Effects of transplanting date, nitrogen nutrition and watering regime on yield, quality and storage of the red onion

Abdalla Hussein Nourai [1]

Abstract

Field experiments were conducted for three consecutive seasons (1989-90, 1990-91 and 1991-92) with the objective of evaluating the effects of three transplanting dates (15 Nov, 15 Dec and 15 Jan), two levels of nitrogen nutrition (43 and 86 kg N ha^{-1}) and two watering regimes (5 and 10 days) on yield, quality and storage of the red onion variety 'Saggai Improved'.

The highest total onion yield (25 tons ha^{-1}) was realized in 1989-90 season while the lowest total yield (17 tons ha^{-1}) was recorded in 1990-91 season. This seasonal variations in onion yields were attributed to the variations of temperatures prevailing during the growing season where high onion yields were realized in the winter seasons.

High onion yields were realized from early transplanted crop (15 Nov.) followed by 15 Dec. and then 15 Jan. transplanted onion. Percentage reductions of 76 and 56 were recorded when the total and marketable yield averaged over the three seasons of onion transplanted in 15 Jan. were compared with the total and marketable yield averaged over the three seasons of onion transplanted in 15 Nov. The high onion yields realized from early transplanting were associated with an increased bulb size, increased incidence of doubles and splits and bolters, and an improved quality and plant stand. However storage losses were higher in early transplanted onion.

The application of nitrogen fertilizer in the form of urea increased onion yield in one out of three seasons.

Increases of 7 and 5 tons ha^{-1} in total and marketable onion yields, respectively were recorded when onion plants were irrigated every 5 days as compared to the yields of onion irrigated every 10 days.

Based on the findings of this study and in order to achieve high onion yields it is recommended that onion could be transplanted during the period 15 Nov. to 15 Dec.

Introduction

Onion is the most important vegetable crop in the Sudan as it ranks first with regard to the area grown and quantities produced. It is grown in different states in the Sudan with Nahr El Neil, Gezira, Northern Darfour, Khartoum and Western Darfour states being the main producing areas (Table 1). Most of the onion produced is consumed locally and only negligible portion of the crop is dehydrated or exported as a fresh crop to neighboring African countries and Saudi Arabia. However, onion is expected to be one of the most important exportable horticultural crops.

Onion transplanting at Nahr El Neil State extends from late July to early March. The early transplanted crop (September-October) is consumed green as salads or it is sold as dry crop after the produce of the preceding season is sold. The late transplanted crop (January-March) is grown mainly for storage to be sold during the period October-January when the prices are high. Onion grown for export should be

[1]Agricultural Research Corporation, Shambat Research Station, P.O. Box 30, Khartoum North, Sudan

planted early to meet the high market demands in the in porting countries (e.g. April-June in Saudi Arabia) and should be of high quality standards.

Onion production, quality and storage is affected by many factors particularly sowing date, nutrition, irrigation, variety etc. The present study was undertaken to examine the effects of transplanting date, nitrogen nutrition and watering regimes on yield, quality and storage of the red onion variety 'Saggai Improved'.

Materials and methods

Field experiments were conducted for three consecutive seasons (1989-90, 1990-91 and 1991-92) at Hudeiba Research Station (Lat. 17° 34´ N, Long. 33° 56´ E and elevation 350 m above sea level). Treatments tested comprised a factorial combination of three transplanting dates (15 Nov., 15 Dec. and 15 Jan.), two nitrogen levels (43 and 86 kg N ha^{-1}) and two watering regimes (5 and 10 days). The treatments were arranged in a randomized complete block design with four replications. Seeds of the red onion variety 'Saggai Improved' were sown in an open field nursery 50 days prior to each transplanting date. Seedlings were raised as twin rows in ridges 60 cm apart running north-south at an intra-row spacing of 10 cm. The gross plot area was 29 m^2 and the net harvested area was 24 m^2. The plants received two initial irrigations for crop establishment before irrigation regimes were imposed. Nitrogen fertilizer, in the form of urea, was applied as two equal doses; one and two months after seedlings transplanting of each transplanting date. Weeds management and trips control were done as recommended. The mean of pooled data for the three seasons pertaining to the number of irrigations and days from seedlings transplanting to harvest are presented in table 2.

