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Effect of Rate and Time of Nitrogen Application on Onion Production in the Central Region of Saudi Arabia

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Abstract. Field experiments were conducted to evaluate the effect of rate and time of nitrogen application on onion cv. Texas Yellow Grano production in Al-Qassim region, Saudi Arabia during the years of 1997, 1998 and 1999. The nitrogen rates were zero, 100, 200 and 300kg ha^{-1}. This amount was applied at transplanting, 15 days later or divided in two equal doses applied 15 and 30 days after transplanting. The onion bulb yield was significantly higher with split application of nitrogen fertilizer and also with 200 kg N ha^{-1}. The leaf area and the leaf dry weight were also significantly higher with the latest nitrogen application and with highest dose of nitrogen fertilizer as compared to the earlier nitrogen application and to the lower dose of nitrogen fertilizer. No treatment interactions were detected. It was concluded that the application of 200 kg N ha^{-1} on 15 and 30 days after transplantation, should give the highest onion yield in the central region of the Kingdom of Saudi Arabia.

Introduction

Onion (*Allium cepa* L.) ranks fourth among the most important vegetable crops grown in the Kingdom of Saudi Arabia. Its production has increased from 15700 tons in 1988 to 210998 tons in 1998 [1]. In the central region, onion is cultivated in a sandy-loam to sandy-clay-loam soil in rotation with cereals or other vegetable crops. Generally, the growers apply nitrogen upto 500 kg N ha^{-1} in the form of urea to obtain higher production [1]. Elsewhere, many studies reported that the application of nitrogen in the range of 50 - 300 kg N ha^{-1} is required to optimize bulb yield and quality of onion [2 - 8].

Murata [9] reported that nitrogen plays an important role in plant photosynthesis by improving leaf area index. He also stated that higher dose of nitrogen application caused reduction in photosynthetic rate by mutual leaf shading due to excessive plant growth. In contrast, the low level of nitrogen application caused reduction in photosynthetic rate due to reduction in chlorophyll contents of plant cells, an effect of that is reversible [10]. It is, therefore, obvious that application of nitrogen at a suitable rate can lead to increase of leaf area and chlorophyll contents thus resulting in higher photosynthetic rate and higher plant yield.

Ahmad [11] reported that onion yield increased significantly with an increase in nitrogen application from 100 to 150 kg ha^{-1}. But further increase in nitrogen application upto 200 kg ha^{-1} did not increase the yield significantly. Hegde [12] found that the bulb production increased by 89 % with increase in nitrogen application from 0 to 80 kg ha^{-1}, but the increase in bulb yield was only 32 % when the nitrogen application was two times higher than the previous rate. Similarly, Hassan and Ayoub [13] studied the effect of three levels of nitrogen (0, 90 and 180 kg N ha^{-1}) and found that the significant increase in yield varied between 18 and 36 % of the control corresponding to 34 to 54 t ha^{-1}, respectively. Pandev [14] tried four levels of nitrogen (50, 100, 150 and 200 kg N ha^{-1}) and observed that a higher yield of marketable bulbs could be obtained by nitrogen application at the rate of 100 kg ha^{-1}. Whereas of the lowest marketable yield was obtained with 50 kg N ha^{-1}. However El-Habbash [15] concluded that using half the amount of ammonium nitrate with double dress nitrogen fertilizer, before planting and the other half 30 days after planting, increased the growth characters of onion plants. Abu-Gerab [16] observed superior growth, yield and quality of onion bulb with two N on compare with three N applications i.e. 55 and 75 days in comparison with 55, 75 and 95 days after transplanting. In another study, Mostafa and Ahmad [17] showed that the application of nitrogen fertilizer in two equal doses at three and six weeks after transplanting resulted in maximum growth of onion plants. Recently, El-Kafouri *et al.*, [8] concluded that split application of nitrogen, in two equal doses, 20 and 35 days from sowing at the rate of 214 kg N ha^{-1} as ammonium nitrate (33 % N) can be recommended for producing maximum number of healthy seedlings per square meter at the time of uprooting the seedlings (52 days after sowing).

This study was conducted to evaluate the effect of time and rate of nitrogen application on onion productivity under condition of Central Saudi Arabia.

Materials and Methods

All experiments were carried out at Experimental Farm, College of Agriculture and Veterinary Medicine, King Saud University, Al-Qassim Branch, Kingdom of Saudi Arabia. The geographical location of the experimental farm is 26 22° N, 44° E, with an elevation of 725m above sea level. The experimental soil was sandy in 1997 and sandy-clay-loam during 1998 and 1999 cropping season. The physical and chemical properties of the soils are given in Table 1.

