

Effect of soaked *allium cepa* L. bulbs in growth regulators on their growth and seeds production

Abstract

An field investigation was carried out to obtain the best treatment for onion seed quantity and quality in seasons of 2013/2014 and 2014/2015. The earliness of bolting and bolting period was found from treated onion bulbs with GA3 at 1000ppm and CCC at 100ppm compared to the control during both seasons. The highest significant differences of seed yield, weight of 1000 seeds and seed germination % was found from GA3 at 1000ppm compared to the control. On the other side, there are significant differences in seed yield were found from CCC at 1000 ppm, while the average weight of 1000 seeds and seed germination was obtained from CCC at 100ppm.

Keywords: GA3, CCC, *Allium cepa*, seeds production, soaked bulbs

Volume 4 Issue 3 - 2016

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Received: March 21, 2016 | **Published:** August 09, 2016

Introduction

Onion was grown in Egypt especially in Delta, middle Egypt and south Egypt during the winter seasons, which directs the production for exportation and local consumption. The total cultivated area of onions in Egypt is about 28.28 thousand feddans (Fed.=0.42ha), which the onion cultivation share about 63.2% of total cultivated areas. The cultivation area of onions in Egypt amounted to about 48 000 feddans in 1999, and increased until reached 120.2 million feddans in 2012, by an increase of about 39.9% in 1999.^{1,2}

Effect of soaked bulbs in GA3 on onion seed production.

Gibberellins are one of the main regulators of plant growth and development which repress the growth and promoting cell division and elongation.^{3,4} It is well known that GA3 promotes plant growth and its secondary metabolite production.⁵ The applications of gibberellic acid (GA3) on plants increases plant height and, subsequently, enhance dry weight.⁶ There are a lot off chemicals have been used for increasing seed yield, but the most effective growth regulator was GA3. However, the effect of GA3 on onion seed production is attributed to increasing in number of inflorescences per plant, and/or synchronization of pistillate and staminate patterns.⁷ On other study showed the effect of growth regulators on onion seed production. The seed protein content was increased by 7% by GA3 (100ppm) spray treatment compared to the untreated plants.⁸ Large or medium bulbs sprayed with Gibberellic acid at 50ppm gave significantly higher seed yield per hectare, germination and vigour values compared to other combinations.⁹ Onion plants were sprayed with 50ppm GA3 and tap water at 45days after planting and again 15days later. Spraying plants with GA3 increased these seed yield and quality parameters compared with controls.¹⁰

The plant growth regulators might be important for increasing onion production and GA3 influences growth by promoting elongation of stem and internodes of plant. The treatment with GA3 and their physiological action was found to enhance vegetative growth and plant yield and increase dry weight.¹¹ Gebrilic acid is generally involved in growth and development. They promote seed germination, leaf expansion, stem elongation and flowering initiation. The increasing in wheat growth and their grain yield was attributed to the GA3-priming-

induced modulation of ions uptake and partitioning (within roots and shoots) and hormones homeostasis under saline conditions.¹² In another study, wheat seeds, after treatment with various growth regulators including GA3, showed highest percent germination when treated with 20 mg/L GA3.^{13,14} Phytohormones represent a group of organic molecules that are produced by plant tissues and translocate to some other tissue where they affective many diverse developmental stages.¹⁵⁻¹⁷ Growth phytohormones regulate and integrate the overall growth, development and reproduction in plants by acting as chemical messengers for the communication among cells, tissues and organs.¹⁸

Gibberellins play a major role in diverse growth processes including seed development, organ elongation, senescence and control of flowering time.¹⁹⁻²² Bio-regulators like gibberellins (GA3) have been known to play a vital role in building of plants.²³ Overall, only GA3 supply leads to a vigorous onion and garlic growth and yield¹⁹ those found that GA3 promoted the total plant length of onion and garlic by 35% and 25% of the control, respectively and number of leaves/plant of onion and garlic, fresh and dry weight increased significantly under GA3. Many studies have indicated that the application of growth promoter GA3 can affect the growth and development of bulb crops as well as total yield.^{11,24-28} Correlations of concentration of endogenous level of hormone with specific developmental stages, effects of applied hormones, and the relationship with metabolic activities suggests an involvement of hormones in these metabolic activities.^{29,30}

