Induction of Flowering in Texas Early Grano Onion Cultivar Using Vernalization and Gibberellic Acid under Gezira State Conditions, Sudan

Elfatih A. M. Elsiddig *, Osman M. Elamin ** and Mohamed E. Elkashif **

* Faculty of Agriculture and Natural Resources, University of Bakht Alruda, Ed-Duiem, Sudan.
** Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

Abstract: Field experiments were conducted at the research farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, during seasons of 2008 to 2010. Treatments consisted of vernalization periods, which ranged from 30 to 180 days, vernalization temperatures of zero to 14° C and gibberellin concentrations ranging from zero to 600 ppm. Results indicated that vernalization temperatures of 4 to 5° C for 90 days or more was the key factor for the induction of flowering in Texas Early Grano cultivar. Application of GA3 alone, without vernalization, at all concentrations tested failed to induce flowering. However, the highest bolting percentage and seed yield were obtained by a combination of vernalization at 4 to 5° C for 180 days and the application of GA3 at the rate of 600 ppm. It is recommended to vernalize bulbs of "Texas Early Grano" cultivar at 4 to 5° C for 180 days with the application of GA3 at the rate of 600 ppm for seed production under Gezira conditions.

Index Terms: Onion, bolting, vernalization and gibberellin acid.

I. INTRODUCTION

olting, or seedstalk development, of onion (Allium cepa L.) is important for both bulb and seed production. Plants which bolt do not produce marketable bulbs, but seed yields are directly dependent on flower induction and bolting. Onion requires low temperatures or vernalization for flower induction. In most regions, the mother bulbs of spring-sown cultivars are held in cold storage to fulfill their chilling requirement and then planted in the spring to produce the seed crop. Several workers have reported that optimum duration to fully vernalize onion cultivars at low temperatures (3–11° C) are in the range of 7–90 days [17]; [11]; [14]; [13]; [1]; [12]; [15]). Flowering in bolting resistant cultivars may be particularly difficult and long treatment at low temperature or large bulb size may be required [16]. Although a great deal of work has been reported on the incidence of bolting, no work appears to have been carried out to study the relation between seed yield in onion sets and their chilling requirements.

The introduced cultivar "Texas Early Grano" is widely grown and consumed in the Sudan as a salad crop due to its mild and pleasant taste and low pungency. While seeds of all land races 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 the Sudan. The bulbs need to be subjected to low temperatures (vernalization) to initiate seed stalk formation. The vernalization requirements cannot be satisfied due to the mild winter of the Sudan. Therefore, there is an urgent need to look for other methods that can mimic the effect of low temperature for floral induction of "Texas Early Grano". The present study aims to test the effects of vernalization, Gibberellic acid and their combinations on seed production of "Texas Early Grano" onion cultivar under Gezira State conditions, Sudan.

II. MATERIALS AND METHODS

Field experiments were conducted during the 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). The soil is a heavy cracking clay with a pH of 8.3 and low soluble salts (EC = ds/m). The climate is tropical with hot summers (21 – 41°C) and mild winters (14 - 33°C). Day length is about 11 hours during the winter season and vernalization temperature ranged from zero to 14°C. Two experiments were conducted to study the effects of vernalization periods 45, 90, 135 and 180 days, and/or application of different concentrations of gibberellic acid (0, 150, 300, 450 and 600 ppm) on the growth and development of the seed stalk of onion cultivar Texas Early Grano during autumn and winter seasons of 2008/09 and 2009/10.

III. RESULTS

Effects of vernalization period and levels of GA3 on bolting of onion during seasons 2008/09 and 2009/10.

The main effects of vernalization period and levels of GA3 on bolting of onion cultivar "Texas Early Grano" during seasons 2008/09 and 2009/10 are shown in tables 1 and 2. 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. Vernalization period 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 the 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 seed the stalk (40.8 and 34.7 in both seasons, respectively), the lowest 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). [5], [6], [7], [9], [10] and [8] obtained similar results. They showed that onion bulbs stored in 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.

