry bulb wt (g)	1st category bulbs (Ton/ha)	2nd category bulbs (Ton/ha)	Marketable (1st + 2nd) bulbs (Ton/ha)	3rd category bulbs (Ton/ha)	Total bulbs (1st+2nd+3rd) (Ton/ha)
Plant population:			**First growing season (2000/2001)**			
67 Plants/m^2	4.7 a	0.6 a	2.4 a	3.0 a	0.12 a	3.1 a
83 Plants/m^2	4.1 a	0.4 a	2.8 a	3.2 a	0.22 a	3.4 a
Mean	4.4	0.5	2.6	3.1	0.17	3.3
LSD $_{0.05}$	4.9	6.6	2.8	3.7	0.95	2.8
Cultivars:						
Lot No. 96367-73100	3.9 b	0.4 a	2.3 b	2.7 b	0.21 a	2.9 b
Lot No. 222181	4.3 ab	0.5 ab	2.6 ab	3.1ab	0.18 ab	3.2 ab
Lot No.7A9062/1	4.9 a	0.7 a	2.9 a	3.6 a	0.12 b	3.7 a
Mean	4.4	0.5	2.6	3.1	0.17	3.3
LSD $_{0.05}$	0.8	0.2	0.4	0.5	0.064	0.54
Nitrogen doses:						
100 kg N/ha	3.9 b	0.4 a	2.3 b	2.7 b	0.21 a	2.9 b
120 kg N/ha	4.4ab	0.5 a	2.6 ab	3.1ab	0.16 a	3.3 ab
140 kg N/ha	4.6 ab	0.6 a	2.6 ab	3.3 a	0.15 a	3.4 a
160 kg N/ha	4.7 a	0.5 a	2.8 a	3.3 a	0.18 a	3.5 a
180 kg N/ha	4.4 ab	0.4 a	2.7 ab	3.2 ab	0.15 a	3.3 ab
200 kg N/ha	4.2 ab	0.5 a	2.5 ab	3.0 ab	0.17 a	3.2 ab
Mean	4.4	0.5	2.6	3.1	0.17	3.3
LSD $_{0.05}$	0.6	0.3	0.4	0.5	0.11	0.45

Table 2. *Continued*

Treatments	**Average dry bulb wt (g)**	**1st category bulbs (Ton/ha)**	**2nd category bulbs (Ton/ha)**	**Marketable (1st + 2nd) bulbs (Ton/ha)**	**3rd category bulbs (Ton/ha)**	**Total bulbs (1st+2nd+3rd) (Ton/ha)**
Significant level						
Plant population	Ns	Ns	Ns	Ns	Ns	Ns
Onion Cv's	*	Ns	*	*	*	*
Pop. x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x doses	Ns	Ns	Ns	Ns	Ns	Ns
Doses x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x Cv's x Doses	Ns	Ns	Ns	Ns	Ns	Ns
Plant population:			**Second growing season (2001/2002)**			
67 Plants/m^2	6.6 a	2.4 a	2.0 a	4.4 a	0.05 a	4.4 a
83 Plants/m^2	5.3 b	1.7 a	2.6 a	4.4 a	0.07 a	4.4 a
Mean	5.95	2.0	2.3	4.4	0.06	4.4
LSD $_{0.05}$	0.83	4.3	3.1	1.2	0.34	1.6
Cultivars:						
Lot No. 96367-73100	5.8 a	1.8 a	2.4 a	4.2 a	0.08 a	4.3 a
Lot No. 222181	5.8 a	2.0 a	2.2 a	4.3 a	0.05 a	4.3 a
Lot No.7A9062/1	6.3 a	2.3 a	2.3 a	4.6 a	0.06 a	4.7 a
Mean	5.95	2.0	2.6	4.4	0.06	4.4
LSD $_{0.05}$	0.85	0.6	0.5	0.61	0.034	0.6
Nitrogen doses						
100 kg N/ha	5.5 b	1.8 a	2.2 a	4.0 b	0.05 a	4.1 b
120 kg N/ha	6.1 ab	2.2 a	2.2 a	4.4 ab	0.08 a	4.5 ab
140 kg N/ha	6.8 a	2.2 a	2.8 a	5.0 a	0.07 a	5.1 a
160 kg N/ha	5.7 b	2.0 a	2.2 a	4.1 b	0.06 a	4.2 ab
180 kg N/ha	6.3ab	2.3 a	2.3 a	4.6 ab	0.06 a	4.6 ab
200 kg N/ha	5.4 b	1.8 a	2.2 a	3.9 b	0.06 a	4.0 b
Mean	6.0	2.0	2.3	4.4	0.06	4.4
LSD $_{0.05}$	0.9	0.6	0.6	0.67	0.05	0.68
Significant level						
Plant population	*	Ns	Ns	Ns	Ns	Ns
Onion Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Nitrogen doses	*	Ns	Ns	*	Ns	*
Pop. x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x doses	*	Ns	Ns	**	Ns	**
Doses x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x Cv's x Doses	Ns	Ns	Ns	Ns	Ns	Ns