Effect of soaked bulbs in CCC on onion seed production

Cycocel (CCC) (chlormequat; 2-chloroethyl trimethyl ammonium chloride) is a synthetic plant growth retardant used on ornamental plants for inducing dwarfism in plants and shorter internodes, stronger stems and green leaves. The CCC, is an inhibitor of gibberellins biosynthesis, has a profound effect on plant growth, it not only retards stem growth, but also reverses root growth capacity.³¹ The terms growth retardants is used for all chemicals that retard cell division and cell elongation in shoot tissues and regulate plant height physiologically without formative effects.³² Although growth reduction effect of cycocel is common growth reduction percentage, flowering, leaf area and chlorophyll content, flower shape and colour responses of plants to this chemical can vary depending on the dose or concentration, method, site of application, species and cultivar

and also growing season,^{33–35} showed results of an experiment which carried out to establish the effect of cycocel concentrations (0, 1000, 1500, 2000ppm) on the quality characters of Kharif Onion viz., TSS, Sulphur and Protein content (%) in bulbs.

CCC sprayed at the umbels significantly increased the gynogenic embryo rate, which was more than three times higher than the control.³⁶ Spraying onion plants with CCC reduced seed stalk height and diameter, umbel diameter and average number of flowers per umbel. Percentage germination of the seeds produced and 1000-seed weight.¹⁰ Moreover, the heaviest fresh and dry weights of flowers/plant were gained by 2000ppm CCC-sprayed plants.³⁴ Cycocel (CCC) is an onion compound and regarded as most consumed moderator of plant growth especially in Europe and nowadays, is frequently applied to decrease the dormancy and control the germination growth of cultivating plants.³¹ CCC prevents the activities of synthesized anti-covering enzyme and decreases the plant height.³⁷ Seed performance of plants treated with CCC leads to the increases in root growth and water potential in the leaves.³¹ Also, Cycocel decreases the height of plant and increases the vertical growth of branches so that the plant receives much light to do photosynthesis which improves the yield of seeds.³⁸ Treatment with CCC (chloromequat) and camposan M (ethephon), when applied in combination, reduced plant height and increased the resistance of the peduncles to bending, thereby facilitating mechanical seed harvest.³⁹ The objective of this study was to investigate the effects of GA3 and CCC on leaf photosynthesis, flowering scapes number and seed yield, seed weight, seed germination percentage. In this thesis, we describe the experiments in which GA3 and CCC were applied to *Allium cepa*, in an attempt to enhance the plant growth and seed yield as well as improvement of the seed quality.

Materials and methods

Allium cepa L. cv Giza 20 which is the most popular variety in A. R. Egypt was used in this investigation. Onion bulbs of used variety Giza 20 in this investigation were obtained from Onion Research Section, Agricultural Research Center, Giza. The present investigation was implemented in cooperation between Horticulture Department, Faculty of Agriculture, Al-Azhar University, Cairo and Horticulture Department, Faculty of Agriculture and Natural Resources Aswan University during the two successive winter seasons of 2013/2014 and 2014/2015. Two experiments were established to evaluate the treatments with GA3 and CCC on onion vegetative growth, earliness of flowering, seed quantity and seed quality. Design of these experiments was complete randomized blocks with three replicates. Mother bulbs (4–6cm diameter) were cultivated at 27 December each year in rows 3meters long and 70cm width. The distance between plants was 25cm and the unit area of each plot was 6m² (contained on three ridges) which consists of 36 mother bulbs in each plot.

Effect of soaked bulbs in GA3 on onion seed production

In this experiment the treated bulbs with Berelex 10% gibberellic acid (GA3) and used in contrast to tap water treatment as a control. GA3 was obtained from Starchem company at Kilo 28 Cairo–Alexandria st. and used at the concentration of 250, 500, 1000ppm. The bulbs were soaked in previous concentrations of the GA3 in polyethylene bags for 36 hours then cultivated directly in experimental filed plots.