Different levels of GA3 showed highly significant effects on number of days to the appearance of the seed stalks, number of seed stalks per plant, number of florets per umbel, number of days to harvest seeds and percentage of bolting, and showed significant effects on length of seed stalk and one thousand seed weight during season 2008/09. During season 2009/10 it showed significant effects on number of days to the appearance of the seed stalk, number of seed stalks per plant, and showed highly significant effects on number of florets per umbel, number of days to harvest seeds, percentage of bolting and one thousand seed weight, and showed no significant effects on length of seed stalk. The results indicated that the highest responses of these parameters, in both seasons, were obtained with the application of GA3 at the levels of 300, 450 and 600 ppm. Similar results were obtained by [2] who studied the effect of three growth regulators including GA3 at 25, 50 and 75 ppm on seed production of onion. They found that GA3 increased length of flower stalks, number of flowers per plant and seed yield per plant but the highest seed yield was obtained with the application of GA3 at 75 ppm.

Table 1. The main effects of vernalization period and levels of GA_3 on bolting of onion cultivar "Texas Early Grano" during season 2008/09.

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

*, ** and NS indicate significance at P≤0.05, 0.01 and not significant, respectively.

Vernalization period (days)	No of days to the appearance of the seed stalk	No of seed stalks/ plant	No of florets/ umbel	No of days to harvest seeds	Length of seed stalk (cm)	Bolting (%)	Weight of 1000 seeds (g)	Seed yield (kg/ha)
45	0	0	0	0	0	0	0	0
90	58.9 a	1.4 (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 (1.5) 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 (1.6) a	170.0 a	72.1 b	66.0 a	94.8 a	4.1 a	71.4 a
Significant level	**	*	**	**	**	**	*	**
GA_3 level (ppm)								
0	53.0 a	1.7 (1.4) bc	137.2 e	80.7 a	59.9 c	64.4 d	3.8 ab	41.5 b
150	51.1 b	1.4 (1.3) c	164.5 b	77.1 b	60.9 bc	72.3 c	3.7 b	43.4 a
300	48.9 c	2.2 (1.6) a	146.3 d	75.8 c	63.6 a	71.4 c	4.0 a	39.1 c
450	46.7 d	1.7 (1.5) bc	156.3 c	72.0 d	61.4 b	77.1 a	4.1 a	31.6 d
600	47.6 d	1.9 (1.6) ab	183.1 a	72.9 d	61.8 b	74.1 b	3.9 a	42.8 a
Sig. level	**	**	**	**	*	**	*	**
C.V (%)	12.11	20.97	23.91	7.02	11.77	9.99	8.43	11.92

Numbers between two brackets indicate transformed data.

Table 2. The main effects of vernalization period and levels of GA_3 on bolting of onion cultivar "Texas Early Grano" during season 2009/10.

Vernalization period (days)	No of days to the appearance of the seed stalk	No of seed stalks/ plant	No of florets/ umbel	No of days to harvest seeds	Length of seed stalk (cm)	Bolting (%)	Weight of 1000 seeds (g)	Seed yield (kg/ha)
45	0	0	0	0	0	0	0	0
90	58.7 a	1.5 b	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
Significant level	**	*	**	**	**	**	*	**
GA_3 level (ppm)								
0	49.6 a	1.8 b	136.3 c	135.6 a	61.6	69.8 c	3.5 c	46.6 b
150	46.3 b	2.0 ab	166.7 b	125.3 b	62.3	69.7 c	3.8 b	47.7 a
300	45.7 b	2.3 a	179.9 a	123.9 c	64.2	74.4 b	4.0 b	43.0 c
450	46.2 b	2.2 a	179.6 a	124.0 c	64.2	74.0 b	4.4 a	34.4 d
600	46.4 b	2.1 ab	180.1 a	126.2 b	63.2	75.8 a	4.4 a	46.6 b
Sig. level	*	*	**	**	NS	**	**	**
C.V (%)	7.44	26.45	22.14	5.31	6.62	14.53	5.50	14.3

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

*, ** and NS indicate significance at P≤0.05, 0.01 and not significant, respectively.

Interaction effects of vernalization period and levels of GA3 on bolting of onion during seasons 2008/09 and 2009/10.