The plants were harvested when they were fully matured and the bulbs were graded into large, small, doubles and splits, bolters, off-types, physically injured and rotted bulbs. The number and weight of each bulb grade were recorded. The weights of doubles and splits and bolters were expressed as percentage of total yield. The percentages of total soluble solids (%TSS) and dry matter (%D.M) were determined in 5 bulbs randomly picked from each plot. Data was statistically analysed and combine analysis was conducted for total and marketable yields (Gomez and Gomez 1984).

Observations on the effects of the treatments on onion storage were carried by weighing (20-30 kg) from each treatment and stored in sacks for a period of 3 months under wooden 'Rakuba'. Bulbs were weighed every month to assess storage losses mainly due to moisture loss and rotting.

Results

Table 2 shows that the early transplanted onion (15 Nov.) requires more irrigations and stayed for a longer period in the field.

Total yield

Table 3 shows that the seasonal differences in onion total yield were very substantial. The highest onion total yield (25 tons ha^{-1}) was recorded in 1989-90 season while the lowest onion total yield (17 tons ha^{-1}) was recorded in 1990-91 season.

The effects of transplanting date on onion total yield were very highly significant (P=0.001) in all seasons (Table 3). The onion yield averaged over the three seasons was highest (33 tons ha^{-1}) when onion seedlings were transplanted on 15 Nov. An overall percentage reductions in onion yield of 36 and 76 were realized when the

total yield of onion seedlings transplanted on 15 Dec. and 15 Jan., respectively were compared with the total yield of onion seedlings transplanted on 15 Nov.

The effect of nitrogen nutrition on total yield was only significant (P=0.01) in one out of three seasons where total onion yield was increased as a result of the application of nitrogen at the rate of 86 kg N ha^{-1} (Table 3).

Marked reductions in total onion yield were realized when onion was subjected to longer watering regime (10 days). An overall reduction of 29% in total onion yield was recorded when the total onion yield of plants irrigated every 10 days was compared with the total onion yield of plants irrigated every 5 days (Table 3).

Marketable yield

The effects of seasons, transplanting dates, nitrogen nutrition and watering regimes on marketable onion yield were similar to their effects on total onion yield. However, marketable onion yield was improved when onion plants were transplanted on 15 Dec. (Table 4).

Marketable bulb weight

Delaying onion transplanting to 15 Dec. and 15 Jan. resulted in consistently marked reductions in marketable bulb weight (Table 5). The application of nitrogen fertilizer at the rate of 86 kg N ha^{-1} increased marketable bulb weight in one out of three seasons while irrigation interval every 10 days resulted in highly significant (P=0.001) reductions in marketable bulb weight (Table 5).

Doubles and splits and bolters

High incidence of doubles and splits (Table 6) and bolters (Table 7) was realized in early transplanted onion (15 Nov.) as compared to the late transplanted onion (15 Dec. and 15 Jan.).

Effects of nitrogen nutrition on both doubles and splits and bolters were not consistent. High level of nitrogen fertilizer (86 kg N ha^{-1}) significantly (P=0.05) increased the percentage by weight of doubles and splits (Table 6) while it significantly (p=0.01) reduced the percentage by weight bolters (Table 7) in one out of three seasons.

Generally, longer watering interval (10 days) decreased the incidence of doubles and splits and premature bolting. However, the effects of water stress were only significant in one out of three seasons (Tables 6 and 7).

The pooled data of the effects of transplanting date, nitrogen nutrition and watering regime on onion quality, plant stand and storage losses are presented in table 8. Delaying onion transplanting to 15 Jan. decreased % T.S.S, % dry matter and plant stand. The percentage weight loss due to storage was higher in the early transplanted onion (15 Nov.) as compared to late transplanted onion (15 Dec. and 15 Jan). There were no apparent effects of nitrogen nutrition and watering regime on % T.S.S, % dry matter and plant stand. However, while nitrogen nutrition had no apparent effect on loss of weight during storage, longer watering interval (10 days) increased storage losses (Table 8).