Effect of soaked bulbs in CCC on onion seed production

The experiment was carried out to determine the effect of cycocel (CCC) treatments on onion seed production. Bulbs were treated

with the growth regulator CCC in addition to tap water as a control. Cycocel abbreviated as CCC (2-chloroethyl trimethyl ammonium chloride), was obtained from Win lab company (6 Courtyard workshops Bath st., Market Harborough, Leicestershire, UK) and used at the concentration of 50, 100, 150ppm. The bulbs were soaked in previous concentrations of the growth regulator in polyethylene bags for 36hours then cultivated directly in experimental filed plots.

Determination procedures

Physical characteristics: Determinations were carried on the following aspects:

- i. Earliness of flowering: Number of days from bulbs cultivation until the umbel emergence.
- ii. Time period of flowering: Calculated from date of umbels emergence until the last one at 90days old.
- iii. Number of umbel scapes/plot: The total numbers of umbel scapes/plot were counted.
- iv. Height of umbel scape: The height of umbel scape (cm) determined after 60days from umbel scape emergence.
- v. Diameter of umbel scape: Was estimated (cm) and took place from widest part of the swollen umbel scape emergence on the upper part under the umbel directly.
- vi. Umbel diameter: The umbels diameter was estimated (cm).

Seed characteristics: Determinations were carried on the following aspects:

- i. Weight of 1000 seeds: Weight of 1000seeds was balanced (gm).
- ii. Seed yield/plot: Onion seed yield was harvested at 168–173days after the bulbs cultivation before most of the umbel being exposed their black seed and 20-30% of capsules were splatted. Onion umbels were harvested in the morning to prevent shattering of seed. Data were recorded on seed yield such as total seeds weight per plot (gm).
- iii. Seed germination percentage: Onion seed were stored at room temperature for 4months after harvesting, then the following measurements were recorded, i.e. weight of 1000seeds, germination percentage and as the method described by Scott et al.⁴⁰ The germination percent of seed were calculated according to the following equations: Germination %=Number of the germinated seeds/ Initial seeds number*100.

Statistical analysis: All experiments were statistically analyzed in a complete randomized design with three replicates. Obtained data were subjected to the analysis of variance procedure and means were compared by L.S.D. method at 5% level of significant according to.⁴¹

Results and discussions

Effect of soaked bulbs in GA3 on onion seed production

The soaked onion bulbs in GA3 levels showed in (Table 1) that the treatment with 1000ppm gave the least number of days and significantly increased the earliness of flowering during both seasons. In the same trend our results exhibited that GA3 with 1000ppm gave the highest significant increment in bolting period and number of scapes. These results may be due to growth regulators (GA3) are considered to be the key factors in vegetative growth and earliness

of flowering and higher rate significantly increases bolting.^{21,42} One of the common effects of gibberellic acid (GA3) is that it stimulates bolting. Whether this holds true for onions, was studied in several experiments involving variations in the concentration of GA3, duration of treatment and date and method of application. Apparently onion plants are very sensitive to GA3 shortly after the beginning of bolting.⁴³ This phenomenon known as bolting, affects severely the yield and quality of lettuce due to stem elongation and is stimulated by both high temperatures and endogenous metabolism of gibberellic acid (GA).^{44,45} Rabinowitch et al.,⁴⁶ found that the application of GA3 at 500 to 1000ppm enhanced flowering of normal genotypes and improved seed yields in onion plants.

