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Improving Seed Germination and Seedling Vigor Traits of Onion (*Allium cepa* L.) By using Soaking Pretreatments

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ABSTRACT

Onion (*Allium cepa* L.) seeds lose viability within 1 -2 years and exhibit a short lifespan. In this study, a factorial experiment in a randomized complete block design with six replications was conducted to determine the effects of soaking seeds for 24 h in distilled water (DW); aerated distilled water (ADW), 0.1% of each (succinic acid, aerated succinic acid (ASA), ascorbic acid, aerated ascorbic acid, nitroben (N), and aerated nitroben (AN) separately; and control (germinating seeds on filter paper with DW), and incubating at a constant temperature of 20°C in the dark. Seeds soaked in ASA showed the highest germination, speed of germination index (SGI), seedling vigor index, seedling dry weight and seedling length (cm). High SGI was also noted in seeds soaked in AN. Seeds soaked in N showed high germination rate and germination energy. The highest values of germination time GT, abnormal seedling percentage, and dead seed percentage were recorded with control treatment. Thus, the germination methods affected the germination traits as well as seedling growth of onion seeds.

Keywords: Onion (*Allium cepa* L.), Germination, Soaking, Aeration, Ascorbic acid, Succinic acid, Nitroben

INTRODUCTION

Onion (*Allium cepa* L.) is one of the oldest vegetables that has been cultivated since at least 4000 BC; it is an important export crop in Egypt. Seed quality is determined by numerous factors, including germination potential and seed vigor, that might remarkably influence desirable plant establishment and stand quality (Basra *et al*., 2002). Storing onion seeds for long periods is difficult as they rapidly lose their viability and vigor (Khan *et al*., 2004). Seed preparation for agriculture is an important factor in reducing the cost of production, increasing yield, and improving quality because ensuring improved production factors or hybrid varieties, good land service, and modern technologies in agriculture is important. The use of highly homogenous seeds can reduce the amount required for agriculture, as well as aid in the activation and acceleration of germination and ensure homogeneity of plant growth (Boras and Zaidan, 2004). Water treatments, including seed soaking in water or solvents, are used to activate and accelerate germination (Basaran, 2017; Bennett and Waters Jr, 1987).

The percentage of germination decreases significantly after a year of seed storage. Several studies suggested that soaking and aerating soaked onion seeds in some growth regulators or other such solutions can improve the germination and growth of seedlings. Slow-germinating seeds require a long time to germinate, which might expose them to risks from unfavorable conditions (Basra *et al*., 2002). Because seed germination effectively accelerates the growth rate of plants, early seed germination ensures good quality of seedlings that can show early and vigorous growth under field conditions (Boras and Zaidan, 2004). Some studies have shown that treatment with aerated medium can accelerate germination, thereby increasing seed strength and seedling growth rate (Bewley and Black, 1978; Niazy and M, 2014).

This study aimed to increase seed viability by increasing the germination percentage of onion seeds and promoting seedling growth to achieve higher productivity. Further, we determined the effects of different soaking pretreatments on improving the quality of seedlings such that they are able to withstand adverse environmental conditions during cultivation in the field and thus determine the most effective pretreatment for onion seeds.

MATERIALS AND METHODS

Plant material and Experimental Setup.

The experiments were performed using equal-sized onion (*A. cepa* L. 'Giza 6' seeds obtained from the Seed Technology Research Unit, Mansoura, Agricultural Research Center, Egypt. Seed quality was tested according to the rules of (AOSA, 1992). Seeds were surface-sterilized with 5% sodium hypochlorite solution for 5 min and then rinsed twice with autoclaved distilled water (Khan *et al*., 2004). Seeds were soaked for 24 h in distilled water (DW); aerated distilled water (ADW); 0.1% of each (succinic acid, aerated succinic acid (ASA), ascorbic acid, aerated ascorbic acid, nitroben (N) which a bio- fertilizer (Shaalan *et al*., 2001), and aerated nitroben (AN) separately.

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Control seeds were germinated on filter paper. The ratio of seeds to aqueous solutions was 1:5. The soaking solutions were continuously aerated using an air pump. Seeds for all treatments were incubated in the dark and at a constant temperature of 20°C. At the end of treatments, seeds were dried at room temperature to eliminate excess superficial moisture and sown in Petri dishes.

A factorial experiment was conducted in randomized complete block design with six replications.

The following factors were investigated:

Seed germination and vigor tests

Onion seeds were considered germinated when the radicle length was at least 2 mm. Germination percentage (GP) was calculated by counting only normal seedlings after 14 days of planting according to ISTA (1999). Speed of germination index (SGI) was calculated according to the Association of Official Seed Analysis (AOSA, 1992) by using the following formula: SGI = (No. of germinated seeds/days of first count) +… + (No. of germinated seeds/days of final count). Germination energy (GE) was the percentage of germinated seeds on the fourth day after planting relative to the total number of seeds tested (Ruan *et al*., 2002). Germination rate (GR) was defined as follows:

$$GR = \frac{a + (a + b) + (a + b + c) \ldots (a + b + c + m)}{n\,(a + b + c + m)}$$

where **a, b, and c are the numbers of seedlings in the first, second, and third counts; m is the number of seedlings in the final count; and n is the number of counts (Bartlett, 1937).**

Dead seed percentage (DSP) was calculated by counting only seeds that did not produce any radicle.

