Effects of sowing date on vegetative growth, yield and storability of two onion (*Allium cepa* L.) cultivars in the River Nile State, Sudan

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ABSTRACT

Onion is one of the most important vegetable crops in the Sudan. Sowing date and cultivars are crucial factors for onion production and storability in the River Nile State. Therefore, the objective of this study was to determine the effects of sowing date on vegetative growth, yield and storability of the two onion (*Allium cepa* L.) cultivars Baftaim and Abuferwa in the River Nile State, Sudan. Experiments were carried out at Shendi Research Station farm during two consecutive seasons of 2014/15 and 2015/16. Treatments consisted of three sowing dates, which were first week of December, January and February. Treatments were arranged in a split- plot design with three replicates. Main plots were assigned to the sowing dates and sub-plots to the cultivars. Results showed that the first week of December sowing date significantly resulted in the most vigorous vegetative growth and the highest total yield in both seasons. The cultivar Baftaim had more vigorous vegetative growth, larger bulb size and higher total yield than the local cultivar Abufrewa in both seasons. However, Abufrewa cultivar had higher dry matter content and better storability than Baftaim. Early transplanting of onion in the first week of December resulted in higher postharvest losses than late transplanting in both seasons. It is recommended to transplant Baftaim cultivar in the first week of December for immediate marketing and Abufrewa in the first week of February for long term storage.

INTRODUCTION

Onion is one of the most popular vegetable crops in the Sudan and is an integral part of almost all Sudanese dishes all over the country. Area of production is estimated at 25000 ha, annually, primarily as a winter crop for fresh consumption (Ahmed, 2015). The River Nile, Gezira, and Kassala States are the main areas for production of winter onion, especially Shendi area as a late winter crop. There have been efforts to export fresh onion to Arabian Gulf and West European countries during November to May (Elkashif *et al*., 2006).

Onion growth is dependent on environmental conditions such as photoperiod and temperature. During early growth and development, onion requires cool temperatures (6 to 20°C), but during bulb initiation and development, warmer temperatures (25º to 27°C) are required (Brewster, 2008). Onion cultivars differ with regard to minimum day length required for bulbing and, hence, sowing date is critical and may also differ from year to year (Ansari, 2007). The introduced onion cultivars such as Baftaim have been reported to give the highest total marketable yield in the range of 26.3-44.4 t/ha, compared to the local genotypes such as Abufrewa (Mohammed, 2008)

Onion production is greatly influenced by sowing date, which is one of the most important factors that greatly influence growth and yield of onion. Early planting gives the longest growth cycle (Patil, *et al.* 2012). Therefore, emphasis must be given to increase the yield of onion by adopting the optimum sowing date. George *et al.* (2009) reported that the highest total bulb yield was obtained when onion seedlings were transplanted in early winter.

The storability of onion bulbs is limited by weight loss, sprouting and storage diseases. Under poor storage conditions, serious losses occur due to water loss, rotting, sprouting and rooting (Elkashif *et al*., 2006). There are many kinds of traditional storage methods in the Sudan, but the most common and popular method is open-field storage.

Onion cultivars differ in their storability. Generally, cultivars with high total soluble solids (TSS) and dry matter content and high pungency have longer shelf lives compared to mild cultivars with low TSS (Elkashif *et al*. 2006). Ahmed *et al*. (2015) reported highly significant differences among onion cultivars in weight loss. The least weight loss was recorded for Fadasi, while the highest weight loss was recorded for Baftaim. These results were explained by the fact that Fadasi had higher dry matter and total soluble solids contents compared to Baftaim. Despite the achievements in post-harvest technology, losses during storage still pose a great problem (Kukanoor, 2005). There is a need to investigate the effects of sowing date on yield and storability of onion. Therefore, the objective of this research work was to find out the effects of sowing date on vegetative growth, yield and storability of two onion cultivars in the River Nile State, Sudan.

