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Onion (*Allium cepa* L.) Bulb Crop Production Using Sets of Two Sudanese Cultivars

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Abstract: The objective of this research was to determine production requirement for onion bulb crop using sets as, rarely but of high potential, planting material. An experiment was carried out at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum for two consecutive growing seasons,(2010/11 and 2011/12). Treatments comprised two cultivars (Saggai and Kamlin), three set sizes (small 1-1.5 cm diameter; medium 1.6-2.1 cm and large 2.2-2.7 cm) and three planting dates (15th of August, September and October). Treatments were arranged in a split split plot design with three replications, where cultivars were randomized in the main plots, set sizes in the sub-plots and planting dates in the sub-sub plots. Results indicated that increasing set size from small to large size significantly promoted plant growth. Medium set size resulted in significantly higher average bulb weight, total and marketable yields than small and large sets; however, bulb splitting and premature bolting (negative quality traits) were also high. So marketable yield represented a range of 40-46 %, 39-49 % and 25-53 % of the total yields over the two years when medium, large and small were used respectively. Plant growth, average bulb weight, bulb diameter, total and marketable yields were significantly higher from sets planted in October and in September than in August; yet, bolting was also significantly higher. Early planting in August significantly increased bulb dry matter. Saggai cultivar had higher tendency for bolting and splitting than Kamlin when sets were used as planting material. Total and marketable yields were significantly higher from medium sets planted in October and September than in August. It is concluded that use of sets as planting material is as good as transplants, if not better, as it is more easy and adaptable to the continuously changing growing environment in terms of climate change and production cost.

Key words: *Allium cepa* L., onion sets, planting date, onion, premature bolting, bulb splitting.

INTRODUCTION

Importance of onion, in terms of area under production or quantities consumed locally, regionally and globally, cannot be over emphasized (FAO 1998; 2015). Onion bulb crop production can be by using direct seed, transplants and small sets. The former two methods have been mostly used in Sudan, but the latter is rarely in spite of the fact that it can be most appropriate to meet the current continuously changing production environment in the main production States.

Generally time of planting onion seedlings or sets should be such that it ensures sufficient amount of vegetative growth before bulbing initiation to produce high yield. Indeed, number of leaves per plant, leaf length, plant height, plant fresh and dry weights, bolting (premature or annual) tendency and total yield have been shown to increase by earl planting (Verma *et al.* 1972; El Murabaa *et al.*1974; Moursi, *et al.*1974; Omran *et al.* 1979). Also bolting percent has been shown not only to increase by earl planting but also decreased markedly with late planting (Aura 1967; Hassan 1977; Suh *et al.* 1996).

Size of the onion set is a very important attribute that affects vegetative growth, bulbing, bolting and time of maturity, eventually affecting yield and bulb quality. For instance, large sets promoted total yield, but also bulb splitting and bolting, while medium and small sets increased marketable yield and number of intact single center bulbs (Vander Meer 1982; Matlob and El-Haber 1983; Koriem and Farag 1990; Nourai 1993; Ali 1998; Nourai 2004). It can be inferred from previous reports that the optimum set diameter which gives the best yield and quality varies depending on cultivar and growing environment.

In response to the recent advent of expansion in areas under production of onion in Sudan, the objective of this research has been to provide necessary information for production of onion using the optimum set size and planting date ,which lends more flexibility to national onion production at large and improves yield and quality.

MATERIALS AND METHODS

The experiment was carried out at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum for two consecutive growing seasons (first season, 2010/2011 and second season, and 2011/2012) at Shambat. Shambat lies at 15° 40' N and 32° 32' E. The climate is semi arid tropical with maximum and minimum temperatures as high as 41.6°c in summer and as low as 14.1°c in winter (Adam 1996). Treatments comprised two cultivars (Kamlin and Saggai), three set sizes (small 1-1.5 cm diameter; medium 1.6-2.1 cm and large 202-2.7 cm) and three planting dates (15^{th} of August, September and October). Sets of each season were produced in the preceding one and stored at room temperature (available to farmers) from March until July and used in the experiment in August. Treatments were arranged in a split split plot design with three replications. Cultivars were randomized in the main plots, set sizes in the sub plots and planting dates in the sub sub plots. Recommended dose of phosphorus in form of super phosphate at the rate of 80 kg/ha was applied to each plot before each planting date. Nitrogen in the form of urea at the rate of 120 kg N/ha was applied in two equal dozes; the first three weeks after sets' planting and the second six weeks later. Onion sets of each planting date were planted on both sides of the ridges at spacing of 0.7m and 0.1m between ridges and sets respectively. Experimental plots included four ridges each of three meters long and 0.7m wide. Irrigation, weeding and plant protection measures were carried as required. The first planting date of the first season was lost due to irrigation problems.