(Ns): No significant differences;
(*): Significant differences at P ≤ 0.05;
(**): High significant differences at P ≤ 0.01;
Within each column, means for each treatment having different letters are significantly different at the 5% level according to LSD test.

In both growing seasons, both planting densities have produced similar quantities of dry bulbs. Also, the marketable and total bulb yield from cultivar of lot No. 7A9062/1 was better than the yield from that of lot No. 222181 which is in turn of better yield than that from cultivar of lot No. 96367-73100. The production components of dry yield showed that the productivity using 140 kg N/ha was significantly higher than the productivity using the other doses as indicated in Table 3.

Table 3. Overall effect of plant population and nitrogen doses on the dry onion production of three onion cultivars at the mature harvesting stage over both seasons of (2000/2001+2001/2002)

Treatments	Marketable (1st + 2nd) bulbs (Ton/ha)	3rd category bulbs (Ton/ha)	Total bulbs (1st+2nd+3rd) (Ton/ha)
Plant population:			
67 (Plants/m^2)	7.4 a	0.18 a	7.5 a
83 (Plants/m^2)	7.5 a	0.29 a	7.8 a
LSD $_{0.05}$	4.9	0.61	4.3
Cultivars:			
Lot No. 96367-73100	6.9 b	0.29 a	7.2 b
Lot No. 222181	7.3 b	0.23 b	7.5 b
Lot No.7A9062/1	8.1 a	0.18 c	8.3 a
LSD $_{0.05}$	0.43	0.04	0.41
Nitrogen doses:			
100 (kg/ha)	6.8 c	0.26 a	7.0 c
120 (kg/ha)	7.5 abc	0.25 a	7.8 abc
140 (kg/ha)	8.3 a	0.22 a	8.6 a
160 (kg/ha)	7.5 abc	0.24 a	7.7 ab
180 (kg/ha)	7.7 ab	0.21 a	7.9 ab
200 (kg/ha)	6.9 bc	0.22 a	7.1 bc
LSD $_{0.05}$	0.9	0.12	0.9
Significant level:			
Plant population	Ns	Ns	Ns
Onion Cv’s	**	**	**
Nitrogen doses	*	Ns	*
Population x Cv’s	Ns	Ns	Ns
Population x doses	*	Ns	*
Doses x Cv’s	Ns	Ns	Ns
Population x Cv’s x doses	Ns	Ns	Ns

(Ns): No significant differences;
(*): Significant differences at $P \leq 0.05$;
(**): High significant differences at $P \leq 0.01$;
Within each column, means for each treatment having different letters are significantly different at the 5% level according to LSD test.

