

Effect of vernalization period and bulb size on bolting of onion cultivar “Texas Early Grano” grown under Gezira conditions, Sudan

Elfatih A.M. Elsiddig¹, Osman M. Elamin² and Mohamed E. Elkashif²

¹Faculty of Agriculture and Natural Resources, University of Bakht Er-Ruda, Ed-Duiem, Sudan.

²Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

ABSTRACT

Texas Early Grano onion cultivar is very popular in Sudan and is used mainly as a salad vegetable. Unfortunately, this cultivar does not flower and produce seeds under Sudan conditions and seeds should be imported from abroad. Attempts to produce seeds of this cultivar under Gezira conditions have failed. Therefore, the objective of this research was to study the effects of bulb size and vernalization on the induction of flowering of Texas Early Grano onion cultivar. Experiments were conducted at the research farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, during the winter seasons of 2008/09 and 2009/10. Treatments consisted of vernalization periods ranging from 45 to 180 days, storage temperatures of 4 to 5⁰C, and bulb size which was small and medium. Treatments were arranged in a randomized complete block design with three replicates. Results indicated that vernalization duration significantly affected emergence percentage. As vernalization duration increased, emergence percentage increased in both seasons. Bulb size had no significant effects on emergence percentage. Vernalization temperatures of 4 to 5⁰C for 90 days or more was the key factor for the induction of bolting of Texas Early Grano cultivar. To obtain the highest bolting percentage and seed yield, a combination of vernalization at 4 to 5⁰C for 180 days and medium-sized bulbs should be recommended.

INTRODUCTION

Onion (*Allium cepa* L.), which belongs to the family Alliaceae, is one of the most important monocotyledonous, cross-pollinated, cool season vegetable crops. In Sudan, onion is one of the most important and popular vegetable crops. Variation in production seasons in the different regions of Sudan makes it available throughout the year. The main production areas are Gezira, Shendi and Kassala. Total production of onion in Sudan is around 1.12 million tons (F.M.A, 2011).

The introduced cultivar “Texas Early Grano” is widely grown and consumed in Sudan as a salad vegetable crop due to its mild and pleasant taste and low pungency. While seeds of all landraces are produced locally, seeds of “Texas Early Grano” have to be imported from western seed companies. Bulbs of “Texas Early Grano” failed to bolt when grown for seed production in Sudan (Abu-Sarra, 2003). The bulbs need to be stored under low temperatures for a long time to initiate seed stalk formation. The low temperature requirement for bolting of this cultivar cannot

be satisfied due to the mild winter of Sudan. Some studies have shown that induction of bolting can be achieved by storage under low temperatures (Aura, 1963; Krawiec, 2002). Brewster (1982), analyzing the physiology of onion plant flowering, found out that floral initiation takes place at low temperatures. Therefore, the objective of this study was to investigate the effects of vernalization duration, bulb size and their combinations on seed production of “Texas Early Grano” cultivar under Gezira State conditions, Sudan.

MATERIALS AND METHODS

Experiments were conducted during winter seasons of 2008/09 and 2009/10 in the research farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan (lat. 14° 25' N, longitude 33° 30' E). They were carried out to study the effects of two bulb sizes: small size (20–59 mm diameter) and medium size (60–90 mm diameter) and vernalization periods 45, 90, 135 and 180 days, on sprouting, growth and induction of the seed stalk of onion cultivar Texas Early Grano.

Bulbs of the onion cultivar Texas Early Grano were harvested in the last week of April in both seasons of 2008/09 and 2009/10. They were divided into two sizes: small (20–59 mm diameter) and medium (60–90 mm diameter). They were then stored at 4–5°C and 80% RH for 45, 90, 135 and 180 days.

The land was plowed, harrowed, leveled and made into plots 2 × 4 m. Bulbs, after removal from storage, were planted at an inter and intra-row spacing of 80 cm and 30 cm, respectively, in both seasons. Treatments were arranged in a randomized complete block design with three replicates. Bulbs were planted in the first week of November in both seasons. Cultural practices were carried out as recommended by the Agricultural Research Corporation. Data recorded consisted of emergence percentage, number of days to the appearance of the seed stalk, number of florets per umbel, number of seed stalks per plant, length of the seed stalks (cm), bolting percentage, number of days to harvest the seeds, weight of 1000 seeds (g) and seed yield (kg/ha).

Statistical analysis

Data were subjected to analysis of variance procedure using MSTAT-C program. Means were separated using Duncan Multiple Range Test at 5% level of significance.