MATERIALS AND METHODS

Study site

This experiment was carried out at Shendi Agricultural Research Station Farm during two consecutive seasons (2014/15 and 2015/16). Shendi is located at 16º 42′N and 33º 62′E and altitude of 366 masl. It lies close to the eastern bank of the river Nile, River Nile State, Sudan. The soil is classified as Entisol. The parent material of the soil is river Nile alluvium deposits. It is very deep (more than 2 meters), well drained, leveled and uniform. It has dark grayish brown color on the top (0 – 40 cm) to dark yellowish brown in the sub-soil while the structure is clay loam.

Cultivars

Cultivars used were Baftaim and Abufrewa. Baftiam was obtained from Shendi Agricultural Research Station and Abufrewa was bought from farmers in Shendi area. Baftiam was chosen because it is a popular cultivar which has been recently introduced in the area. Abufrewa is the local cultivar which has been cultivated for a long time and has good storability.

Treatments consisted of three sowing dates; first week December, January and February and two cultivars; Baftaim and Abuferwa. The experimental design was a spilt –plot with three replicates. Sowing dates were assigned to the main plots and the cultivars to the sub-plots.

Seeds of the two cultivars were sown in the nursery and transplanted in the field according to the previously mentioned sowing dates. The land was disc plowed, harrowed and made into plots of 3×4 m. Onion seedlings were transplanted on flat plots. Inter- and intra- row spacing was 15 and 10 cm, respectively. Cultural practices of irrigation, fertilization, pest and weed control were carried out as recommended by the Agricultural Research Corporation (ARC), Sudan. Plot size was 12 m^2.

Data collected

Plant height

Plant height (cm) was measured from the ground level to the tip of the longest leaf of five plants randomly selected from the middle rows in each plot, using a meter rule, starting at one month after sowing and at monthly intervals until maturity.

Bulb diameter

Bulb diameter (cm) was measured using a vernier caliper.

Bulb dry matter content

A random sample of sliced fresh onion (five onion bulbs) from each treatment was weighed and then placed in an oven at 80°C for 48 hours. The sample was weighed till a constant weight was obtained. Dry matter content of bulbs (%) was calculated using following equation (Elkashif *et al*. 2006).

$$\text{Dry matter (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Bulb yield

One square meter from the middle rows of each treatment was harvested and total yield (ton/ha) was determined.

Bulb sorting

The percentages of doubles and bolted bulbs were determined for each treatment.

Storability of onion bulbs

Samples of 5 kg of bulbs were taken randomly from each treatment after harvest , packed in jute bags and stored in a well-ventilated store. Bulbs were weighed monthly for a period of 4 months. Cumulative weight loss of onion bulbs was calculated using the following formula:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight – weight at designated time}}{} \times 100$$

Initial weight

Statistical analysis

Data were statistically analysed using the standard analysis of variance procedure. Treatment means were separated using Duncan's Multiple Range Test at 5% level of significance.

RESULTS AND DISCUSSION

Growth parameters

Table 1 shows highly significant effects of sowing date on growth parameters of onion in both seasons. The highest values of plant height, bulb diameter and bulb dry matter content were recorded for the first week of December sowing date and the lowest values were recorded for the first week of February, in both seasons. This was due to the fact that the first week of December sowing date provided low temperatures which encouraged the vegetative growth of onion, however, the late sowing date (first week of February) exposed the crop to the early high temperatures of summer which adversely affected vegetative growth. Similar results were obtained by George *et al.* (2009) who reported that early planting gave the highest values of growth parameters. Also, Patil, *et al.* (2012) reported that onion development was dependent on environmental conditions such as photoperiod and temperature. Ansari (2007) found that during early growth and development of onion, cool temperatures of 6º to 20°C were required, but during bulb initiation and development, warmer temperatures of 25º to 27°C were important. The length of the growing period varied with cultivar and climate, but in general, it ranged between 130 to175 days (Brewster, 2008).

Table 1. Main effects of sowing date on growth parameters of onion (seasons 2014/15 and 2015/16).

Sowing date	Plant height (cm)	Bulb diameter (cm)	Bulb dry matter (%)
Season 2015/16		Season 2014/15	
1st week of Dec	**49.0 a**	**7.3 a**	**20.5 a**
1st week of Jan	49.0 a	6.1 b	**20.7 a**
1st week of Feb	26.0 b	5.3 c	**19.8 b**
Sig. level	***	**	***
C.V (%)	9.4	13.9	**13.7**

Means in a
column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test.
** and *** indicate significance at 1% and 0.1% levels, respectively.