Total uptake and wasted nitrogen quantity (kg/ha)

The interactive and separate effects of plant density, cultivars and nitrogen doses showed that the “plant population x nitrogen doses” was the only interaction to induce significant differences among values of the parameters studied to investigate the absorbing and wasted nitrogen quantity (kg/ha) in both growing seasons. The interaction of “83 plants/m^2 x 140 kg N/ha”, which gave the best results of dry onion yield components (Table 1), was one of the best in improving the global absorbed nitrogen amount (Table 4), and consequently minimizing the wasted quantity of applied nitrogen (Table 5). Other combinations like “67 plants/m^2 x 180 kg N/ha” or “67 plants/m^2 x 200 kg N/ha” were of high absorbing nitrogen amount, but the wasted quantity was high since the applied nitrogen amount is high. In contrast, the highest lost quantity of nitrogen was due to using the combination of “83 plants/m^2 x 200 kg N/ha” (Table 5). Resemblance to what was discussed in the dry production; this is due to the fact that, at both plant populations, the higher nitrogen doses produced almost inferior results of dry onion (Table 1). The extra doses of nitrogen have a direct effect on the global loss.

Table 4. Combined effects of “plant population x nitrogen doses” on some parameters of nitrogen absorption in relation to each nitrogen dose over both growing seasons of (2000/2001+2001/2002)

Plant population (plants/m^2)	Total added Nitrogen (kg/ha) $^{(z)}$	Kg/ha N in mark. category bulbs$^{(1)}$	Kg/ha N in all category bulbs$^{(2)}$	Kg/ha Total N in crop $^{(3)}$
67	200	113.7 c	116.1 c	174.8 de
	240	141.8abc	144.8abc	216.7bcde
	280	140.1abc	143.5abc	215.2bcde
	320	157.5 ab	160.0abc	248.3 ab
	360	168.3 ab	172.3 ab	256.2 a
	400	169.3 ab	173.6 ab	263.3 a
83	200	113.8 c	119.2 c	167.9 e
	240	129.4 bc	134.7 bc	182.9 cde
	280	180.8 a	185.3 a	242.8 ab
	320	141.6abc	147.8abc	198.6 bcde
	360	162.2 ab	166.2 ab	229.6 abc
	400	147.0abc	151.9abc	222.2 abcd
$LSD_{0.05}$		43.6	44.7	52.2

Within each column, interactive means for each variable having different letters are significantly different at the 5% level according to LSD test.
- $^{(1)}$: 1^{st} + 2^{nd} categories.
- $^{(2)}$: 1^{st} + 2^{nd} +3^{rd} categories.
- $^{(3)}$: 1^{st} + 2^{nd} +3^{rd} categories + canopy.

$^{(z)}$: Summation of added nitrogen over both growing seasons.

Table 5. Combined effects of “plant population x nitrogen doses” on the wasted nitrogen quantity (kg/ha) in relation to each nitrogen dose over both growing seasons of (2000/2001+2001/2002)

Plant Population (plants/m^2)	Total added nitrogen (kg/ha) $^{(z)}$	Kg/ha N loss up to mark. category bulbs$^{(1)}$	Kg/ha N loss up to all category bulbs$^{(2)}$	Kg/ha total N loss$^{(3)}$
67	200	86.3 f	83.9 f	25.2 e
	240	98.2 ef	95.2 ef	23.3 ef
	280	139.9 de	136.5 de	64.8 de
	320	162.5 cd	160.0 cd	71.7cde
	360	191.7 bc	187.7 bc	103.8bcd
	400	230.7 ab	226.4 ab	136.7 ab
83	200	86.2 f	80.8 f	32.1 e
	240	110.6 ef	105.3 ef	57.1 de
	280	99.2 ef	94.7 ef	37.2 e
	320	178.4 cd	172.2 cd	121.4 bc
	360	197.8 bc	193.8 bc	130.4 ab
	400	253.0 a	248.1 a	177.8 a
$LSD_{0.05}$		44.1	44.7	52.2

Within each column, interactive Means for each variable having different letters are significantly different at the 5% level according to LSD Test.