The interaction effects of vernalization period and levels of GA3 on bolting of onion cultivar "Texas Early Grano" during seasons 2008/09 and 2009/10 are presented in tables 3 and 4, respectively. Results showed significant interaction effects of vernalization period and levels of GA3 on all parameters except number of seed stalks per plant in both seasons. The earliest flowering (35.3.8 and 32.2 days) and seed harvesting (67.8 and 97.3 days), highest values of florets per umbel (203.5 and 268.7), percentage of bolting (98.3% and 98.5%) and seed yield per hectare (86.5 and 92.9 kg) were obtained by the vernalization period of 180 days with the application of GA3 at the level of 150 ppm in both seasons. On the other hand, the longest seed stalks (68.3 and 68.9 cm) were obtained by the vernalization periods of 90 and 180 days with the application of GA3 at the levels of 300 ppm and 450 ppm in both seasons, respectively. The highest weight of one thousand seeds (4.5 and 4.6 g) was obtained by the vernalization periods of 135 and 180 days with the application of GA3 at the levels of 450 and 600 ppm in both seasons, respectively. The variation in the results of seed stalk length during both seasons could be attributed to the effect of the environment, since the genotypes used were identical. [3] and [4] demonstrated that the seed stalk elongation rate was increased by long photoperiods and higher temperatures. Since the photoperiod during the two seasons was the same, the differences in length of the seed stalk could only be attributed to differences in temperature.

Table 3. Interaction effects of vernalization period and levels of GA_3 on bolting of onion cultivar "Texas Early Grano" during season 2008/09.

Treatments		No of days to the appearance of the seed stalk	No of seed stalks/ plant	No of florets/ umbel	No of days to harvest seeds	Length of seed stalk (cm)	Bolting (%)	Weight of 1000 seeds (g)	Seed yield (kg/ha)
Vern. period (days)	GA_3 levels (ppm)								
	0	60.8 b	1.0 (1.2)	149.3 f	91.3 a	63.6 d	30.3 k	3.4	8.6 j
	150	64.2 a	1.0 (1.2)	153.5 def	89.8 a	65.4 bcd	38.1 j	3.7	8.2 j
90	300	59.5 b	1.5 (1.4)	155.0 de	83.0 b	65.6 bcd	43.9 h	4.1	7.7 j
	450	51.3 d	1.8 (1.5)	198.2 ab	76.7 cd	68.3 a	39.2 ij	3.9	9.3 j
	600	58.8 b	1.7 (1.5)	194.0 b	77.3 c	67.2 ab	40.8 i	3.8	9.6 j
	0	52.0 cd	2.1(1.6)	131.0 h	74.8 d	59.3 e	72.6g	4.0 b	39.6 g
	150	53.8 c	1.9 (1.5	157.8 d	72.0 e	60.5 e	80.7 e	3.9 b	35.6 h
135	300	44.0 g	2.8 (1.8)	126.2 h	72.5 e	66.4 abc	75.7 f	3.9 b	47.0 f
	450	47.8 e	1.7 (1.4)	104.8 i	71.5 e	60.8 e	95.8 b	4.5 a	33.0 i
	600	45.5 fg	2.6 (1.7)	139.7 g	72.3 e	64.1 cd	86.9 d	4.3 ab	40.0 g
	0	46.3 ef	1.8 (1.5)	131.3 h	75.8 cd	56.9 fg	90.4 c	4.1 ab	76.4 c
	150	35.3 j	1.2 (1.2)	203.5 a	67.8 f	56.7 fg	98.3 a	3.3 c	86.5 a
180	300	43.3 g	2.3 (1.6)	200.3 a	75.3 cd	58.7 ef	94.6 b	4.0 b	62.7 d
	450	40.8 h	1.5 (1.4)	166.0 c	69.0 f	55.2 gh	96.3 ab	3.9 b	52.7 e
	600	38.3 i	1.7 (1.5)	151.7 ef	69.0 f	54.1 h	94.6 b	3.9 b	78.9 b

Sig. level	**	NS	**	**	**	**	*	**
C.V (%)	12.11	20.97	23.91	7.02	11.77	9.99	8.43	11.9

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

*, ** and NS indicate significance at P≤0.05, 0.01 and not significant, respectively.