Concerning to the effect of GA3 concentration on height of umbel scape, diameter of umbel scape and diameter of umbel were showed in Table 2. The obtained results showed that high significant differences were found in scape height, scape diameter and umbel diameter. This might be due to the increasing of cell division which occurred the rapid of plant growth by elevated level of GA3 application.^{47,48} GA3 application did not significantly affect plant fresh weight; however it increased leaf number and plant height and could allow for higher plant density and therefore higher total yield. Therefore, in any case, high doses of GA3 should be avoided regardless of growing conditions and nitrogen application rate. GA3 should be applied in low doses (up to 25mg L⁻¹) in combination with low to middle doses of GA3.⁴⁹ Lovato et al.,⁵⁰ reported that foliage spraying with 20ppm GA3 before bolting induced a slight earliness in seed maturity and increased seed yield. Apart from its role in inducing anthesis, GA has been suggested to increase growth rate of plants and total seed yield by Passam et al.⁵¹ Referring to the effect of GA3 on total seed yield, average weight of 100seeds and germination percentage were in Table 3. Our results cleared that the highest values was obtained with the treatment of GA3 at 1000ppm level and significantly increased during the two experimental seasons. Gibberellic acid (GA3) has been shown to increase onion seed germination, root length, and shoot dry weight after seed treatment.⁵² Reghin et al.,⁵³ reported that the effect of doses of gibberellic acid on increased flowering percentage, seed yield, earliness of the anthesis and seed maturation. Here, cytokinins are thought to be essential for cell division whereas IAA and gibberellins functions are important to cell enlargement in the growing pod.⁵⁴ These results may be due to the effect of GA3 on cell elongation, cell division which turn resulted increasing the growth parameter of onionumbel and seed production.^{10,55,56} Onion flowers had male-sterile mostly during the beginning of flowering and became male-fertile in a later stage and may be GA3 application increased the onion flower fertility.

Effect of soaked bulbs in CCC on onion seed production

Concerning the effect of cycocel with different level on earliness

Table 1 Effect of soaked bulbs in GA3 concentrations on earliness of bolting, bolting period and number of scapes umbel/plant of onion c.v Giza 20 during seasons of 2013/2014 and 2014/2015

Characters	Earliness of onion bolting (number of days)		Bolting period (number of days)		Number of umbel scapes/plot	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Control	77.32	71.17	29.92	23.18	164.57	168.02
250ppm	74.63	71.65	30.57	27.28	172.27	168.12
500ppm	73.14	70.49	30.8	25.37	170.2	176.92
1000ppm	70.38	67.81	32.2	28.5	179.01	182.55
L.S.D at 5%	2.69	2.29	0.27	0.38	0.46	5.58

of flowering, Bolting period and Number of scapes per plants were shown in Table 4. The latest of earliness of flowering and the highest values of bolting period was obtained with CCC at 100ppm, while the highest counted numbers of scapes per plants were obtained with CCC at 50ppm during both successive seasons. This result may be due to the application of cycocel was associated with the increased cytokinin biosynthesis and in parallel prolonged the developmental life-span of tiller producing buds. Several reports demonstrate that growth retardants such as CCC affect the plant height, increase the shoots diameter and standing, reduce seed yield loss and hence may go to increased seed yield per plant and plot.^{31,57,58} Moreover, cycocel treatments increased the number and longevity of tillers, branches, leaf area and eventually went to elevated photosynthesis.^{59,60} Foliar application with cycocel also increased plant dry weight, 1000 seeds weight in branches, harvest index and seed yield.⁶¹ Highest value in diameter of umbel scape was recorded at CCC 150ppm and the biggest diameter of umbel was reached with CCC treatment at 100ppm during both experimental seasons. These results may be due to soaked bulbs into the concentrations of cycocel (Table 5). Cycocel (CCC) is an onion compound and regarded as most consumed moderator of plant growth especially in Europe and nowadays, is frequently applied to decrease the dormancy and control the germination growth of cultivating plants.³¹ CCC prevents the activities of synthesized anti-covering enzyme and decreases the plant height.³⁷ Seed performance of plants treated with CCC leads to the increases in root growth and water potential in the leaves.³¹ Based on some research results, cycocel reduces the stem length and enhances the number of seeds in the ears.³⁷ Therefore, the seed yield is enhanced and the growth moderator increases the yield through changing Photo assimilates and directing them toward the targeted destination.³⁸ Referring to the effect of cycocel levels on onion total seed yield, average weight of 1000 seeds and germination percentage was recorded in Table 6.

The obtained results showed that an significant increment in onion total seed yield with cycocel treatment at 50ppm, average weight of 1000seeds and seed germination percentage at 100ppm during both experimental seasons. The superiority of CCC might be own to its effect on the seed yield, seed weight and seed germination percentage or the its effect on the appearance of flowering scapes and consequently the period of flowering. Also might be attributed to the effect of CCC on the length of scapes, whereas, with treating plants by CCC, the flower scapes were more shorter with bigger diameter and consequently, chances of butterflies at active to visit the flowers are being more.^{10,47,56,62,63} Also, they promoted the flowering parameters.⁶⁴⁻⁶⁶ Also, Hassanein et al.⁶⁶ on Dahlia pinnata, they found that both of CCC and Alar at 1000ppm increased chlorophyll a, b and carotenoides contents of leaves may be due to the co factor to seed assimilation.

