Effect of plant population and nutrition on yield and quality of onion in Kassala

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Abstract

Prompted by the farmers practices in Kassala of growing onions at wide spacing, as determined by the transplanting laborers, and applying liberal amounts of urea, without using phosphate fertilizer, this work was designed and executed at Kassala Research Farm to rectify these management practices for better bulb yield and quality of the white variety El Hilo onion. Two separate experiments were conducted. Experiment I was conducted for three seasons to test the effect of 4 levels of nitrogen, viz. 0, 43, 86 and 129 kg N/ha at two plant populations of 90 plants/m^2 (5x20 cm) and 45 plants/m^2 (10x20 cm). Experiment II was conducted for four seasons to test the effect of NP fertilizers. Planting at the closer spacing of 5x20 cm increased bulb yield by 7.6% compared to 10x20 cm across the three seasons. Application of nitrogen significantly increased the yield by 9.4-14.3% when 43 kg/ha was applied. The increment in yield was negligible when further applications were made. Likewise, yield response to phosphorus was statistically significant, when 43 kg P_2O_5/ha was applied causing an increase of 9.5%. Further addition of phosphorus had limited effect on bulb yield. Although NP interaction was not significant**,** the combination 43 kg.N/ha + 43 kg P_2O_5/ha produced the highest economic bulb yield. Nitrogen application increased bulbs size and reduced the incidence of bolting. Based on bulb yield response and economic returns, it was recommended to apply 43 kg.N/ha + 43 kg P_2O_5/ha for onions grown at plant population of 90 plants/m^2 in the area northwest of Kassala.

Introduction

Farmers in Kassala grow red onion cultivars as an early crop, while the white variety El Hilo is grown in the main winter season for dehydration. They used to apply liberal amounts of urea (200-400 kg/feddan), especially for the early crop. They usually do not use phosphate fertilizer for vegetable crops or fruit trees. Onions are transplanted into flat bed, at wide and irregular plant spacing. The soil north-west of Kassala, where the experimental farm is located is sedimentary, ranging from fine sand to sand to silty clay loams and clay loams and is classified as vertic ustifluvent. Soil analysis in this area revealed high content of nitrogen and organic carbon in the top 30 cm layer, (Van Der Kevie and Burayma, 1976). However, intensive onion production in two seasons/year in Kassala may call for fertilizer application for the shallow rooted onion crop coupled with the appropriate plant population. The following two experiments were conducted to investigate the effect plant density and NP nutrition on yield and quality of onion in Kassala area.

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I. Effect of intra-row plant spacing and level of nitrogen on bulb yield and quality

Materials and methods

The experiment was conducted for three seasons (1988-89, 1989-90 and 1990-91) in Kassala Research Farm, where the soil is classified as salty clayey loamy soil. The treatments tested were two intra-row spacings of 5x20 and 10x20 cm equivalent to calculated plant densities of 90 and 45 plant/m2, respectively, and four levels of nitrogen, viz. 0, 43, 86, and 129 kg N/ha in form of urea.

The treatments were entered in a RCB design factorially arranged in three replicates. Seedlings 7-8 weeks old of the white variety El Hilo were transplanted in 21 m^2 flat beds on dates shown in Table 1 together with the specifications of other field practices. Nitrogen in the form of urea was split applied 1 and 2 months after transplanting. Weeds were controlled using Ronstar 25% at 1.31 kg. a.i/ha., with no supportive hand weeding, while thrips were controlled with malathion. The plots were irrigated at intervals of 7-10 days till maturity. Bulbs were harvested when plants reached full neck break and became dry. Data recorded included total bulb yield, marketable yield, percentage of large, medium and small bulbs, besides percentage of double/split bulbs and bolters.

Results

Total bulb yield

The effect of intra-row spacing on total bulb yield was statistically significant (P=0.01) in season 1989-90 (Table 2). Closer intra-row spacing of 5 cm increased bulb yield by 7.6% over 10 cm in the overall mean of the three seasons. On the other hand, nitrogen application at the rate of 43 kg/ha significantly increased mean bulb yield (P=0.05) by 9.4% when compared to the control (ON), further nitrogen applications had no significant effect on bulb yield.