$^{(1)}$: Added N dose minus absorbed N by marketable category bulbs (2^{nd} +3^{rd} categories).

(2): Added N dose minus absorbed N by all category bulbs (1st + 2nd +3rd categories).
(3): Added N dose minus absorbed N by crop (1st + 2nd +3rd categories + canopy).
(z): Summation of added nitrogen over both growing seasons.

The available nitrogen was absorbed, in the first season, with better efficiency by the higher plant density than by the lower plant density, leading consequently to lower amount of wasted quantity. Cultivar of lot No. 7A9062/1 was more efficient than other cultivars as it showed significant absorbing superiority and consequently lowered the amount of wasted quantities in all listed parameters in Table 6 - 1st season. Good nitrogen status in the second season had minimized the variations among various cultivars and consequently they showed comparable results of absorbing capacities (Table 6 - 2nd season).

Out of the interactive effects, nitrogen doses had clearly induced significant differences among values of all parameters studied for the nitrogen content and wasted quantities in the 1st, 2nd and both growing seasons (Tables 6 and 7). Absorbing and wasted quantities (kg/ha), were increased by raising the nitrogen dose from 100 kg/ha to 200 kg/ha.

Table 6. Effect of plant population and nitrogen doses on nitrogen absorption and loss in relation to each nitrogen dose in the first and the second growing seasons (1999/2000 and 2000/2001)

Treatments	Kg/ha N in mark. cat.(1)	Kg/ha loss N (up to mark. cat.)	Kg/ha N in all cat.(2)	Kg/ha loss N (all cat.)	Kg/ha N in crop(3)	Kg/ha tot. N loss
Plant population:	**First growing season (1999/2000)**					
67 Plants/m^2	48.1 a	101.9 a	50.2 a	99.9 a	80.6 a	69.4 a
82 Plants/m^2	52.2 a	97.8 a	55.7 a	94.3 a	81.5 a	68.5 a
LSD $_{0.05}$	50.8	50.8	35.4	35.4	57.6	57.6
Cultivars:						
Lot No. 96367-3100	44.0 b	106.0 a	47.4 b	102.6 a	71.9 b	78.1 a
Lot No .222181	48.0 b	102.0 a	50.8 b	99.2 a	79.2 b	70.8 a
Lot No. 7A9062/1	58.4 a	91.6 b	60.5 a	89.5 b	91.9 a	58.1 b
LSD $_{0.05}$	7.8	7.8	7.8	7.8	11.0	11.0
Nitrogen doses						
100 kg N/ha	36.8 d	63.2 f	39.7 d	60.3 f	61.2 d	38.8 d
120 kg N/ha	44.5 cd	75.5 e	46.9 cd	73.1 e	73.7 cd	46.3 d
140 kg N/ha	49.9 bc	90.1 d	52.3 bc	87.7 d	77.6 bc	62.4 c
160 kg N/ha	54.0 ab	106.0 c	56.9 ab	103.1 c	88.3 ab	71.7 c
180 kg N/ha	55.4 ab	124.6 b	58.0 ab	122.0 b	89.5 ab	90.5 b
200 kg N/ha	60.3 a	139.7 a	63.6 a	136.4 a	95.5 a	104.2 a
LSD $_{0.05}$	8.1	8.1	8.0	8.0	13.1	13.1
Significant level						
Plant population	Ns	Ns	Ns	Ns	Ns	Ns
Onion Cv's	*	*	*	*	*	*
Nitrogen doses	***	***	***	***	***	***
Pop. x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x dose	Ns	Ns	Ns	Ns	Ns	Ns