Table 2 shows significant effects of cultivars on growth parameters of onion in both seasons. The maximum values of plant height and bulb diameter were recorded for Baftaim and the minimum values were recorded for Abufrewa in both seasons. However, the dry matter percentage was highest in Abufrewa and the lowest value was recorded for Baftaim. These results indicated that the introduced cultivar, Baftaim, had more vigorous vegetative growth which resulted in larger bulbs compared to the local cultivar Abufrewa. Mofadel *et al.* (2000) reported that the local genotypes had the highest values of dry matter content compared with introduced ones. Mohammed (2008) found that the introduced genotypes had vigorous vegetative growth, large bulb size and high yields but low dry matter content compared with local genotypes.

Table 2. Main effects of cultivars on growth parameters of onion (seasons 2014/15 and 2015/16).

Cultivars	Plant height (cm)	Bulb diameter (cm)	Bulb dry matter (%)
		Season 2014/15	
Baftaim	45.5	7.5	**15.3**
Abufrewa	38.8	6.2	**22.8**
Sig. level	**	*	**
C.V (%)	15.9	12.6	**11.7**
		Season 2015/16	
Baftaim	46.6	7.4	**15.4**
Abufrewa	40.4	6.3	**23.3**
Sig. level	*	*	**
C.V (%)	9.4	13.9	**14.8**

* and ** indicate significance at 5% and 1% levels, respectively.

Table 3 shows significant interaction effects of sowing date and cultivars on growth parameters of onion in the first season only. The highest values of plant height and bulb diameter were recorded for the first week of December sowing date with Baftiam and the lowest values were recorded for the first week of February sowing date with Abufrewa. This may be due to the fact that the first week of December sowing date provided optimum environmental conditions which encouraged the vegetative growth of onion. However, the late sowing date (first week of February) exposed the crop to adverse environmental conditions which negatively affected vegetative growth. The highest values of dry matter content were recorded for the first week of February sowing date with Abuferwa and the lowest values were recorded for the first week of December sowing date with Baftaim cultivar. The early transplanting of the introduced Baftaim cultivar (first week of December) gave large bulb sizes, high water content and low dry matter content of bulbs compared with late transplanting (first week of February). Mohammed (2008) reported that the local genotypes gave the highest values of dry matter content compared with introduced genotypes.

Table 3. Interaction effects of sowing date and cultivars on growth parameters of onion (season 2014/15)

Sowing date	Cultivars	Plant height (cm)	Bulb diameter (cm)	Bulb dry matter (%)
1st week of December	Baftaim	58.2a	7.4a	**17.4c**
	Abufrewa	47.8b	6.3b	**22.4b**
1st week of January	Baftaim	47.9b	7.2a	**18.2c**
	Abufrewa	40.1c	6.9 b	**23.4a**
1st week of February	Baftaim	28.4d	5.8b	**18.6c**
	Abufrewa	23.4e	5.1bc	**23.9a**
Sig. level		*	*	**
C.V (%)		15.9	31.0	**21.7**

Means in a column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test.

* and ** indicate significance at 5% and 1% levels, respectively.

Bulb quality and total yield

Table 4 shows significant effects of sowing date on bulb quality and total yield of onion in both seasons. The highest values of bolters, doubles and total yield were recorded for the first week of December sowing date and the lowest values were recorded for the first week of February sowing date in both seasons. Early transplanting subjected onion plants to cooler temperatures which resulted in vigorous and healthy growing plants with a large leaf area which promoted the production of large bulbs and, hence, increased total yield. Along the same lines, the low yield obtained in the late sowing date was most probably due to the fact that late transplanting subjected onion plants to a shorter cool period and warm temperatures which were not sufficient to enhance vegetative growth and, hence, resulted in low yields. Also, late transplanting resulted in small-sized bulbs with reduced incidence of doubles and bolters. Similar results were reported by Nourai (1992) who showed that high onion yields were recorded by early transplanting and were associated with an increased bulb size and increased incidence of doubles and bolters.