A random sample of 10 plants was taken from each plot, 3 months after planting and data on plant height (cm), average leaf number per plant, plant fresh and dry weights (g) were recorded. Number of premature bolting (%) was recorded in each plot one week before harvesting. At crop maturity, plants of the middle ridge were harvested, cured for 10 days and data were calculated for total and marketable yields (t/ha.), average bulb weight (g), bolting and splitting percentage, bulb diameter(cm), bulb shape index(Height/ diameter) and bulb dry matter content (%). All collected data were statistically analyzed using SAS soft ware 2000 version 9.00.

RESULTS AND DISCUSSION

Vegetative growth:

Set size and planting date significantly affected plant height, number of leaves per plant, plant fresh and dry weights in both seasons (Table 1). Growth parameters increased with increasing set size and delaying of planting date till October. The highest growth performance was obtained from large sets and late planting in October in both seasons. The favourable effect of late planting on vegetative growth of onion sets could be attributed to the relatively cool weather prevailing during the active growth stage of onion plant. October is actually a pre-winter month in Sudan, where night temperature starts to decline i.e. conducive to vegetative growth and consequently high yield. On the other hand, poor growth performance in August could be due to the high temperature prevailing during the sensitive stage of active growth. While the positive effect of large set size on vegetative growth, reported above, is in line with other relevant research (Van der Meer 1982; Matlob and El-Haber 1983; Nourai 1993; Ali_1998), positive effect of late planting in October on vegetative growth, however, was contradictory to that reported by Moursi *et al.* (1975) in Egypt. This discrepancy could be attributed to cultivars used and/or environmental variations.

Table 1. Effect of set size and planting date on the plant height(cm), number of leaves per plant and plant fresh and dry weights(g) of Saggai and Kamlin cultivars, three months after planting.

Treatment	Plant height	Leaves per plant	Plant fresh weight	plant dry weight
Cltivars:		First season 2010/2011		
Kamlin	63.7	14.8	212.2	19.7
Saggai	6207	15.2	225.3	21.6
SE±	0.90	0.30	4.40	0.96
Set sizes:				
Large	65.4^{a}	15.9^{a}	246.3^{a}	21.1^{a}
Medium	62.7^{a}	15.5^{a}	221.1^{b}	19.9^{a}
Small	61.4^{a}	13.7^{b}	118.8^{c}	20.6^{a}
SE±	0.80	0.34	5.80	0.94
Planting dates:				
August 15	-	-	-	-
September 15	59.8^{b}	14.7^{a}	158.9^{b}	16.9^{b}
October 15	66.6^{a}	15.3^{a}	278.6^{a}	24.2^{a}
Cultivars:		Second season 2011/2012		
Kamlin	52.2	10.8^{b}	116.7^{b}	12.2
Saggai	54.7	11.9^{a}	131.3^{a}	13.5
SE±	0.48	0.13	1.5	0.43
Set sizes:				
Large	54.9^{a}	12.2^{a}	152.5^{a}	15.4^{a}
Medium	45.3^{b}	11.3^{b}	129.2^{b}	12.3^{b}
Small	51.2^{a}	10.6^{b}	90.3^{c}	10.5^{c}
SE±	0.63	0.28	3.30	0.66
Planting dates:				
August 15	40.3^{c}	8.4^{c}	47.8^{c}	5.4^{c}
Septemper 15	52.1^{b}	11.8^{b}	105.8^{b}	9.9b
October 15	67.9^{a}	13.9^{a}	218.3^{a}	23.3^{a}
SE±	0.42	0.23	3.2	0.66

Means within columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan Multiple Range Test.

Bulb Yield

Planting date and set size significantly affected average bulb weight, total and marketable yields. Late planting in October and medium size set resulted in high yield and yield components while low yield was associated with August planting date (Table 2). This is a reflection of the vegetative growth at early stage shown in Table1. As a criterion for financial returns, the higher the marketable yield the better. It represented 30 % of the total yield of Kamlin and 40 % of total yield of Saggai cultivars in the first season; in the second season, however, it represented 54% in Kamlin and 44 % of Saggai. Of the total yield produced by planting medium, large and small set size in the first season, marketable yield represented 40 %, 39 % and25 % respectively; in the second season, however, its proportion of the total yield was 46 %, 49 % and 53 %,respectively for medium, large and small sets. Average bulb weight, total and marketable yields were highest in October followed by September and August planting dates; yet marketable yield represented 45 %, 50 % and 58 % of the total yield of October, September and August respectively meaning higher percentage of undesirable bulb characters (splitting and bolting) in October than in August. Also medium set size resulted in the highest average bulb weight, total and marketable yields (Table 2).Salokangag (1967) and Pandey *et al.* (1992), likewise demonstrated that the highest marketable yield and consequently the net returns were obtained from planting medium set size compared to small or large set size indicating its economic feasibility for onion production.