Numbers between two brackets indicate transformed data.

Table 4. Interaction effects of vernalization period and levels of GA_3 on bolting of onion cultivar "Texas Early Grano" during season 2009/10.

Treatments		No of days to the appearance of the seed stalk	No of seed stalks/ plant	No of florets/ umbel	No of days to harvest seeds	Length of seed stalk (cm)	Bolting (%)	Weight of 1000 seeds (g)	Seed yield (kg/ha)
Vern. period (days)	GA_3 levels (ppm)								
	0	61.3 a	1.0	79.2 i	154.7 a	49.3 g	28.4 k	3.1 c	6.8 j
	150	59.0 b	1.3	107.2 h	149.3 b	57.6 f	41.1 j	3.6 bc	8.5 ij
90	300	57.7 b	1.8	111.2 h	148.2 bc	57.1 f	44.4 i	3.9 b	9.9 i
	450	57.8 b	1.8	141.3 f	145.8 d	57.0 f	51.7 h	4.2 ab	10.1 i
	600	57.7 b	1.7	150.3 e	146.2 cd	58.3 f	46.0 i	4.1 ab	10.0 i
	0	48.5 c	1.8	121.7 g	131.0 e	66.9 bcd	86.3 d	3.5 bc	50.8 e
	150	47.8 cd	2.2	124.3 g	129.2 e	63.9 e	74.8 g	3.7 b	41.8 g
135	300	46.3 d	2.3	165.2 d	123.8 f	66.5 cd	87.5 d	3.8 b	52.9 e
	450	46.7 d	2.3	161.8 d	123.5 f	67.6 abc	79.3 f	4.1 ab	37.0 h
	600	46.3 d	2.2	150.8 e	123.7 f	63.8 e	83.0 e	4.4 a	46.6 f
	0	38.8 e	2.5	208.0 c	121.0 g	68.6 ab	94.6 b	3.9 b	82.1 b
	150	32.2 h	2.5	268.7 a	97.3 k	65.4 de	98.5 a	4.6 a	92.9 a
180	300	33.2 gh	2.8	263.5 a	99.8 j	68.9 a	91.5 c	4.4 a	66.0 c
	450	34.2 fg	2.5	235.5 b	102.7 i	68.2 abc	91.3 c	4.5 a	56.0 d
	600	35.2 f	2.5	239.0 b	108.7 h	67.8 abc	93.1 bc	4.5 a	83.1 b
Sig. level		**	NS	**	**	**	*	*	**
C.V (%)		7.44	26.45	22.14	5.31	6.62	14.53	5.50	14.3

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

*, ** and NS indicate significance at P≤0.05, 0.01 and not significant, respectively.

IV. CONCLUSIONS

Seeds of onion cultivar "Texas Early Grano" can be successfully produced by vernalization at temperatures of 4 to 5° C for a period of 180 days at Gezira conditions. Application of GA_3 alone, without vernalization, at all concentrations tested failed to induce flowering of onion cultivar "Texas Early Grano" when planted off season but it enhanced the effect of vernalization on bolting and seed production. Future research work is needed to test the ability of GA_3 to induce flowering on non-vernalized bulb of the onion cultivar "Texas Early Grano" at the main season of onion seed production.

V. REFERENCES

[1] Bertaud, D.S., 1988. Effects of chilling duration photoperiod and temperature on floral initiation and development in sprouted and unsprouted onion bulbs.In: Proceedings of the fourth EUCARPIA Allium Symposium, Institute of Horticultural Research, Wellesbourne, UK, pp. 245–261.

[2] Bhople, S. R., V. N. Dod, S. G. Bharad, S. V. Gholap and B. J. Jad hao. 1999. Seed production of onion as influenced by the application of growth regulators. J. of Soils and Crops 9: (1):78- 79.

[3] Brewester, J. L. 1982. Flowering and seed production in over wintered cultivars of bulb onion, I. Effects of different raising environments, temperatures and day lengths. Journal of Horticultural Sciences 57: 93 – 96.