Table 4. Main effects of sowing date on bulb quality and total yield of onion (seasons 2014/15 and 2015/16).

Sowing date	Bolters (%)	Doubles (%)	Total yield (t/ha)
		Season 2014/15	
1st week of Dec	64.2a	30.8a	45.5 a
1st week of Jan	53.7b	25.4b	32 b
1st week of Feb	32.9c	23.6b	27 c
Sig. level	***	***	***
C.V (%)	15.4	12.2	29.0
		Season 2015/16	
1st week of Dec	61.2a	32.8a	41.0a
1st week of Jan	50.1b	27.2b	28.0b
1st week of Feb	37.6c	24.1c	23.0c
Sig. level	*	**	**
C.V (%)	18.3	15.7	21.6

Means in a column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test.
* and** indicate significance at 5% and 1% levels, respectively.

Table 5 shows significant effects of cultivars on bulb quality and total yield in both seasons. Baftaim cultivar had the lowest values of doubles and bolters but had the highest total yield, whereas Abufrewa cultivar recorded the highest values of doubles and bolters and the lowest total yield in both seasons. These results indicated that the introduced cultivar Baftaim was superior to the local cultivar Abufrewa in both bulb quality and total yield. These results were in agreement with those of Mofadel *et al.* (2000) who reported that the introduced cultivars such as Baftaim showed higher values of bulb weight compared to the local cultivar such as Abufrewa. Ansari (2007) reported that the doubles phenomenon was related to genetic factors and affected by specific cultural practices such as sowing date and plant density.

Table 5. Main effects of cultivars on bulb quality and total yield of onion (seasons 2014/15 and 2015/16).

Cultivars	Bolters (%)	Doubles (%)	Total yield (t/ha)
		Season 2014/15	
Baftiam	28.6b	20.0b	45.0 a
Abufrewa	45.0a	29.5a	28.4 b
Sig. level	*	*	**
C.V (%)	15.4	12.2	21.0
		Season 2015/16	
Baftaim	35b	19b	42a
Abufrewa	46a	32a	23b
Sig. level	*	**	**
C.V (%)	18.3	15.7	21.6

* and** indicate significance at 5% and 1% levels, respectively.

Table 6 shows significant interaction effects of sowing date and cultivars on bulb quality and total yield in the first season only. The highest values of total yield were recorded for Baftaim cultivar transplanted in the first week of December and the lowest values were recorded for Abufrewa transplanted in the first week of February. Abufrewa cultivar had higher percentages of bolters and doubles compared with Baftaim. Similar results were obtained by Nourai (1992) who reported that high onion yields were produced from early transplanting, but with high percentages of doubles and bolters. These results were also in agreement with the findings of Mohammed (2008) who reported that the percentage of doubles varied greatly among cultivars and the lowest percentage was obtained from the introduced Baftaim cultivar compared to the local cultivar Abufrewa.

Table 6. Interaction effects of sowing date and cultivar on bulb quality and total yield of onion (season 2014/15).

Sowing date	Cultivars	Bolters (%)	Doubles (%)	Total yield (t/ha)
1st week of December	Baftaim	21.6d	19.7d	45.2a
	Abufrewa	39.4 a	24.1c	30.9c
1st week of January	Baftaim	18.8e	26.1c	37.7b
	Abufrewa	33.9b	31.5b	26.7d
1st week of February	Baftaim	17.3e	31.7b	31.9c
	Abufrewa	26.4c	37.0a	21.6e
Sig. level		*	*	**
C.V (%)		15.4	12.2	12.0

Means in a column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test.

* and ** indicate significance at 5% and 1% levels, respectively.

Weight loss

Table 7 shows significant effects of sowing date on weight loss of onion during storage in the second season only. The highest values of weight loss were recorded for the first week of December sowing date and the lowest values were recorded for the first week of February sowing date. This was probably due to the fact that early transplanting resulted in large bulbs with low dry matter content which subjected them to high water loss compared with small bulbs with high dry matter content in the late transplanted onion. These results were in line with those of Nourai (1992) who reported that the percentage of weight loss during storage was higher in the early transplanted onion.

Table 7. Main effects of sowing date on cumulative weight loss (%) of onion during storage (season 2015/16).