Seedling vigor tests

At the final count, ten normal seedlings from each replicate were randomly selected to measure the following seedling characters: seedling length (SL, cm) was measured 14 days after planting. Seedling dry weight (SDW, g) was determined by drying the seedlings in a hot-air oven at 85°C for 12 h, according to Krishnasamy and Seshu (1990). Seedling vigor index (SVI) was calculated using the following equation SVI = SDW × GP, according to Abdul-Baki (1980). Normal seedling percentage (NSP) was calculated by counting the number of normal seedlings. Abnormal seedling percentage (USP) was calculated by counting the number of abnormal seedlings.

Experimental design and statistical analysis

The data for the estimated characters were statistically analyzed using analysis of variance for completely randomized design, as described by (Gomez and Gomez, 1984). Differences between means were compared using Fisher's protected *LSD* test at $P < 0.05$ (Duncan, 1955).

RESULTS AND DISCUSSION

The SGI was highly significantly affected by seed soaking treatments and showed the lowest value of 3.54 compared with that of the control (Table 1, Fig. 1). Onion seeds soaked in ASA showed significantly higher seed germination vigor traits except GE compared with those of the other seed soaking treatments (Table 1, Fig. 1). The highest GE (60.67) and GR (0.77) were noted when seeds were soaked in N (Table 1, Fig. 1). The GR of onion was increased compared with that of the control (Table 1, Fig. 3). The highest DSP (10.25) was noted for the control. Conversely, soaking of onion seeds in ASA reduced the DSP as compared with that of the other treatments (Table 1, Fig. 2); this finding is in agreement with the results of (Bewley and Black, 1978; Rahman *et al*., 2015; Rehman *et al*., 2015). The improvement in germination of the treated seeds could be attributed to the removal of the phenolic component, coumarin and abscisic acid the source of inhibitory material and improvement of the permeability of the seed coat. Further, dissolved oxygen could increase the enzymatic activity, sugar amount, and seed protein and DNA contents that increased with each cell division; these products were then transferred to the main growth areas of the embryonic axis and used for producing new substances that promoted germination and increased seed strength (Smith and Cobb, 1992).

Control onion seeds showed significantly higher GT (6.24) compared with that of the other seed soaking treatments (Table 1, Fig. 2). Onion seeds soaked in N showed markedly reduced GT (5.09) compared with that of the other treatments (Table 1, Fig. 3). This result that soaking of seeds in ASA increases the germination vigor of onion is in agreement with those of previous studies (Bewley and Black, 1978; Black *et al*., 1974; Noorhosseini *et al*., 2017).

Table 1. Average values of germination percentage (GP), speed of germination index (SGI), germination time (GT), germination rate (GR), germination energy (GE), and dead seed percentage (DSP) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

Characters Treatments	Germination Percentage (GP)	Speed of germination index (SGI)	Germination Time (GT)	Germination Rate (GR)	Germination Energy (GE)	Dead Seeds percentage (DSP)
Control (cont.)	62.33	3.54	6.24	0.60	34.00	10.25
Water (DW)	69.00	4.25	5.65	0.69	45.33	8.83
Aerated water (ADW)	75.67	4.70	5.46	0.72	49.00	7.75
Succinic acid (SA)	80.67	4.95	5.43	0.72	53.67	6.83
Aerated Succinic acid (ASA)	88.33	5.06	5.70	0.68	49.67	5.00
Ascorbic acid (AA)	76.00	4.65	5.27	0.74	52.33	7.92
Aerated Ascorbic acid (AAA)	75.67	4.67	5.54	0.70	45.00	6.75
Nitroben (N)	69.67	5.10	5.09	0.77	60.67	6.92
Aerated Nitroben (AN)	75.00	5.17	5.39	0.72	56.00	5.92
F test	**	**	**	**	**	**
BLSD (5%)	0.3	0.4	0.2	0.4	0.7	0.2

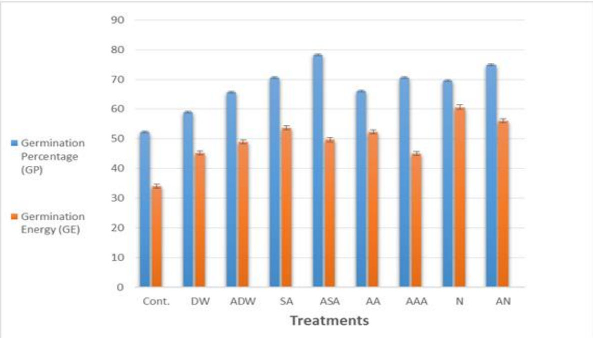

Figure 1. Histogram showing the average germination potential (GP) and germination energy (GE) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