Table 2 Effect of soaked bulbs in GA3 concentrations on height of umbel scape, diameter of umbel scape and diameter of umbel of onion c.v Giza 20 during seasons of 2013/2014 and 2014/2015

Characters	Height of umbel scape (cm)		Diameter of umbel scape (cm)		Diameter of umbel (cm)	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Control	85.34	72.83	2.133	2.07	2.62	2.56
250ppm	90.68	76.66	1.771	1.88	2.44	2.82
500ppm	92.22	78.39	1.943	1.96	2.81	2.92
1000ppm	88.75	76.12	1.896	1.87	2.95	3.36
L.S.D at 5%	0.67	0.78	0.14	0.14	N.S	0.33

Table 3 Effect of soaked bulbs in GA3 concentrations on seed yield/plot, average weight of 1000 seeds and seed germination percentage of onion c.v Giza 20 during seasons of 2013/2014 and 2014/2015

Characters	Seed yield/Plot (g)		Average weight of 1000 Seeds (g)		Seed germination percentage	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Control	583.15	550.5	4.41	4.19	86.32	84.29
250ppm	621.83	556.21	4.9	4.44	90.11	87.13
500ppm	614.76	571.74	4.98	4.64	90.49	88.2
1000ppm	643.1	595.16	5.31	4.82	92.58	89.47
L.S.D at 5%	17.08	17.19	0.21	0.28	2.59	3.51

Table 4 Effect of soaked bulbs in CCC concentrations on earliness of bolting, bolting period and number of umbel scapes/plot of onion c.v Giza 20 during seasons of 2013/2014 and 2014/2015

Characters	Earliness of onion bolting (Number of days)		Bolting period (Number of days)		Number of umbel scapes/plot	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Control	80.05	71.13	27.43	22.42	179.52	156.21
50ppm	77.07	71.6	33.52	22.27	192.02	174.5
100ppm	72.38	68.73	35.82	24.24	188.09	170.97
150ppm	76.17	70.03	31.81	22.84	184.51	170.12
L.S.D at 5%	3.15	1.86	3.39	0.58	0.42	0.521

Table 5 Effect of soaked bulbs in CCC concentrations on height of umbel scape, diameter of umbel scape and diameter of umbel of onion c.v Giza 20 during seasons of 2013/2014 and 2014/2015

Characters	Height of umbel scape (cm)		Diameter of umbel scape (cm)		Diameter of umbel (cm)	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Control	77.92	68.47	1.87	2.092	2.7	2.37
50ppm	73.68	67.45	1.91	2.04	2.93	2.6
100ppm	72.83	66.1	2.08	2.22	3.21	2.77
150ppm	70.14	65.55	2.2	2.6	2.88	2.47
L.S.D at 5%	1.95	1.64	0.17	0.07	0.23	N.S

Table 6 Effect of soaked bulbs in CCC concentrations on seed yield/plot, average weight of 1000 seeds and seed germination percentage of onion c.v Giza 20 during seasons of 2013/2014 and 2014/2015

Characters	Seed yield/plot (G)		Average weight of 1000 seeds (G)		Seed germination percentage	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Control	555.67	533.33	4.7	4.04	85.42	87.08
50ppm	586.67	573.33	4.45	4.61	84.04	89.61
100ppm	542.67	534.33	4.88	4.98	88.08	90.43
150ppm	566.33	533.33	4.53	4.62	85.95	86.43
L.S.D at 5%	14.1	33.92	N.S	0.34	1.34	N.S

Conclusion

The study concluded that the favorable growth regulators level to produce high seed yield with best quality was obtained from GA3 at 1000ppm and CCC at 50ppm. GA3 and CCC application significantly varied the scape length, umbel diameter, seed yield per plant, weight of thousand seeds and germination % of onion.

Acknowledgements

None.

Conflict of interest

The author declares no conflict of interest.

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