Table 6. *Continued*

Treatments	**Kg/ha N in mark. cat.(1)**	**Kg/ha loss N (up to mark. cat.)**	**Kg/ha N in all cat.(2)**	**Kg/ha loss N (all cat.)**	**Kg/ha N in crop(3)**	**Kg/ha tot. N loss**
Doses x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x Cv's x doses	Ns	NS	Ns	Ns	Ns	Ns
Plant population:	**Second growing season (2000/2001)**					
67 Plants/m^2	100.4a	49.6 a	101.6 a	48.4 a	148.5 a	1.45 a
82 Plants/m^2	93.6 a	56.4 a	95.2 a	54.8 a	125.8 a	24.2 a
LSD $_{0.05}$	17.7	17.7	10.5	10.5	24.2	24.2
Cultivars:						
Lot No. 96367-3100	97.3 a	52.7 a	99.1 a	50.9 a	136.7 a	13.3 a
Lot No. 222181	93.2 a	56.8 a	94.2 a	55.7 a	134.2 a	15.9 a
Lot No. 7A9062/1	100.4a	49.6 a	101.7 a	48.3 a	140.7 a	9.3 a
LSD $_{0.05}$	15.0	15.0	15.4	15.4	17.3	17.3
Nitrogen doses:						
100 kg N/ha	77.0 c	23.0 c	77.9 c	22.1 c	110.2 d	- 10.2 c
120 kg N/ha	91.1bc	28.9 c	92.8 bc	27.2 c	126.0 c	- 6.0 c
140 kg N/ha	110.6a	29.5 c	112.1 a	27.9 c	151.4ab	- 11.4 c
160 kg N/ha	95.6ab	64.4 b	97.0 ab	63.0 b	135.2bc	24.8 b
180 kg N/ha	109.9a	70.1 b	111.2 a	68.8 b	135.4 a	26.6 b
200 kg N/ha	97.9ab	102.1 a	99.2 ab	100.8 a	146.9ab	53.1 a
LSD $_{0.05}$	15.1	15.1	15.3	15.3	15.5	15.5
Significant level						
Plant pop.	Ns	Ns	Ns	Ns	Ns	Ns
Onion Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Nitrogen doses	***	***	***	***	***	***
Pop. x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x dose	**	**	**	**	*	*
Doses x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x Cv's x Doses	Ns	Ns	Ns	Ns	Ns	Ns

- (Ns): No significant differences;
- (*): Significant differences at $P \leq 0.05$;
- (**): High significant differences at $P \leq 0.01$;
- (***): Very high significant differences at $P \leq 0.001$;
- Within each column, means for each treatment having different letters are significantly different at the 5% level according to LSD test.
- (1): 1st + 2nd categories.
- (2): 1st + 2nd +3rd categories.

- (3): 1st + 2nd +3rd categories + canopy.

Table 7. Effect of plant population and nitrogen doses on global nitrogen absorption and loss in relation to each nitrogen dose over both growing seasons (2000/2001+2001/2002)

Treatments	Kg/ha N absorbed by mark. cat.(1)	Kg/ha N loss (up to mark. cat.)	Kg/ha N absorbed by all cat.(2)	Kg/ha N loss (up to all cat.)	Kg/ha N absorbed by crop(3)	Kg /ha total N loss
Plant population:						
67 plants/m^2	148.5 a	151.5 a	151.7 a	148.3 a	229.1a	70.9 a
83 plants/m^2	145.8 a	154.2 a	150.8 a	149.2 a	207.3 a	92.7 a
LSD $_{0.05}$	33.0	33.0	24.9	24.9	33.4	33.4
Cultivars:						
Lot No.96367-3100	141.3 a	158.7 a	146.6 a	153.4 a	108.6 b	91.4 a
Lot No.222181	141.2 a	158.8 a	145.1 a	154.9 a	213.4 ab	86.6ab
Lot No.7A9062/1	158.8 a	141.2 a	162.2 a	137.8 a	232.6 a	67.4 b
LSD $_{0.05}$	20.1	20.1	20.2	20.2	22.6	22.6
Nitrogen dose(z):						
200 (kg/ha)	113.8 c	86.2 e	117.6 c	82.4 e	171.4 c	28.6 d
240 (kg/ha)	135.6 b	104.4 d	139.7 b	100.3 de	199.8 b	40.2cd
280 (kg/ha)	160.5 a	119.5 d	164.4 a	115.6 d	229.0 a	51.0 c
320 (kg/ha)	149.6 ab	170.4 c	153.9ab	166.1 c	223.5 a	96.5 b
360 (kg/ha)	165.2 a	194.8 b	169.2 a	190.8 b	242.9 a	117.1b
400 (kg/ha)	158.2 a	241.8 a	162.8 a	237.2 a	242.7 a	157.3a
LSD $_{0.05}$	18.0	18.0	18.2	18.2	21.3	21.3
Significant level						
Plant population	Ns	Ns	Ns	Ns	Ns	Ns
Onion Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Nitrogen doses	***	***	***	***	***	***
Pop. x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x doses	*	*	*	*	**	*
Doses x Cv's	Ns	Ns	Ns	Ns	Ns	Ns
Pop. x Cv's x doses	Ns	Ns	Ns	Ns	Ns	Ns