Table 1. Initial characteristics of the different soil textures used

Characteristics	Cropping season 1997	Cropping season 1998 and 1999
Particle size distribution(%)		
Coarse sand	50.20	48.70
Fine sand	39.50	22.30
Silt	1.60	7.60
Clay	8.60	21.40
Soluble cations(meq l^{-1})		
Ca^{++}	12.10	9.80
Mg^{++}	4.60	6.20
Na^{+}	17.40	14.40
Soluble anions(meq l^{-1})		
Cl^{-}	12.80	10.10
HCO_3^{-}	6.00	7.70
$SO_4^{=}$	15.30	12.40
EC (dSm^{-1} at 25° C)	3.56	4.10
pH (paste)	8.10	7.80
Organic carbon	Trace	Trace
Nitrogen	Trace	Trace

Procedure

Onion (*Allium cepa* L.) cultivar Texas Yellow Grano was planted as a test crop, using a seedling rate of 330,000 plants ha^{-1}. The experiment was planted in field having a plot area of 6.30 m^2 (1.8m x 3.5m). The spacing between raws was 60cm and within raws 10cm. The length of every row was 3.5m. Aditional NPK fertilizer was applied to every experiment at the rate of 350 kg N ha^{-1} 200 kg P_2O_5 ha^{-1} (calcium superphosphate, 16 % P_2O_5) and 60 kg K_2O ha^{-1} (potassium sulfate). The nitrogen fertilizer applied as urea (46 % N), treatments were applied into four doses for field application as follows;

B1 (0 kg N ha^{-1}), B2 (100 kg N ha^{-1}), B3 (200 kg N ha^{-1}) and B4 (300 kg N ha^{-1}).
There were three time intervals of nitrogen application to crop which were:
A1- All the nitrogen amount was applied at the time of transplanting,
A2- All the nitrogen amount was applied 15 days after transplanting,
A3- the nitrogen amount was splitted into two doses; the first dose was applied 15 days after transplanting, while the other was applied 15 days later.

The treatments were arranged in a split plot design using nitrogen application time as main plot and fertilizer rate as subplot.

The seed sowing dates during 1997, 1998 and 1999 experiments were 20/11/96, 15/11/97 and 05/12/98, respectively, while the transplanting dates during 1997, 1998 and 1999 experiment were 18/01/97, 19/01/98 and 05/02/99, respectively. The harvesting dates during 1997, 1998 and 1999 experiments were 15/05/97, 15/05/98 and 03/06/99, respectively.

Surface irrigation was used. The amount of irrigation water applied was to 12 ml per plot per every irrigation time. The chemical composition of irrigation water is given in table 2.

Table 2. Initial characteristics of the irrigation water used

Water characteristics	1997	1998 and 1999
EC (mmoh.cm^{-1})	1.80	1.10
Soluble cations(meq l^{-1})		
Ca^{++}	8.00	4.66
Mg^{++}	3.20	2.01
Na^{+}	6.50	5.00
K^{+}	0.24	0.17
Soluble anions(meq l^{-1})		
Cl^{-}	5.50	5.15
CO3	None	None
HCO3	3.10	2.75
SO4	5.00	3.94
PPM	1204	736
SAR	3.08	2.70
Water pH	6.90	6.77

Plant growth measurements include leaf area, leaf fresh weight, leaf dry weight, fresh and dry weight of bulb. The crop yield was taken on whole plot basis. Leaf area and leaf weight (fresh and dry) was measured on some randomly selected plants. Leaf area was measured using the leaf area meter instrument (CI – 202, CID, INC.). To determine the dry weight of leaf and bulb; the plant material was dried in an oven at 65-70^{o} C to a constant weight.

The data obtained were statistically analyzed. Mean separations were calculated using the least significant differences (LSD) ($p= 0.05$) [18, p.625].

Results and Discussion

Leaf area

Mean leaf area did not show significant increases with nitrogen application at the different application times during the three crop seasons (Table 3). Although there was an increasing trend in the leaf area with a delay in the time of nitrogen application, the difference was not significant among different periods.

Combined analysis showed that the highest level of nitrogen caused a significantly increase in leaf area compared to lower level.

Leaf dry weight

The difference in leaf dry weight was not significant in 1997 and 1998 but in 1999, A1 plants had significant lower leaf dry weight compared to other treatments.