Marketable yield is the total bulb yield, but excluding small bulbs of diameter less than 3 cm. The effects of intra–row spacing and nitrogen on the mean marketable yield of the three seasons were not significant. The response to nitrogen was higher at the closer spacing of 5 cm compared to 10 cm in all seasons (Table 3).

Double/Split Bulbs (%)

These are the visually apparent double or split bulbs without dissection. They are accepted in the dehydration industry and in the local fresh market, but rejected by export standards. The effect of plant spacing and nitrogen application on % of doubles and split bulbs was very small (less than 5%).

Bolters (%)

The effect of either intra-row spacing or nitrogen application were statistically not significant. However, closer spacing of 5x20 cm increased percentage of bolters by 14.5%, while nitrogen application decreased the incidence of bolting (Table 4).

Economic returns

Based on the prices of 2004, the proposed dose of urea fertilizer was highly economical with marginal rate of returns of 300%.

II. Effect of NP fertilizers on bulb yield and quality

Materials and methods

The experiment was conducted for four seasons (1984-85, 1989-90, 1990-91, and 1991-92).Treatments tested were three nitrogen levels viz. 0, 43 and 86 kg N/ha urea and three phosphorus levels viz. 0, 43 and 86 kg P_2O_5 /ha from Triple Super Phosphate. Treatments were arranged factorially in a randomized complete block design with four replications. Seedlings of white onion cultivar (El Hilo) were transplanted when 7 weeks old in flat subplots 7x3 m^2 at the spacing of 20x10 cm making 13 rows/treatment. Planting dates were 18 Nov 1984, 4 Dec 1989, 26 Nov 1990 and 17 Nov 1991 for the four seasons, respectively.

Phosphorus fertilizer was incorporated in the soil before planting, while nitrogen fertilizer was broadcasted at one and two months after transplanting. Weeds were chemically controlled with Ronstar 25 with no supportive hand weeding, while malathion and danitol were used for thrips and make sure of the speding used for maggots. The plot was regularly irrigated at 7 days intervals till the first signs of neck break when irrigation interval was extended to 10 days till complete maturity (toppling over of tops). The crop was harvested on 29 March 1985, 11 April 1990, 30 April 1991 and 16 April 1992, and bulbs sorted out into medium-large bulbs (diamer $\geq$ 3 cm), double/split bulbs and bolters.

Results

Total bulb yield

As shown in Table 5, the separate effects of either nitrogen or phosphorus on onion bulb yield were statistically highly significant (P = 0.01, Table 5). Application of nitrogen over 43 kg/ha level had very limited and non-significant effect on bulb yield. Similarly, application of phosphorus beyond 43 kg/ha had non-significant effect on bulb yield. The effect of NP interaction was not significant, but the combination of 43 kg P_2O_5 and 43 kg N per hectare produced a yield not significantly different from the combination 86 kg P_2O_5 and 86 kg N (Table 5).

Marketable yield

The effect of nitrogen alone on marketable yield was statistically highly significant (P = 0.01). Applying 43 or 86 kg N/ha increased the marketable yield similarly by 21.6% and 22.7%, respectively, over the control (Table 6). Applying extra nitrogen over 43 kg/ha had a very limited effect on marketable yield.

The mean effect of phosphorus on marketable yield over 4 seasons was statistically highly significant (P = 0.01). Application of 43 kg or 86 kg P_2O_5/ha increased the marketable yield similarly by 11.4% over the control. The response to the interaction of NP was statistically not significant.

Doubles and split bulbs

The application of nitrogen and/or phosphorus at the levels tested did not produce noticeable effects on the percentage of double and split bulbs

Bolters

The most remarkable effect of nitrogen application was expressed in the suppression of premature bolting of El Hilo cultivar. The effect was statistically highly significant (P = 0.01). The percentage of bolters was significantly reduced by application of 43 and 86 kg N/ha as compared with the control (Table 7). The lower dose of 43 kg N/ha reduced bolters by 22.5% while at 86 kg N/ha the reduction reached 43.8%. The same effect was consistent in the 4 seasons. Phosphorus application did not give a noticeable effect on bolting.