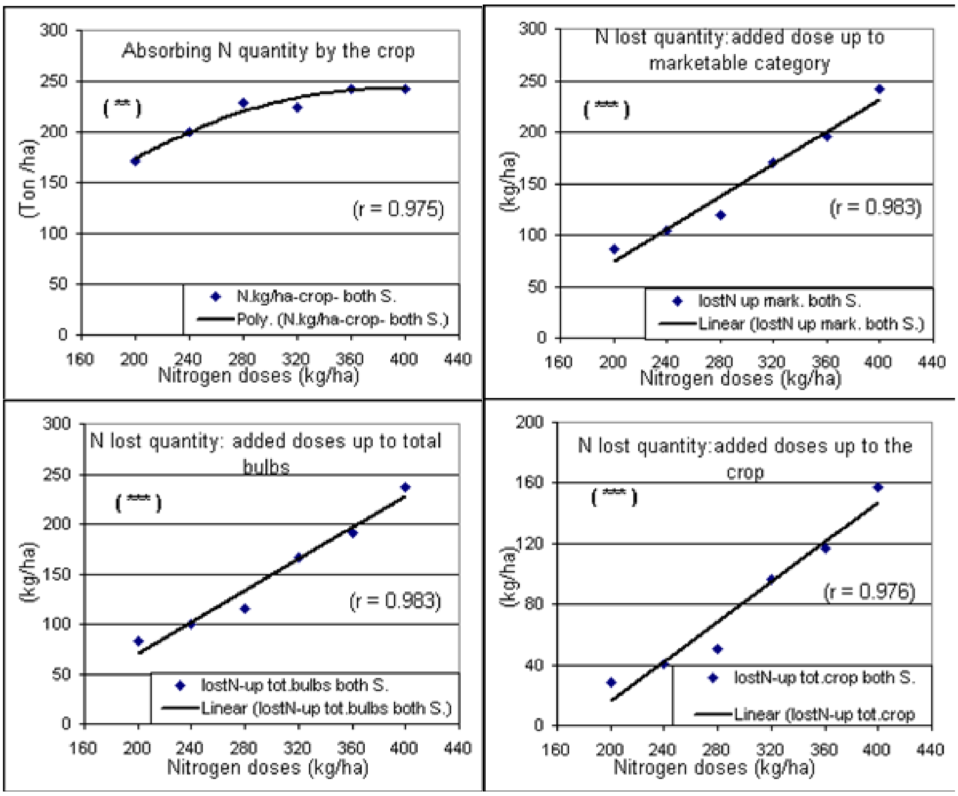
- (Ns): No significant differences;
- (*): Significant differences at P ≤ 0.05;
- (**): High significant differences at P ≤ 0.01;
- (***): Very high significant differences at P ≤ 0.001;
- Within each column, means for each treatment having different letters are significantly different at the 5% level according to LSD test.
- (1): 1st + 2nd categories.

(2): 1st + 2nd +3rd categories.

(3): 1st + 2nd +3rd categories + canopy.