During 1999, the difference in dry weight was not significant between A1 and A3 as well as between A2 and A3 treatments.

The difference in leaf dry weight was not significant among various treatments receiving different amount of nitrogen fertilizer. The data indicate that the application of nitrogen did not cause any significant effect of leaf dry weight, which is highly unusual as compared to the leaf area per plant.

Table 3. Effect of time and rate of nitrogen application on onion leaf area and dry weight during the years 1997, 1998 and 1999

Time of application*	Leaf area plant^{-1} (cm^2)				Leaf dry weight plant^{-1} (g)			
	1997	1998	1999	Combined	1997	1998	1999	Combined
A 1	229.33a	372.33a	461.0 a	354.22 b	2.33a	2.79a	3.22b	2.17b
A 2	223.67a	403.00a	492.67a	373.11ab	2.05a	2.79a	3.71a	2.71b
A 3	224.67a	447.33a	523.67a	398.56a	2.23a	2.55a	3.59a	3.51a
L.S.D (5%)	112.25	97.60	62.71	42.30	1.21	0.33	0.39	0.71
N levels (kg ha^{-1})								
B1 0	225.33ab	432.67a	479.33b	379.11b	2.23a	3.02a	3.26a	2.84a
B2 100	238.0ab	400.0a	493.67b	377.22b	2.19a	2.95a	3.03a	2.81a
B3 200	201.33b	465.67a	509.00a	392.00b	2.01a	2.24a	2.98a	2.41a
B4 300	268.33a	418.33a	594.67a	427.11a	2.42 a	2.78a	2.98a	2.73a
L.S.D (5 %)	48.74	68.78	78.02	22.86	0.45	0.705	0.529	0.284

* A1- All the nitrogen amount was applied at the time of transplanting,
A2- All the nitrogen amount was applied 15 days after transplanting,
A3- the nitrogen amount was splitted into two doses; the first dose was applied 15 days after transplanting, while the other was applied 15 days later.

Bulb yield

Application of nitrogen at two equal doses 15 and 30 days after transplanting significantly increased the bulb yield. (Table 4).

Mean bulb yield showed significant increase with nitrogen application at the different application times during the 1997 and 1998 crop seasons. There was a significant increase in the bulb yield with delaying the time of nitrogen applications and the third treatment resulted in the highest bulb yield. (Table 4).

Bulb dry weight

Mean bulb dry weight did not show significant increases with nitrogen application at the different application times during the three seasons, except a slight significant difference between A2 and either A1 and A3 at 1998 season. Although there was an increasing trend in the bulb dry weight with delaying the time of nitrogen application, the difference was not significant among the different application times during 1997 and 1999 seasons, while a slight difference occurred between 1998 season treatments with A3 being the highest. (Table 4).

Table 4. Effect of time and rate of nitrogen application on onion yield during the years 1996, 1997 and 1998

Time of application*	Bulb yield (T H^{-1})				Bulb dry weight plant^{-1} (g)			
	1997	1998	1999	Combined	1997	1998	1999	Combined
A 1	12.39 b	33.48 c	48.81 a	31.56 b	3.26 a	5.98 b	8.24 a	5.83 a
A 2	12.01 b	36.64 b	44.53 a	31.06 b	3.40 a	6.36ab	8.20 a	5.99 a
A 3	13.92 a	47.03 a	48.18 a	36.38 a	3.30 a	6.67a	7.85 a	5.94 a
L.S.D (5%)	01. 27	02.08	04.31	01.27	0.68	0.56	0.68	0.29
N levels (kg ha^{-1})								
B1 0	10.68 a	30.54 b	41.77 c	27.66 b	2.57 c	5.25 c	6.40 b	4.74 c
B2 100	13.36 a	41.17 a	49.61 a	34.91 a	3.67 a	6.99 a	8.84 a	6.50 a
B3 200	12.30 a	41.62 a	50.60 a	34.84 a	3.44bc	6.44 c	8.69 a	6.19 b
B4 300	13.27 a	41.08 a	47.38 b	33.91 a	3.43ab	6.28 b	8.46 a	6.06 b
L.S.D (5%)	03.15	02.34	01.49	01.20	0.48	0.55	1.16	0.39

* A1- All the nitrogen amount was applied at the time of transplanting.
A2- All the nitrogen amount was applied 15 days after transplanting.
A3- the nitrogen amount was splitted into two doses; the first dose was applied 15 days after transplanting, while the other was applied 15 days later.