Economic Evaluation

The highest economic returns were achieved when applying 43 kg N + 43 kg P_2O_5/ha. This was equivalent to 94 kg urea/ha + 94 kg super phosphate/ha. The yield increased by 85 sacs/ha over the control which gave net return of 195 thousands Dinars per hectare. On the other hand, doubling the fertilizer dose, i.e. applying 188 kg from each of urea and Triple Super phosphate, increased the yield by 5 sacks/ha only (Table 8). Therefore, the cost of the extra fertilizer added over 94 kg urea + 94 kg triple Super Phosphate was more than the value of the increase in yield.

Discussion

The response of onion bulb yield to nitrogen application at Kassala Research Farm was low at 43 kg N/ha. Applying 86 or 129 kg N/ha for onions at Kassala either depressed the yield or produced an uneconomic increase in yield. The soil analysis of the silty clay loams of the recent Gash Delta, northwest of Kassala, where the research farm is located, unlike the soil of the central clay plain, contained a high percentage of organic nitrogen reaching 0.092-0.15% in the upper 30 cm, and high organic carbon of 0.87-1.41% (Van Der Kevi and Burayma, 1976). These highly productive fertile soils require less nitrogen than the soils of the central clay plain where studies on fertilizer requirements of onions reported higher yield responses to nitrogen application (Hassan and Ayoub, 1978; Hassan, 1984; Khashmelmous, 1993).

The low response to phosphorus application of 9.5% increase in yield at 43 kg P_2O_5/ha. and 11.3% at 86 kg P_2O_5/ha may also be associated with adequate phosphorus level in the Gash Delta soils.

Doubling and splitting of bulbs are usually associated with large sized-bulbs. The same problem was encountered at El Hudeiba and Gezira in onion fertilization. Although doubles are locally marketable, they are unfavorable and can be minimized through high plant population or variety improvement.

Premature bolting is a serious problem in onion production, resulting in reduced yield and quality. Nitrogen application minimized the incidence of bolting. This favorable response was also reported by Hassan and Ayoub (1978).

In conclusions, therefore, it is not economic to apply more than 43 kg N + 43 kg P_2O_5/ha in Kassala area. In locations exposed to annual flooding by the Gash river where new soil is sedimented every year, the use of inorganic fertilizers may not be necessary or economical. It is worth mentioning that Kassala farmers only use fertilizer (urea) extensively for onions, while most of the other vegetables and fruit trees are not fertilized.

Recommendations

Based on the limited response of onion to high application of nitrogen and phosphorus fertilizer, it is recommended to use the low dose of 43 kg N/ha + 43 kg P_2O_5/ha. The soil is usually flooded by the Gash river in years of high flood. A high plant density of 90 plants/m^2 (i.e. 5x20 cm) is recommended in flat beds of the silty clay loam soil in Kassala area.

References

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Table 1. Experimental details

Details	1988-89	1989-90	1990-91
Nitrogen	0, 43, 86, 129 kg/ha	0, 43, 86, 129 kg/ha	0, 43, 86, 129 kg/ha
In-row (cm)	5, 10	5, 10	5, 10
Row (cm)	20	20	20
Subplot	$3x7m^2$	$3x7m^2$	$3x7m^2$
Seedling age	7 wks	7 wks	7 wks
Transpl. date	16/10/1988	6/12/1989	28/10/1990
N application	15/11+15/12	27/12+5/2	27/11+26/12
Irrigations	18	17	18
Weed control	Ronstar25	Ronstar25	Ronstar25
Pest control	Thrips	Thrips	Thrips
Harvest date	11/3/89	14 –18/4/90	16 –18/4/91

Table 2. Mean effects of in–row spacing and level of nitrogen on bulb yield (t/ha) of onion across 3 seasons.