Sowing date	**Months**			
	1	2	3	**4**
	Cumulative weight loss (%)			
1st week of Dec	23.4a	26.9a	34.5a	**43.6a**
1st week of Jan	17.7b	23.6b	29.1b	**38.3b**
1st week of Feb	13.3c	18.5c	25.2c	**32.7c**
Sig. level	***	**	**	*
C.V (%)	11.8	8.8	8.9	**6.7**

Means in a column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test.

*, ** and *** indicate significance at 5%, 1% and 0.1% levels, respectively.

Table 8 shows significant effects of cultivars on weight loss of onions during storage in both seasons. Abufrewa recorded the least percentage of weight loss compared to Baftaim which recorded the highest percentage of weight loss in both seasons. This was most probably due to the fact that the local cultivar Abufrewa had higher dry matter content and higher pungency which resulted in lower weight loss compared to Baftaim cultivar. These results were in line with the reports of Ahmed *et al.* (2015) who found that the characteristics which enhanced superior storage quality of onion were high total soluble solids, high dry matter content and pungency. They also reported that the introduced genotypes had poor keeping quality while the local genotypes had good storability.

In conclusion, it is recommended to transplant Baftaim cultivar in the first week of December for immediate marketing and Abufrewa in the first week of February for long term storage.

Table 8. Main effects of cultivar on weight loss (%) of onion during storage (seasons 2014/15 and 2015/16).

Cultivar	Months			
	1	2	3	4
	Cumulative weight loss (%)			
	Season 2014/15			
Baftaim	17.3	22.5	29.9	46.1
Abufrewa	10.6	16.3	17.8	27.7
Sig. level	*	*	*	*
C.V (%)	13.9	11.8	10.2	7.2
	Season 2015/16			
Baftaim	25.3	38.0	50.6	57.5
Abufrewa	11.6	14.7	18.9	27.3
Sig. level	*	*	*	*
C.V (%)	11.8	11.6	8.9	6.8

* indicate significance at 5% level.

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النمو الخضري و الإنتاجية والمقدرة التخزينية لصنفين من البصل تأثير تاريخ الزراعة علي

بولاية نهر النيل، السودان(*Allium cepa* L.)

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الخلاصة

يعتبر البصل من اهم محاصيل الخضر في السودان . المعاملات الفلاحية مثل تاريخ الزراعة والاصناف تعتبر من العوامل الهامة جدا في انتاج وتخزين البصل في ولاية نهر النيل. هدفت الدراسة إلي معرفة تأثير تاريخ الزراعة علي النمو الخضري والإنتاجية والقدرة التخزينية لصنفين من البصل. أجريت هذه التجربة).اشتملت 015/16 و-2014/15بالمزرعة التجريبية بمحطة بحوث شندي ، ولاية نهر النيل في الموسمين المعاملات علي ثلاثة تواريخ للزراعة وهى الاسبوع الأول من ديسمبر ويناير وفبراير مع صنفين من البصل وهى بافطيم و ابوفريوة. استخدم تصميم القطع المنشقة بثلاث مكررات. وزعت معاملات تاريخ الزراعة على القطع الرئيسية والاصناف على القطع الثانوية. أظهرت النتائج أن زراعة البصل في الاسبوع الأول من ديسمبر أعطت افضل نمو خضري وأعلى إنتاجية في كلا الموسمين. الصنف بافطيم أعطى أفضل نمو خضري وأكبر حجم للأبصال وأعلي إنتاجيه مقارنة مع الصنف أبوفريوة في كلا الموسمين. لكن الصنف أبوفريوة أعطي أعلي نسبه من المادة الجافة و افضل قدرة تخزينية مقارنة بالصنف بافطيم. زراعة البصل مبكرا في الاسبوع الاول من ديسمبر أعطت أعلى فاقد ما بعد الحصاد بالمقارنة مع الزراعة المتأخرة في كلا الموسمين. استنادا علي هذه النتائج نوصي بزراعة الصنف بافطيم في الاسبوع الأول من ديسمبر للتسويق العاجل وزراعة الصنف ابوفريوة في الاسبوع الاول من فبراير للتخزين طويل الامد.