Discussion

Results of the experiments reported here indicated that marked seasonal variations in onion yield were encountered. These variations were associated with temperatures prevailing during the growing winter season where higher onion total yields were realized in the cooler winter seasons of 1989-90 and 1991-92 as compared to onion yields recorded in the warmer winter seasons of 1990-91.

The effects of transplanting date on onion yield and bulb characteristics were consistently very marked. High onion yields were realized from early transplanted crop (15 Nov. and 15 Dec.) compared to the onion yield of late transplanted onion crop (15 Jan.). The high onion yields recorded from early transplanted crop were associated with an increased bulb size, percentage by weight doubles and splits, percentage by weight bolters, %T.S.S, % dry matter and improved plant stand. Increases in onion yield as a result of early transplanting were in accordance with the findings of studies carried out in Sudan at various research stations for both transplanted and directly sown onion. These studies were performed at Hudeiba (El Hilo, 1966 and 1967 and El Hilo and Mohamed Ali, 1971 and 1972), Shendi (Mohamed, 1987), Gezira (Hassan, 1969, 1970, 1971, 1972 and 1974 and Ahmed, 1978) and Kassala research stations (Osman, 1979a, 1980, 1981, and 1982). These researchers studied the effects of a series of sowing dates verging from early August to mid March on yield and quality of onion. However, all these researchers, except Mohamed (1987), had not used fixed transplanting dates in their repeated sowing date studies. The results of these research workers indicated an increased onion yields as a result of early sowing.

Increases in onion yields realized from early transplanted onion crop, reported here, were associated with an increased percentage by weight doubles and splits and bolters. Doubling, splitting, and bolting are undesirable characters as they lower the quality of onion particularly onions produced for export or processing. Early transplanted onions were subjected to cooler temperatures particularly during the period November-February which resulted in vigorously and healthy growing plants having large leaf area. These plants produced large bulbs which are vulnerable to doubling and splitting. Also the cooler temperature during the early stages of crop establishment are conducive to seed stalk formation (pre-mature bolting). The incidence of doubling and splitting and bolting was markedly reduced by delayed transplanting because the plants of late transplanted onion crop were subjected to shorter cooler period which is not sufficient to enhance vegetative growth. Later in the season these plants were exposed to longer days and warm temperatures which enhance bulbing resulting in small-sized bulbs with reduced incidence of doubles, splits and bolters. It is well documented that onion plants require short days and cooler temperatures in the early stages of crop establishment to enhance vigorous vegetative growth prior to the onset of warm temperatures and longer days later in the growing season which promote bulbing (Jones and Mann, 1963).

The increase of doubles, splits and bolting associated with early planting is a big threat to onion industry targeted for processing or export which requires early planting and it exerts a big challenge for breeding onion verities suitable for export and processing with less incidence of doubles, splits and bolters.

The increase of nitrogen level from 43 to 86 kg N ha^{-1} resulted in one and two tons ha^{-1} increases in the overall mean of three seasons of total and marketable yields, respectively. Positive responses due to nitrogen application reflected as an increased onion yield were reported from different agro ecological zones in the Sudan including Hudeiba, Gezira, Rahad, and Kassala (El Hilo, 1969; Hassan, 1977; Hassan and Ayoub, 1978; Abu Sarra *et al*., 2001, and Osman, 2005).

Frequent irrigation every 5 days resulted in marked increases in onion yields which amounted to 7 and 5 tons ha^{-1} in the overall mean of the three seasons of total and marketable yields, respectively. The increases in onion yields due to frequent irrigation were associated with an increased bulb size. Reductions in onion yield as a result of water stress were in accordance with the findings of Osman (1979 b) and Hassan (1984) and were attributed to reduced root and plant growth and enhanced maturity which resulted in small-sized bulb (Jones and Mann, 1963 and Hassan, 1988).