Treatment		1988-89	1989-90	1990-91	Means	% Change
Spacing (cm)	Nitrogen (kg/ha)					
5x20	ON	18	18	19	19	
	43	22	19	25	22	+19
	86	21	22	23	22	+20
	129	22	23	23	23	+23
10x20	ON	20	17	22	20	
	43	19	17	23	20	
	86	17	18	22	19	
	129	22	20	23	22	+10
	S.E(±)	1.5	1.4	1.7	0.8	
	C.V (%)	18	12	12	7	
Means:	Spacing (cm)					
	5x20	21	21	21	22	+8
	10x20	18	18	22	20	
	S.E(±)	1.0	0.7	0.8	0.4	
	Nitrogen					
	ON	19	18	21	19	
	43	21	18	24	21	+9
	86	19	20	23	21	+7
	129	23	22	23	22	+17
	S.E (±)	1.5	1.0	1.138	0.568	

Table 3. Mean effects of intra-row spacing and level of nitrogen on marketable yield (t/ha) of onion across 3 seasons.

Treatment		Marketable yield (t/ha)				
Spacing (cm)	N (kg/ha)	1988-89	1989-90	1990-91	Means	% Change
5x20	ON	10	13	14	12	
	43	13	12	20	15	+23
	86	14	15	20	16	+32
	129	15	17	20	17	+41
10x20	ON	13	13	20	15	
	43	12	13	21	15	+1
	86	12	13	20	15	-2
	129	15	14	21	17	+11
	S.E(±)	2.2	1.5	1.9	0.8	
	C.V(%)				9	
Means						
	Spacing:					
	5x20	13	14	19	15	
	10x20	13	13	21	16	
	S.E(±)	1.1	0.8	0.9	0.4	
	Nitrogen:					
	0N	11	13	17	14	
	1N	13	13	21	15	+11
	2N	13	14	21	16	+13
	3N	15	16	20	17	+24
	S.E(±)	1.6	.11	1.3	0.5	
	C.V (%)	30	20	16	9	

Table 4. Effect of intra-row spacing and nitrogen fertilizer on bolters of onion across two seasons, 1989-90 and 1990-91.

Treatment		89/90	90/91	Means	%
Spacing cm	N (kg/ha)	% Bolters	% Bolters		Change
5x20	0	12	3	8	
	43	14	3	9	+19
	86	9	1	5	-27
	129	5	1	3	-55
10x20	0	9	2	6	
	43	11	1	6	
	86	9	1	5	
	129	7	1	4	-24
	S.E(±)	3	0.5	1.2	
	C.V %	53	49	30	
Means					
	Spacing cm				
	5x20	10	2	6	+15
	10x20	9	2	5	-13
	S.E(±)	1.5	0.3	0.6	
	Nitrogen kg/ha				
	0	10	3	6	
	43	13	2	7	
	86	9	1	5	-17
	129	6	1	4	-42
	S.E(±)	2	0.4	1	
	C.V (%)	**53**	**49**	**30**	

Table 5. Effect of NP fertilizers on pulb yield of onions in 4 seasons at Kassala.

Treatment		1984-85	1989-90	1990-91	1991-92	Means	% change
kg N/ha	kg P_2O_5/ha	t/ha	t/ha	t/ha	t/ha	T/ha	
0	0	21.2	21.1	15.9	29.8	22.0	
0	43	25.4	21.7	18.7	36.2	25.5	+15.9
0	86	25.5	24.4	22.7	35.4	26.9	+22.5
43	0	25.0	26.5	21.2	35.7	27.3	+24.2
43	43	26.0	28.3	23.4	37.1	29.7	+34.9
43	86	29..9	29.8	18.6	34.6	28.1	+27.8
86	0	27.4	26.1	20.5	34.7	27.2	+23.6
86	43	26.7	26.5	20.2	41.0	28.6	+30.0
86	86	31.9	31.9	21.5	36.1	30.1	+37.0
	C.V (%)						
	S.E (±)	1.6	1.7	1.3	1.0	0.9	
Means							
	kg N/ha						
	0	24.1	22.4	19.1	33.7	24.8	
	43	28.5	28.1	21.1	35.8	28.4	+14.3
	86	28.7	27.9	20.7	37.3	28.7	+15.4
	S.E (±)	0.9	1.0	0.8	2.1		
	kg P_2O_5/ha						
	0	24.9	22.4	19.1	33.8	24.8	
	43	27.4	28.2	21.1	35.8	28.4	+9.5
	86	28.9	27.9	20.7	37.3	28.7	+11.3
	S.E (±)	0.9	1.0	0.8	1.1	0.6	

Table 6. Effect of NP fertilizers on Marketable bulb of onions in 4 seasons at Kassala.