In terms of different nitrogen levels, the bulb dry weight showed a significant increase with an increase in nitrogen application with the treatments of 100 kg N ha^{-1} being the best.

In terms of different nitrogen treatment levels, the bulb yield was significantly effected by the amount of nitrogen applied. Control treatment showed a significant low production. There were no significant differences between B2 and B3 treatments, whereas the treatment of 100-kg N ha^{-1} gave the best result.

The lowest yield in 1997 could be attributed to the coarse texture of the soil. It is clear that delayed application of nitrogen enhanced the crop yield significantly than the earlier application. This could be due to the low requirement for nitrogen at the early stages of crop growth as compared to later stages of crop growth. However, the results indicated that the application of nitrogen at later stages of crop growth is more beneficial to achieve higher crop yield.

Onion bulb yield mean ranged between 10.68 and 13.36 t h^{-1} (1997), 30.54 and 41.62 t h^{-1} (1998) and 41.77 and 50.60 t h^{-1} (1999) in different N levels (Table 4). The difference in bulb yield was not significant among various treatments in 1997. The mean bulb yield increased significantly with an increase in nitrogen application compared to the control treatment during 1998. But no significant differences were observed between other treatments. Similarly, the bulb yield increased significantly with an increase in nitrogen application than the control treatment. The difference in yield was not significant between B3 and B4, but it was significant between B2 and B4 treatments. The results show that the application of 100 and 200 kg nitrogen ha^{-1} at two doses, 15 and 30 days after transplanting would be sufficient to obtain a bulb yield of up to 50 t h^{-1}

under the existing crop growing conditions. It was concluded that the combination of 200 kg N ha^{-1} together with split nitrogen application, 15 and 30 days after transplantation, should give the highest onion yield in the central region of the Kingdom of Saudi Arabia. This further suggests that excess application of nitrogen over 200 kg N ha^{-1} will not be economically feasible for higher crop production.

Nitrogen application at the rate over 300 Kg h^{-1} has resulted in low bulb production. This could obviously be ascribed to the high foliage development at the expense of bulb yield. Riekels [3] stated that high rates of nitrogen could cause excessive leaf growth at the expense of bulb development and this may account for the overall reduction in yield.

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تأثير معدلات ومواعيد إضافة السماد النيتروجيني في إنتاجية محصول البصل في المنطقة الوسطى من المملكة العربية السعودية

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ملخص البحث. تعرض هذه الدراسة نتائج تجربة أجريت لمدة ثلاثة مواسم لتوضيح تأثير معدلات ومواعيد إضافة السماد النيتروجيني في إنتاجية محصول البصل (صنف تكساس يلو جرانو). اشتملت التجربة على أربعة مستويات من النيتروجين (٠، ١٠٠، ٢٠٠ و ٣٠٠ كجم/هكتار) وثلاثة مواعيد لإضافة السماد (كامل الكمية عند زراعة الشتلات ، وكامل الكمية بعد١٥ يوماً من زراعة الشتلات والموعد الثالث قسم إلى جزأين: نصف الكمية الأول أضيف بعد١٥ يوماً من زراعة الشتلات والنصف الثاني بعد٣٠ يوماً من زراعة الشتلات) أجريت هذه الدراسة خلال الأعوام ١٩٩٧ و ١٩٩٨و ١٩٩٩م. في المنطقة الوسطى من المملكة العربية السعودية.

أشارت النتائج إلى زيادة في مساحة الأوراق وكذلك الوزن الجاف للأوراق بإضافة السماد النيتروجيني على دفعتين ١٥و ٣٠ يوماً بعد الشتل وكذلك بزيادة معدل الإضافة. كما أن هناك زيادة معنوية في المحصول الكلي للبصل ووزن البصلة الواحدة، وذلك بإضافة السماد على جزأين، وكذلك نتيجة للتسميد بمعدل ٢٠٠ كجم/هكتار. أما التسميد بمعدل ٣٠٠ كجم/هكتار فقد أدى إلى زيادة المجموع الخضري على حساب محصول البصل النهائي. و توصي هذه الدراسة بإضافة التسميد بمعدل ٢٠٠ كجم نيتروجين/هكتار على دفعتين (١٥و ٣٠ يوماً) بعد زراعة الشتلات؛ لأنه سيعطي أفضل إنتاجية للبصل تحت ظروف المنطقة الوسطى من المملكة العربية السعودية.