Bulb quality

Bulb dry matter, diameter and shape index were not significantly and consistently different between cultivars in both seasons, but values were invariably higher for Saggai than Kamlin. Cultivars were significantly different regarding bulb splitting and bolting, which were higher in Saggai than Kamlin. Again bulb dry matter, diameter and shape index were not significantly and consistently different among planting dates in both seasons; yet there was a trend for increase in values for October planting and large set size. Bulb splitting and bolting were significantly affected by set size and set planting date in both seasons (Table 3). They were highest in large followed by medium and small set sizes. October planting resulted in higher bolting percentage than September and August in both seasons. Bulb bolting exhibited the same pattern of bulb splitting in response to set size *i.e.* large and medium set size resulted in higher percentage than those of small sets. The high percentage of bolting resulting from planting large sets might be attributed to the early initiation of inflorescence primordia shortly after planting stimulated by the large carbohydrate reserves which is essential for vernalization (Zeevart 1974). That is, plants grown from large sets had reached the optimum stage to receive vernalization stimulus earlier than plants from medium and small sets. The early high and cool plant canopy resulting from large sets (Table 1) might have also enhanced factors inducing premature bolting. These results are in line with earlier research which showed that large sets had more tendencies for bolting than small sets. (Koriem and Farag 1990; Pandey 1992). Bulb splitting associated with set sizes, reported in this research, is corroborated by early studies which showed that lage sets produced higher percentage of doubles (splitting) than small sets (Rabinowitch 1979; Shalaby *et al.*1991; Pandey 1992). The high percentage of bolting with late planting in October could be attributed to the plants reaching the critical stage responsive for the prevailing low temperature and became vernalized faster. Ho (1956) indicated that onion plants with sufficient leaves to initiate bulb division (splitting) only formed flower buds when the mean minimum temperature was less than 5°c and maximum less than 10°c. After all the range of low temperature required for bolting initiation is a function of cultivars and geographical location. The increase in bulb splitting observed with late planting (October/September) could be attributed to high vegetative growth at bulbing stage which makes them more prone to doubling/splitting incidence. El-Haron (1977) stated that environmental factors influencing the vigorosity of the onion plant might influence the occurrence of double bulbs.

Table 2. Effect of set size and planting date on average bulb weight (g), total and marketable yields (t/ha) of Kamlin and Saggai cultivars for 2010/2011 and 2011/2012 seasons.

Treatment	Average bulb weight	Total yield	Marketable yield
Cltivars:		First season 2010/2011	
Kamlin	11.9(+10%)	29.2(+28%)	8.8 (30%)
Saggai	109.3	22.9	9.1 (40%)
SE±	3.20	1.80	0.68
Set sizes:			
Large	104.3[b]	23.1	9.1[a] (39%)
Medium	126.2[a]	28.0	11.1[a] (40%)
Small	113.4[b]	26.9	6.6[b] (25%)
SE±	4.10	1.60	1.05
Planting dates:			
August 15	-	-	-
September 15	114.0	26.6	10.4 (39%)
October 15	115.2	25.4	7.2 (28 %)
SE±	5.50	1.30	0.50
Cultivars:		Second season 2011/2012	
Kamlin	121.6(+6%)	23.9	13.0[a] (54 %)
Saggai	114.9	25.4(+6%)	11.2[b] (44 %)
SE±	2.10	0.49	0.02
Set sizes:			
Large	118.9	24.2[b]	11.8 (49%)
Medium	122.9	26.7[a]	12.4 (46 %)
Small	113.0	23.2[b]	12.3 (53%)
SE±	4.20	0.38	0.10
Planting dates:			
August 15	60.8[c]	11.9[c]	6.9[c] (58 %)
Septemper 15	125.1[b]	25.8[b] (+117%)	13.0[b] (50%)
October 15	168.8[a]	36.3[a]	16.4[a] (45 %)
SE±	3.65	0.21	0.14

Means within columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test

Values in parentheses represent percent increase over the lowest value of the parameter (+) or proportion of marketable to total yield (%).

Table 3. Effect of set size and planting date on bulb dry matter (%), bulb diameter (cm). bulb shape index, Bulb splitting (%) and bulb bolting (%).