Treatment		1984-85	1989-90	1990-91	1991-92	Means	% change
kg N/ha	kg P_2O_5/ha	t/ha	t/ha	t/ha	t/ha	t/ha	
0	0	19.0	18.8	13.8	27.7	19.8	
0	43	22.1	19.0	17.1	34.5	23.1	+17
0	86	21.9	19.0	20.6	33.7	23.8	+20
43	0	24.6	25.0	19.6	34.0	25.8	30
43	43	29.0	27.5	21.9	36.1	28.6	+45
43	86	28.5	28.6	16.9	33.0	26.8	+35
86	0	26.2	24.9	18.9	32.7	25.7	+30
86	43	25.7	25.3	19.1	40.1	27.6	+39
86	86	30.4	29.5	20.3	34.8	28.7	+45
	C.V (%)	10.2	12.6	12.1	10.0	8.8	
	S.E (±)	1.7	2.2	1.6	1.97	1.13	
Means							
	kg N/ha						
	0	21.0	19.2	17.2	31.9	22.3	
	43	27.4	27.1	19.5	34.4	27.1	+22
	86	27.4	26.6	19.4	35.9	27.3	+23
	S.E (±)	0.98	1.25	0.93	2.18	0.65	
	kg P_2O_5/ha						
	0	23.2	22.9	17.4	30.5	23.8	
	43	25.6	23.9	19.4	36.9	26.5	+11
	86	26.9	25.9	19.3	33.8	26.5	+11
	S.E (±)	0.98	1.25	0.93	1.14	0.65	

Table 7. Effect of NP fertilizers on percentage bolters in onions across 4 season at Kassala Research Station

Treatment		1984-85	1989-90	1990-91	1991-92		
		% Bolters	% Bolters	% Bolters	% Bolters		% change
kg N/ha	kg P_2O_5/ha					Means	
0	0	28.4	25.2	18.2	4.1	19.0	
0	43	19.5	17.8	8.9	4.4	12.7	
0	86	29.6	29.6	11.3	5.5	19.0	-40.0
43	0	17.7	16.2	7.4	4.1	11.4	-26.3
43	43	21.4	21.9	9.3	3.3	13.8	-27.4
43	86	22.9	21.0	6.5	4.8	9.8	-48.4
82	0	17.3	14.1	4.6	3.1	10.6	-44.2
86	43	17.2	13.5	6.8	4.7	8.3	-56.3
86	86	12.0	11.2	7.3	2.7	*	
	C.V (%)	28.98	40.62	38.16	32.73	22.81	
	S.E (±)	3.457	5.448	2.403	0.768	1.500	
Means							
	kg N/ha						
	0	25.9	24.2	12.8	0.7	16.9	
	43	20.7	19.7	7.7	4.0	13.1	-22.5
	86	15.5	12.9	6.2	3.5	9.5	-43.8
	S.E (±)	1.9	3.14	1.39	0.93	0.87	
	kg P_2O_5/ha						
	0	21.1	18.5	10.0	3.8	13.4	
	43	19.4	17.7	8.3	4.1	12.4	
	86	21.5	20.6	8.4	4.3	13.7	
	S.E (±)	1.99	3.14	1.39	0.44	0.87	

Table 8. Economic evaluation of NP application.

Treatment	Total yield	Gain in yield		Added Fertilizer		Cost of Added Fertilizer	
	t/ha	t/ha	Sac/ha	Urea/ha kg	Super P/ha kg	Urea (SD/ha)	Super P (SD/ha)
0	22.01						
43 kg N + 43 kg P_2O_5/ha	29.70	7.69	85	94	94	9025	9025
86 kg N + 86 kg P_2O_5/ha	30.15	8.14	90	188	188	18050	18050
Difference of 2 $ 3		0.45	5	94	94	9025	9025

Value of added yield	Cost of added Fertilizer	Net Benefit (SD/ha)
85x2500 = 212500	18050	+194450
86+86x2500 =12500	18050	-2334