[4] Brewester, J. L. 1987. Vernalization in the onion, quantitative approach. In: Proceedings of the 45th Easters School in Agric. Sci. Manipulation of flowering. Butterworths, London, UK.

[5] DeMille, B. and G. Vest. 1975. Flowering date of onion bulbs as affected by light and temperature treatments during storage. Journal of the American Society for Horticultural Science 100: 423 – 424.

[6] Hesse, P. S., G. Vest and S. Honma. 1979. The effect of four storage temperatures on seed yield components of three onion inbreds. Hort. Sci. 11: 207 – 215.

[7] Hwang, T.J. 1982. Effects of Low Temperature and Gibberellic Acid on Foral Physiology of *Allium cepa* L. M.Sc. Thesis, National Chung Hsing University, Taichung, Taiwan.

[8] Khokhar, K.M. 2009. Effect of set-size and storage temperature on bolting, bulbing and seed yield in two onion cultivars. Scientia Hort. 122: 187–194.

[9] Khokhar, K.M., P. Hadley and S. Pearson . 2007a. Effect of cold temperature durations of onion sets in store on the incidence of bolting, bulbing and seed yield. Scientia Hort. 112: 16-22.

[10] Khokhar, K.M., P. Hadley and S. Pearson. 2007b. Effect of reciprocal transfers of onion sets between inductive and non-inductive temperatures on the incidence of bolting, bulbing and seed yield. Scientia Hort. 112: 245–250.

[11] Kruzhilin, A.S., Shvedskaya, Z.M., 1962. Peculiarities of phasic development and morphogenesis in onion (*Allium cepa* L.). Fiziologia Rastenii 9, 466–475 [Translated] (cited by Rabinowitch, 1990).

[12] Peters, R., 1990. Seed production in onions and some other Allium species. In: Rabinowitch, H.D., Brewster, J.L. (Eds.), Onions and Allied Crops. Vol. I. Botany, Physiology and Genetics. CRC Press, Boca Raton, Florida, pp.161–176.

[13] Pike, L.M., 1986. Onion breeding. In: Basset, M.J. (Ed.), Breeding Vegetable Crops. AVI Publishing Co., Connecticut, pp. 357–394.

[14] Rabinowitch, H.D., 1985. Onions and other edible Alliums. In: Halevy, A.H. (Ed.), CRC Handbook of Flowering, Vol. I. CRC Press, Boca Raton, Florida, pp. 398–405.

[15] Rabinowitch, H.D., 1990. Physiology of flowering. In: Rabinowitch, H.D.,Brewster, J.L. (Eds.), Onions and Allied Crops. Vol. I. Botany, Physiology and Genetics. CRC Press, Boca Raton, Florida, pp. 133–134.

[16] Shishido, Y., Saito, T., 1977. Studies on the flower bud formation in onion plants. III. Effects of physiological conditions on the low temperature induction of flower buds in bulbs. J. Jpn. Soc. Horticult. Sci. 46, 310 – 316 (Japanese, En. Sum).

[17] Woodbury, G.W., 1950. A study of factors influencing floral initiation and seed stalk development in the onion, *Allium cepa* L. Idaho Agricultural Experiment Station Research Bulletin No. 18.

AUTHORS

First Author: Elfatih A. M. Elsiddig, Ph.D. Agr Faculty of Agricultural Sciences – U of Gezira, Faculty of Agriculture and Natural Resources – University of Bakht Alruda - Ed-Duiem, Sudan. E. mail: fatih702001@gmail.com

Second Author: Osman M. Elamin**,** Professor**,** Faculty of Agricultural Sciences – University of Gezira, Wad Medani, Sudan.

Third Author: Mohamed E. Elkashif, Professor**,** Faculty of Agricultural Sciences – University of Gezira, Wad Medani, Sudan. E. mail: elkashif@yahoo.com

Correspondence Author: Elfatih A. M. Elsiddig,. E. mail: fatih702001@gmail.com. Alternate E. mail: fatih712000@hotmail.com. Contact number: +249912425846 - +249122654161.