The increases in storage losses due to early planting (15 Nov.) and longer watering regime (10 days) suggest the role of transplanting date and irrigation in onion storage which needs further investigations.

Recommendation

Based on the results of the experiments reported here and in order to achieve high onion yields it is recommended that onion could be transplanted during the period 15 Nov. to 15 Dec.

References

Abu Sara, A. F., Khashmelmous, A. E., Abdel Rahim, A. O. S, Hashim. A. A. and Idris, M. M. A. (2001). I-Yield responses of onion to source and rates of nitrogen fertilizer. A paper submitted to the Crop Husbandry Committee, Agricultural Research and Technology Corporation, Wad Medani, Sudan, October 2001. pp: 21.

Ahmed, M. K. (1978). Effect of sowing date and method of planting on yield of onion Ann. Rept. Gezira Res. Station and Substations, 1977/78: 165.

El Hilo, A. E. (1966). Effect of sowing date on yield of onions. Ann Rept. Hudeiba Res. Station. 1966/67:70-71.

El Hilo, A. E. (1967). Effect of sowing date on yield of onions. Ann Rept. Hudeiba Res. Station. 1966/67:72-73.

El Hilo, A. E. (1969). Effect of nitrogen nutrition on yield of onions. Ann Rept. Hudeiba Res. Station. 1968/69: (unpublished).

El Hilo, A. E. and Mohamed Ali, G. H. (1971). Effect of sowing date on yield of onions. Misc. Hort. Res. Respts., 1967- 73: 43 -47.

El Hilo, A. E. and Mohamed Ali, G. H. (1972). Effect of sowing date on yield of onions. Misc. Hort. Res. Respts., 1967- 73: 46 -47.

Gomez, K. A. and Gomez, A. A. (1984). Statistiscal Procedures for Agricultural Research. John Willey and Sons. pp: 680.

Hassan, A. A. (1988). Onion and garlic – Aldar A larabia Lilnasher Wal Tawtheig, Cairo (in Arabic).

Hassan, M. S. (1969). Onion variety and sowing date experiment. Ann. Rept Gezira Res. Station and Substations, 1968/69: 310-311.

Hassan, M. S. (1970). Effect on onion of sowing date, direct seeding and transplanting. Ann. Rept. Gezira Res. Station and Substations, 1969/70: 368 – 370.

Hassan, M. S. (1971). on onion of sowing date, direct seeding and transplanting. Ann. Rept. Gezira Res. Station and Substations, 1970/71: 342 – 343.

Hassan, M. S. (1972). Effect of sowing date, direct seeding and transplanting on onion. Ann. Rept. Gezira Res. Station and Substations, 1971/72: 393.

Hassan, M. S. (1974). Effect of sowing date on onion. Ann. Rept. Gezira Res. Station and Substations, 1973/74: 372 – 373.

Hassan, M. S. (1977). Effect of source, level and time of nitrogen application on yield of onion in Sudan Gezira. Acta Horticulturae, 53: 59 – 63.

Hassan, M. S. and Ayoub, A. T. (1978). Effect of N, P and K on yield of onion in The Sudan Gezira. Expl. Agric., 14: 29 –32.

Hassan, M. S. (1984). Effect of frequency of irrigation and fertilizer nitrogen on yields and quality of onions (*A. cepa*) in the arid tropics. Acta Horticulturae 143: 341-346

Jones. H. A. and Mann L. K., 1963. Onions and their Allies. Interscience Publishers, Inc., New York.

Mohamed, A. K. (1987). Effect of variety, transplanting date and nitrogen fertilizer on yield and quality of onion (*Allium Cepa L.*). Sudan Agric. J. 12: 147 – 157.

Osman. M. E. M. (1979 a). Effect of sowing date and method of planting on growth. and yield of onion. Ann. Rept. Gezira Res. Station and Substations, 1978/79: 353 – 354

Osman. M. E. M. (1979 b). Effect of the frequency of irrigation as related to stag growth on the performance and yield of onion. Ann. Rept. Gezira Res. Station and Substations, 1978/79: 254 – 255.