(z): Summation of added nitrogen over both growing seasons.

With raising nitrogen doses from kg/ha 100 to 200 kg/ha, the absorbing and wasted nitrogen quantities were increased. High nitrogen doses have direct effect on the global nitrogen loss. The correlated regression curves between nitrogen doses and values of some parameters for both seasons, suggested that the increment in the wasted quantity of nitrogen in relation to the administered doses were significantly linear. However, the increments in absorbing nitrogen quantities (kg/ha) were significantly polynomial and showed better absorbing quantities for the doses between 140 and 160 kg/ha (Fig. 1).



(**) Significant correlation at P ≤ 0.01
(***) Significant correlation at P ≤ 0.001

Fig. 1. Correlated regression curves between nitrogen doses and values of some parameters for both growing seasons.

Conclusion

By the end of the second growing season and with the presence of high planting densities, the140 kg N/ha gave the best results for most of dry production components. Also, this dose showed the lowest wasted global nitrogen quantity (51 kg/ha). As more nitrogen is applied, the wasted nitrogen quantity increased. Any additional nitrogen doses are not recommended for improving the yield. In contrast, unabsorbed nitrogen will be denitrified to the atmosphere or leached down to water table and thus increasing the negative impact on the environment.

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إنتاج البصل وامتصاصه للنيتروج ، استجابة لتراكيز نلفة من اليوريا عند زراعته على كثافة نلفة

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ملخص البحث. تم إجراء التجربتين في محطة البحوث الزراعية التابعة للجامعة الأردنية في الغور الأوسط خلال موسمي ٢٠٠٠/٢٠٠١ و ٢٠٠١/٢٠٠٢ لتقييم استجابة ثلاثة اصناف من البصل Texas Early Grano 502 (lot No. 222181 from Royal Sluis, lot No. 7A9062/1 from Bakker Brothers and lot No. 96367-73100 from Amsa Seed.moss. main selection) من حيث الإنتاج الجاف وجودته وكمية النيتروجين الممتصة (كجم/هكتار) لكل من كثافة الزراعة وتركيزات النيتروجين. تهدف هذه الدراسة أيضاً إلى إظهار مستوى الضرر الواقع على البيئة بحساب كمية النيتروجين الضائعة (كجم/هكتار) نسبة لكل تركيز. استخدمت كثافتا زراعة (٦٧ و ٨٣ نبات للمتر المربع) وستة تركيزات من النيتروجين (١٠٠ ، ١٢٠ ، ١٤٠ ، ١٦٠ ، ١٨٠ و٢٠٠ كجم/هكتار) على أصناف البصل الثلاثة.

أشارت النتائج إلى أن كلا الكثافتين أعطتا نتائج متماثلة في جميع مكونات الإنتاج الجاف، وبالنظر إلى الإعتبارات البيئية فقد كانت الكثافة (٦٧ نبات/م٢) أقل ضررا على البيئة لأنها كانت أكثر فعالية في امتصاص النيتروجين وتقليل الكمية المفقودة من الكثافة (٨٣ نبات/م٢)، وقد يكون ذلك مفيدا في تقليل نفقات الإنتاج. أظهر التركيز ١٤٠كجم/هكتار أعلى مقدرة على الإنتاج الجاف من الابصال خاصة المسوق منه في كلا الموسمين وأقل كمية نيتروجين مفقودة بعد انتهاء الموسمين. دلت النتائج على أن التركيز ١٥٠كجم/هكتار هو الأقرب إلى التركيز الأمثل لأنه باستخدام ١٤٠كجم/هكتار تم إعطاء أفضل النتائج للموسم الثاني وما زالت النباتات بحاجة الى ١١كجم/هكتار، بينما باستخدام ١٦٠كجم/هكتار فقد ما يقرب من ٢٥كجم نيتروجين/هكتار وكلما ازداد التركيز ازدادت كمية النيتروجين المفقودة وتفاقم الضرر على البيئة.