RESULTS AND DISCUSSION

Effects of vernalization period and bulb size on emergence percentage during seasons 2008/09 and 2009/10

The main effects of vernalization and bulb size on emergence percentage of onion cultivar Texas Early Grano during seasons 2008/09 and 2009/10 are presented in Table 1. Vernalization period resulted in significant effects on emergence percentage in both seasons. Long vernalization periods (135 and 180 days) showed higher emergence percentages in both

seasons. The chilling effect of vernalization broke bulb dormancy and, hence, increased emergence percentage. Bulb size had no significant effects on

emergence percentage in both seasons. Generally, bulb size of onion affects number of seed stalks rather than emergence percentage.

The interaction effects of vernalization period and bulb size on emergence percentage of onion cultivar “Texas Early Grano” during seasons 2008/09 and 2009/10 are shown in Table 2. There were significant differences in emergence percentage in both seasons. The highest emergence percentages (83.2% and 94.7%) were obtained when medium bulb size was coupled with a vernalization period of 180 days at season 2008/09 and with medium and small bulb sizes when coupled with vernalization periods of 135 and 180 days, respectively for season 2009/10. This data indicates that a vernalization period of 135 days was also sufficient for breaking of bulb dormancy. These results were in line with those reported by Moslehuddin (2008).

Table 1. The main effects of vernalization period and bulb size on emergence percentage of onion cultivar “Texas Early Grano” during seasons 2008/09 and 2009/10.

Vernalization period (days)	Emergence (%)	
	2008/09	2009/10
45	65.0 b	67.1 b
90	68.4 b	65.8 b
135	74.3 a	93.3 a
180	74.5 a	94.0 a
Sig. level	*	*
Bulb size		
Medium	67.5	80.9
Small	64.6	79.2
Sig. level	NS	NS
C.V (%)	18.84	5.28

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

* and NS indicate significance at $P \leq 0.05$ and not significant, respectively.

Table 2. Interaction effects of vernalization period and bulb size on emergence percentage of onion cultivar "Texas Early Grano" during seasons 2008/09 and 2009/10.

Verbalization period (days)	Bulb size	Emergence (%)	
		2008/09	2009/10
45	Medium	70.0c	68.3b
	Small	53.3d	65.8b
90	Medium	76.1abc	66.7b
	Small	53.6d	65.0b
130	Medium	76.7abc	94.2a
	Small	78.9ab	92.5a
180	Medium	83.2a	94.7a
	Small	72.6bc	93.3a
Sig. level		*	*
C.V%		18.84	5.28

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

Effects of vernalization period and bulb size on bolting of onion during seasons 2008/09 and 2009/10

The main effects of vernalization period and bulb size on bolting of onion cultivar "Texas Early Grano" during seasons 2008/09 and 2009/10 are shown in Tables 3 and 4, respectively. Vernalization period manifested highly significant effects on number of days to the appearance of the seed stalk, number of florets per umbel, number of days to harvest seeds, length of the seed stalk, percentage of bolting and seed yield. It also showed significant effects on number of seed stalks per plant and weight of one thousand seeds in both seasons. Our results indicated that the highest values of these parameters in both seasons were obtained with a vernalization period of 180 days followed by 135 days. Vernalization period of 180 days in both seasons markedly resulted in the lowest number of days to the appearance of the seed stalk (40.8 and 34.7 in both seasons, respectively), the smallest number of days to harvest seeds (71.3 and 105.9 in both seasons, respectively) and the longest seed stalks. Moreover, it recorded the

highest values of seed stalks per plant, number of florets per umbel, percentage of bolting, weight of one thousand seeds and seed yield per hectare as compared with other vernalization periods (45, 90 and 135 days). De Mille and Vest (1975), Hesse *et al.* (1979), Hwang (1982), Khokhar *et al.* (2007a; 2007b) and Khokhar (2009) obtained similar results. They showed that onion bulbs stored at temperatures of 2 to 7°C for 90 to 180 days resulted in earlier flowering, highest number of seed stalks per plant, largest seed stalks, highest number of florets per umbel, highest percentage of bolting and the highest seed yield.

Table 3. The main effects of vernalization period and bulb size on bolting of onion cultivar “Texas Early Grano” during season 2008/09.

VP (days)	DF	SS/P	F/U	DHS	LSS (cm)	B (%)	TSW (g)	SY (kg/ha)
45	0	0	0	0	0	0	0	0
90	58.9 a	1.4 b	149.3 c	83.6 a	56.3 c	38.4 c	3.8 b	8.7 c
135	48.6 b	1.7 b	153.2 b	71.3 b	62.2 b	82.3 b	3.8 b	39.0 b
180	40.8 c	2.2 a	170.0 a	72.1 b	66.0 a	94.8 a	4.1 a	71.4 a
Sig. level	**	*	**	**	**	**	*	**
Bulb size								
Medium	47.6	1.8	167.4	77.6	61.3	71.6	3.8	45.2
Small	51.3	1.7	147.6	73.8	61.7	72.1	3.9	34.3
Sig. level	**	NS	**	**	NS	NS	NS	**

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

*, ** and NS indicate significance at $P \leq 0.05$, 0.01 and not significant, respectively.