Osman. M. E. M. (1980). Effect of method of land preparation and sowing date on onion. Ann. Rept. Gezira Res. Station and Substations, 1979/80: 231.

Osman. M. E. M. (1981). Effect method of land preparation and sowing date on onion. Ann. Rept. Gezira Res. Station and Substations, 1980/81: 218.

Osman. M. E. M. (1982). Effect of the bed type and sowing date on onions. Ann. Rept. Gezira Res. Station and Substations, 1981/82: 250-252.

Osman. M. E. M. (2005). Effects of plant population and nutrition on yield and quality of onion (*Alluim cepa L.*) variety El Hilo' in Kassala. A paper submitted to the Crop Husbandry Committee, Agricultural Research and Technology Corporation, Wad Medani, 10 April, 2005. pp:22.

Table 1. Area and production of onion in northern states of the Sudan – 2002-03 season (Horticultural Sector Administration, Ministry of Agriculture and Forestry, Khartoum, Sudan.

.

State	Area (ha)	Total production (in thousand tons)	Average yield Ha^{-1} (tons)
Nahr El Neil	12600	240	19
Gezira	8756	167	19
Northern Darfour	6342	91	14
Khartoum	5772	106	18
Western Darfour	5700	149	26
Sennar	2730	65	24
Southern Darfour	1680	40	24
Kassala	1680	36	21
Northern Kordofan	1583	23	15
Northern State	1060	25	24
White Nile	1050	25	24
Gadarif	399	6	15
Total	49352	973	

Table 2. onion cultural practices.

Transplanting date	**15 Nov.**		**15 Dec.**		**15 Jan.**	
Watering interval	**5 days**	**10 days**	**5 days**	**10 days**	**5 days**	**10 days**
Total number of irritations	27	15	25	14	24	13
Days from seedlings transplanting to harvest	173		153		134	

Table 3. Effects of transplanting date, nitrogen nutrition and watering regime on onion total yield (tons ha^{-1}).

Treatment	1989-90	1990-91	1991-92	Mean	% change
Transplanting date					
15 Nov.	39	26	33	33	-
15 Dec.	26	17	20	21	-36
15 Jan.	9	9	6	8	-76
S.E.±	1.6	1.2	1.0	0.8	
Significance level	***	***	***	***	
N-level (kg N ha^{-1})					
43	22	18	20	20	-
86	27	17	20	21	5
S.E.±	1.5	1.0	0.8	0.7	
Significance level	**	N.S	N.S	*	
Watering (days)					
5	27	22	22	24	-
10	22	13	17	17	-29
S.E.±	1.5	1.0	0.8	0.7	
Significance level	***	***	***	***	
Season mean	25	17	20		
S.E.±		0.8			
Significance level		***			

N.S = Non – significant at p=0.05.
*,**,*** = Significant at p=0.05 p=0.01, p=0.001, respectively.

Table 4. Effects of transplanting date, nitrogen nutrition and watering regime on onion marketable yield (tons ha^{-1})

Treatment	1989-90	1990-91	1991-92	Mean	% Change
Transplanting date					
15 Nov.	19	19	16	18	-
15 Dec.	23	16	19	19	6
15 Jan.	9	9	6	8	-56
S.E.±	1.4	1.0	0.7	0.6	
Significance level	***	***	***	***	
N-level (kg N ha^{-1})					
43	15	14	13	14	-
86	18	15	14	16	14
S.E.±	1.1	0.8	0.6	0.5	
Significance level	**	N.S	N.S	*	
Watering (days)					
5	19	18	15	17	
10	14	11	12	12	-29
S.E.±	1.1	0.8	0.6	0.5	
Significance level	***	***	***	***	
Season mean	17	14	14		
S.E.±		0.6			
Significance level		***			

Table 5. Effects of transplanting date, nitrogen nutrition and watering regime on onion marketable bulb weight (g).