Treatment	bulb dry matter	Bulb diameter	Shape index	Splitting	Bolting
Cltivars:		First season 2010/2011			
Kamlin	21.1	6.2	1.3[b]	25.9[b]	58.7[b]
Saggai	20.8	6.2	1.4[a]	34.5[a]	62.9[a]
SE±	0.32	0.70	0.02	2.10	0.53
Set sizes:					
Large	21.2	6.2	1.4	34.6[a]	70.6[a]
Medium	20.7	6.3	1.4	35.0[a]	65.9[a]
Small	21.2	6.0	1.3	20.9[b]	45.9[b]
SE±	0.39	0.12	0.02	1.80	2.20
Planting dates:					
August 15	-	-	-	-	-
September 15	21.2[a]	6.1	1.35[b]	33.2[a]	59.4[a]
October 15	20.8[a]	6.3	1.40[a]	27.2[b]	62.2[a]
SE±	0.32	0.16	0.02	1.90	2.90
Cultivars:		Second season 2011/2012			
Kamlin	17.9[a]	5.5[b]	1.25[b]	10.8[b]	34.5
Saggai	16.9[a]	5.7[a]	1.35[a]	29.8[a]	35.4
SE±	0.31	0.03	0.012	0.16	0.17
Set sizes:					
Large	17.2	5.6	1.30	23.7[a]	36.2[a]
Medium	17.5	5.6	1.29	23.0[a]	37.3[a]
Small	17.6	5.7	1.27	14.0[b]	31.3[b]
SE±	0.27	0.07	0.021	0.29	0.68
Planting dates:					
August 15	18.2[a]	4.3[c]	1.15[c]	18.4[b]	16.3[c]
Septemper 15	17.0[b]	5.8[b]	1.30[b]	24.4[a]	41.9[b]
October 15	17.2[b]	6.8[a]	1.40[a]	18.0[b]	46.5[a]
SE±	0.32	0.09	0.021	4.10	0.43

Means within columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

CONCLUSIONS

- Highest growth performance occurs with large sets planted in October.
- Medium set size results in significantly higher average bulb weight, total and marketable yields than small and large sets; but bulb splitting and bolting is also high.
- Total and marketable yields are significantly higher from medium sets planted in October and September than in August.
- Use of sets as a planting material is as good as transplants, if not better, as it is more easy to handle with minimum loss and more flexible to suit the diverse growing environments in Sudan.

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إنتاج محصول البصل (*Alliu cepa* L.) باستخدام بصيلات صنفين من الأبصال السودانية

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المستخلص: هدف هذا البحث الى تحديد تأريخ الزراعة الأمثل باستخدام البصيلات لإنتاح محصول البصل. أجرى البحث بالحقل التجريبى بكلية الزراعة، جامعة الخرطوم للموسمين الزراعيين 2011/2010 و2012/2011. تكونت معاملات التجربة من صنفين (كاملين وسقاى) وثلاثة أحجام للبصيلات (كبير، متوسط وصغير) وثلاثة تواريخ للزراعة (15 أغسطس، 15 سبتمبر و15 أكتوبر). التصميم الإحصائى الذى أستخدم كان القطاعات المنشطرة بثلاثة مكررات، حيث وضعت الأصناف فى القطع الرئيسة، حجم البصيلات فى القطع المنشطرة الأولى وتواريخ الزراعة فى القطع المنشطرة الثانية. أشارت النتائج إلى أن النمو الخضرى للنباتات إزداد مع زيادة حجم البصيلة. أعطى الحجم المتوسط للبصيلة زيادة معنوية فى متوسط وزن البصلة والإنتاج الكلى والإنتاج القابل للتسوق أعلى من الحجمين الصغير والكبير؛ ولكن نسبة الأبصال المتفلقة (المزدوجة) والحاملة للساق الزهرى (صفتان سلبيتان للنوعية) كانتا أيضا عالية.

لذلك كان متوسط نسبة الإنتاج القابل للتسوق للإتاج الكلى فى الموسمين 46،49 و53 عند زراعة البصيلات المتوسطة، الكبيرة والصغيرة على التوالى. أيضا أعطت الزراعة فى أكتوبر وسبتمبر زيادة معنوية فى النمو الخضرى، متوسط وزن البصلة، قطر البصلة و الإنتاج الكلى والقابل للتسوق، أعلى من الزراعة فى أغسطس. كانت نسبة الإزهار المبكر أعلى معنويا عند الزراعة فى أكتوبر مقارنة ب سبتمبر وأغسطس. أعطى الصنف سقاى نسبة إزهار مبكر ونسبة تفلق للأبصال أعلى من الصنف كاملين عند إستخدام البصيلات فى الزراعة. أعطى إستخدام بصيلات متوسطة الحجم فى الزراعة فى أكتوبر إنتاج كلى وإنتاج قابل للتسوق أعلى من زراعة الحجم الكبير ومن الزراعة قبل أكتوبر. عموما خلص هذا البحث إلى أن إستخدام البصيلات فى زراعة محصول البصل جيدة، إن لم تماثل إستخدام الشتلات، فإنها أحسن لأنها سهلة الإستعمال ومرنة فى مقابلة ظروف الإنتاج المتغيرة دوما من حيث تغير المناخ وتكلفة الإنتاج.