VP=vernalization period, DF=days to flowering, SS/P=seed stalks per plant, F/U=florets per umbel, DHS=days to harvest seeds, LSS=length of seed stalk, B=bolting, TSW=thousand seed weight and SY=seed yield.

Table 4. The main effects of vernalization period and bulb size on bolting of onion cultivar “Texas Early Grano” during season 2009/10.

VP (days)	DF	SS/P	F/U	DHS	LSS (cm)	B (%)	TSW (g)	SY (kg/ha)
45	0	0	0	0	0	0	0	0
90	58.7 a	1.5b	117.8 c	148.8 a	55.9 c	42.3 c	3.8 b	9.0 c
135	47.1 b	2.2 a	144.8 b	126.2 b	65.7 b	82.2 b	3.9 b	45.8 b
180	34.7 c	2.6 a	242.9 a	105.9 c	67.8 a	93.8 a	4.3 a	76.0 a
Sig. level	**	*	**	**	**	**	*	**
Bulb size								
Medium	46.5	2.2	172.2	125.4	62.7	72.0	4.0	49.5
Small	47.2	1.9	164.8	128.6	63.5	73.5	3.9	37.8
Sig. level	NS	NS	*	*	NS	NS	NS	**

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

*, ** and NS indicate significance at $P \leq 0.05$, 0.01 and not significant, respectively.

VP=vernalization period, DF=days to flowering, SS/P=seed stalks per plant, F/U=florets per umbel, DHS=days to harvest seeds, LSS=length of seed stalk, B=bolting, TSW=thousand seed weight and SY=seed yield.

Bulb size showed highly significant effects on number of days to flowering, number of florets per umbel, number of days to harvest seeds and seed yield (Table 3). However, it had no significant effects on number of seed stalks per plant, length of seed stalk, percentage of bolting and 1000-seed weight in season 2008/09, whereas it showed significant effects on number of florets per umbel, number of days to harvest seeds and highly significant effects on seed yield. However, it had no significant effects on other parameters in season 2009/10 (Table 4). Medium sized mother bulbs in both seasons resulted in the smallest number of days to flowering, the largest number of florets per umbel, the largest number of days to harvest seeds and the highest seed yield. These findings are in line with those of Toman *et al.* (1989), Mostafa *et al.* (1996), Ali *et al.* (1998), Abu-Sarra (2003), Jilani (2004), Mirshekari *et al.* (2008) and Moslehuddin (2008) who stated that the mother bulb size showed significant effects on seed yield parameters of onion.

Interaction effects of vernalization period and bulb size on bolting of onion during seasons 2008/09 and 2009/10

The interaction effects of vernalization period and bulb size on bolting of onion cultivar “Texas Early Grano” during seasons 2008/09 and 2009/10 are presented in Tables 5 and 6, respectively. In both seasons, there were significant interaction effects on all parameters except number of seed stalks per plant during season 2008/09 and weight of one thousand seeds during season 2008/09 and 2009/10. The vernalization period of 180 days coupled with medium bulb size in both seasons resulted in the earliest flowering and seed harvesting, highest values of seed stalks per plant, number of florets per umbel, length of seed stalk, percentage of bolting and seed yield per hectare. These results are in agreement with those of Khokhar (2009) who stated that large bulbs produced greater seed yield, especially when they were stored at temperatures which prevented floral initiation during storage. The vernalization period of 45 days did not induce bolting of onion cultivar Texas Early Grano in all seasons (data not shown). This might imply that it was too short for the induction of flowering in this onion cultivar.

Table 5. Interaction effects of vernalization period and bulb size on bolting of onion cultivar “Texas Early Grano” during season 2008/09.

Treatments		DF	SS/P	F/U	DHS	LSS	B	TSW	SY
VP (days)	BS					(cm)	(%)	(g)	(kg/ha)
90	M	62.3 a	1.3	149.5 c	90.4 a	57.1 c	35.9 e	3.9	8.5 d
	S	55.5 b	1.5	143.9 d	76.9 b	55.5 c	40.9 d	3.8	8.8 d
135	M	50.8 c	2.1	149.4 c	71.8 cd	62.5 b	83.9 b	4.0	39.2 c
	S	46.5 d	1.7	149.1 c	70.9 d	61.9 b	80.7 c	4.2	39.0 c
180	M	40.8 e	2.4	196.1 a	70.6 d	66.1 a	94.8 a	3.7	87.8 a
	S	40.9 e	1.6	156.9 b	73.6 c	65.9 a	94.8 a	3.9	55.1 b
Sig. level		*	NS	**	**	*	**	NS	**
C.V (%)		12.11	20.97	23.91	7.02	11.77	9.99	8.43	11.92

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

*, ** and NS indicate significance at $P \leq 0.05$, 0.01 and not significant, respectively.