Treatment	1989-90	1990-91	1991-92	Mean	% Change
Transplanting date					
15 Nov.	144	125	107	125	-
15 Dec.	93	68	69	77	-38
15 Jan.	51	36	30	39	-69
S.E.±	5.3	3.2	4.0		
Significance level	***	***	***		
N-level (kg N ha^{-1})					
43	91	75	68	78	-
86	101	79	70	83	6
S.E.±	4.4	2.6	3.3		
Significance level	*	N.S	N.S		
Watering (days)					
5	108	96	75	93	-
10	84	57	62	68	-27
S.E.±	4.4	2.6	3.3		
Significance level	***	***	***		
Season mean	96	77	69		

Table 6: Effects of transplanting date, nitrogen nutrition and watering regime on onion percentage by weight doubles and splits.

Treatment	1989-90	1990-91	1991-92	Mean	% Change
Transplanting date					
15 Nov.	18.3	12.8	2.7	11.3	-
15 Dec.	5.5	6.5	1.1	4.4	-61
15 Jan.	2.4	0.6	2.1	1.7	-85
S.E.±	1.4	1.2	0.5		
Significance level	***	***	**		
N-level (kg N ha^{-1})					
43	7.0	6.2	1.7	5.0	-
86	10.5	7.0	2.2	6.6	32
S.E.±	1.1	1.0	0.4		
Significance level	**	N.S	N.S		
Watering (days)					
5	8.9	8.1	2.2	6.4	-
10	8.6	5.2	1.7	5.2	-19
S.E. ±	1.1	1.0	0.4		
Significance level	N.S	**	N.S		
Season mean	8.7	6.6	2.0		

Table 7. Effects of transplanting date, nitrogen nutrition and watering regime on onion percentage by weight bolters.

Treatment	1989-90	1990-91	1991-92	Mean	% Change
Transplanting date					
15 Nov.	27.5	12.9	46.9	29.1	-
15 Dec.	6.9	0.8	2.9	3.5	-88
15 Jan.	0.0	0.2	0.0	0.1	-100
S.E. ±	1.7	1.0	1.6		
Significance level	***	***	***		
N-level (kg N ha^{-1})					
43	12.7	5.8	17.4	12.0	-
86	10.2	3.4	15.8	9.8	-18
S.E.±	1.4	0.8	1.3		
Significance level	N.S	**	N.S		
Watering (days)					
5	11.7	5.6	17.5	11.6	-
10	11.3	3.7	15.8	10.3	-11
S.E. ±	1.4	0.8	1.3		
Significance level	N.S	*	N.S		
Season mean	11.5	4.6	16.6		

Table 8. Effects of transplanting date, nitrogen nutrition and watering regime on pooled data of onion quality, plant stand and storage loss.

Treatment	%T.S.S+	% dry matter	No. of plants m^{-1}	% Weight loss after 3 months*
Transplanting date				
15 Nov.	16.2	16.7	25.5	62
15 Dec.	16.0	16.2	27.1	46
15 Jan.	15.0	15.6	20.5	49
N-level (kg N ha^{-1})				
43	15.5	16.2	24.5	52
86	16.0	16.1	24.3	53
Watering (days)				
5	15.8	16.3	24.9	49
10	15.6	16.0	24.8	56

\+ : pooled data of 3 seasons
* : pooled data of 2 seasons

Table 9. Mean maximum and minimum temperatures (°C) prevailing during the period between seed transplanting and bulb harvesting (Hudeiba Research Station- Meteorological Station).

Season	Temp	Month							
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
	Max.*	38.8	35.6	29.7	30.1	28.4	32.9	39.8	42.8
1989-90									
	Min.**	23.5	20.6	14.2	14.2	12.5	16.4	22.1	25.3
	Max.	40.7	39.9	34.5	28.5	32.4	35.4	41.9	43.3
1990-91									
	Min.	25.5	21.3	19.4	13.7	14.8	17.9	25.1	28.8
	Max.	39.5	34.8	29.1	27.0	26.6	34.8	39.5	41.9
1991-92									
	Min.	24.9	20.2	12.9	11.0	11.4	17.4	20.9	24.5

* : Maximum temperature
** : Minimum temperature