VP= vernalization period, BS=bulb size, M=medium, S=small, DF=days to flowering, SS/P=seed stalks per plant, F/U=florets per umbel, DHS=days to harvest seeds, LSS=length of seed stalk, B=bolting, TSW=thousand seed weight and SY=seed yield.

Table 6. Interaction effects of vernalization period and bulb size on bolting of onion cultivar “Texas Early Grano” during season 2009/10.

Treatments		DF	SS/P	F/U	DHS	LSS (cm)	B (%)	TSW (g)	SY (kg/ha)
VP (days)	BS								
90	M	60.1 a	1.5 b	109.4 f	148.9 a	53.6 d	40.4 f	3.8	8.8 e
	S	57.3 b	1.6 b	126.3 e	148.8 a	58.1 c	44.3 e	3.7	9.3 e
135	M	46.8 c	2.2 ab	153.1 c	123.1 c	66.1 b	80.4 d	4.0	46.9 c
	S	47.5 c	2.1 ab	136.5 d	129.3 b	65.4 b	83.9 c	3.9	44.7 d
180	M	32.7 e	3.0 a	254.1 a	104.1 e	68.7 a	95.3 a	4.2	92.8 a
	S	36.7 d	2.1 ab	231.8 b	107.7 d	66.8 b	92.3 b	4.3	59.3 b
Sig. level		**	*	**	**	**	**	NS	**
C.V (%)		7.44	26.45	22.14	5.31	6.62	14.53	5.50	14.30

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

*, ** and NS indicate significance at $P \leq 0.05$, 0.01 and not significant, respectively.

VP=vernalization period, BS=bulb size, M=medium, S=small, DF=days to flowering, SS/P=seed stalks per plant, F/U=florets per umbel, DHS=days to harvest seeds, LSS=length of seed stalk, B=bolting, TSW=thousand seed weight and SY=seed yield.

CONCLUSION

According to this study, seeds of the onion cultivar “Texas Early Grano” can be successfully produced by using medium bulb size and vernalization at temperatures of 4 to 5⁰ C for a period of 5 to 6 months.

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تأثير فترة الإرتباع وحجم الأبصال في إزهار صنف البصل "تكساس إيرلي جرانو" تحت ظروف الجزيرة،
السودان

الفتاح أحمد محمد الصديق¹ و عثمان محمد الأمين² و محمد الحاج الكاشف²

¹كلية الزراعة والموارد الطبيعية ، جامعة بخت الرضا، الدويم ، السودان.

²كلية العلوم الزراعية ، جامعة الجزيرة ، واد مدني ، السودان.

الخلاصة

يعتبر صنف البصل "تكساس إيرلي جرانو" من الأصناف المعروفة في السودان التي تستخدم كأحد الخضراوات الرئيسية في طبق السلطة. محاولة إنتاج بذور هذا الصنف محلياً لم تعط نتائج إيجابية نسبة لعدم توفر درجات الحرارة المنخفضة اللازمة لتحفيز الإزهار تحت ظروف ولاية الجزيرة. لذا هدفت هذه الدراسة إلى تحفيز الإزهار لإنتاج البذور من هذا الصنف باستخدام ظاهرة الإرتباع (التخزين المبرد) لأحجام مختلفة من الأبصال. أجريت هذه الدراسة بمزرعة كلية العلوم الزراعية، جامعة الجزيرة، واد مدني، السودان خلال موسمي 09/2008 و 10/2009م. شملت التجارب فترات تخزين مبرد تراوحت ما بين 45-180 يوماً في درجات حرارة تراوحت ما بين 4 إلى 5⁰ م ونوعين من حجم الأبصال (صغير ومتوسط). استخدم تصميم القطاعات العشوائية الكاملة بثلاث مكررات. أشارت النتائج إلى أن التخزين المبرد في درجات الحرارة 4 - 5⁰ م هو العامل الرئيسي المحفز للإزهار في صنف البصل "تكساس إيرلي جرانو". التخزين المبرد أظهر تأثيراً معنوياً في نسبة الانبات، فكلما زادت فترة التخزين المبرد زادت نسبة الانبات في كلا الموسمين، بينما لم يؤثر حجم الأبصال في نسبة الانبات. تم الحصول على أعلى نسبة للإزهار وإنتاجية البذور بزراعة الأبصال متوسطة الحجم والمخزنة في درجة حرارة 4 - 5⁰ م لفترة 180 يوماً. لذلك يوصى بتخزين الأبصال متوسطة الحجم في درجات حرارة تتراوح بين 4 - 5⁰ م لفترة 180 يوماً أو أكثر للحصول على بذور صنف البصل "تكساس إيرلي جرانو" تحت ظروف ولاية الجزيرة.