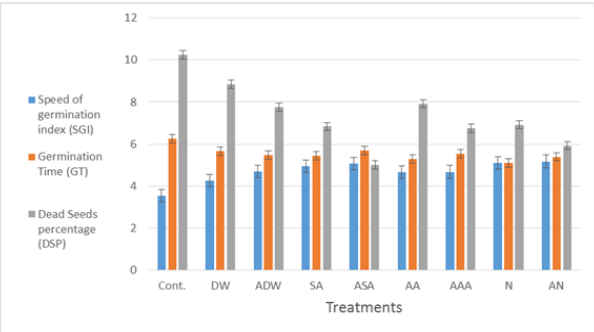

Figure 2. Histogram showing the average speed of germination index (SGI), germination time (GT), and dead seed percentage (DSP) of onion (*Allium cepa* L.) seeds subjected to different soaking treatments.

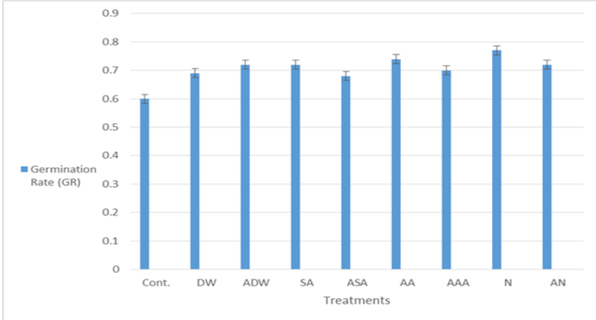

Figure 3. Histogram showing the average of germination rate (GR) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

The statistical analysis of data revealed that SVI was the highest (1009.83) when seeds were soaked in ASA. The control treatment showed the lowest SVI (539.50; Table 2, Fig. 4). Further, soaking onion seeds in ASA markedly increased the SL (12.72 cm; Table 2, Fig. 5), which was consistent with the results of Basaran (2017). Mayer and Mabyer (1982) showed that soaking in aerated solution could increase the nutrient absorption of seeds from the nutrient solution because of an increase in the amount of oxygen dissolved in the solution, which led to an increase in enzymatic activity and the metabolic rate of plants and breakdown of nutrients and their conversion to energy particles that can be immediately used by the embryonic axis for building new materials. All events caused the activation of germination and the rapid development of seedlings depending on the surrounding environmental conditions, leading to the rapid growth of plants.

Table 2. Average values of seedling vigor index (SVI), seedling length (SL, cm), seedling dry weight (SDW), normal seedlings percentage (NSP), and abnormal seedlings percentage (USP) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

Characters Treatments	Seedling Vigor index (SVI)	Seedling Length (SL)(cm)	Seedling Dry Weight (SDW) (gm)	Normal seedlings percentage (NSP)	abnormal seedlings percentage (USP)
Control (cont.)	539.50	9.75	0.018	13.08	1.67
Water (DW)	672.33	10.80	0.020	14.75	1.42
Aerated water (ADW)	768.58	11.15	0.022	16.42	0.83
Succinic acid (SA)	831.00	11.62	0.025	17.67	0.50
Aerated Succinic acid (ASA)	1009.83	12.72	0.028	19.58	0.42
Ascorbic acid (AA)	779.67	11.64	0.018	16.50	0.58
Aerated Ascorbic acid (AAA)	864.33	11.87	0.025	17.67	0.58
Nitroben (N)	807.00	11.59	0.018	17.42	0.67
Aerated Nitroben (AN)	915.17	12.15	0.023	18.75	0.33
F test	**	**	NS	**	**
BLSD (5%)	0.4	--	--	0.2	0.6

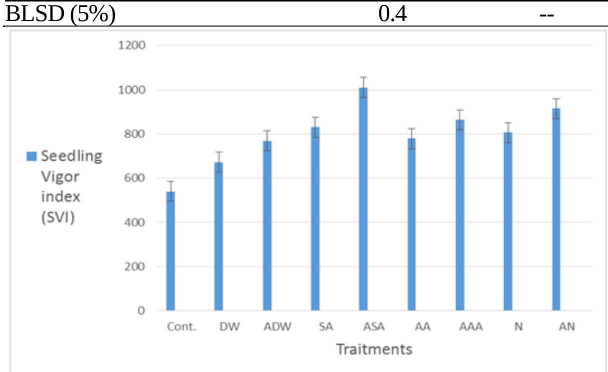

Figure 4. Histogram showing the average of seedling vigor index (SVI) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

Soaking onion seeds in ASA led to the highest values of SDW (0.028 gm; Table 2, Fig. 5). Further, soaking of seeds in ASA increased the NSP (19.58; Table 2, Fig. 6). In contrast, the highest value of USP (1.67) was noted in the control treatment compared with that of the other treatments such as AN that reduced the USP to 0.33 (Table 2, Fig. 7). This finding is consistent with that of Bewley and Black (1978). Hartmann *et al*. (1997) described the role of aeration medium in seed germination. Gas exchange between germination medium and embryo is essential for rapid and uniform germination. Oxygen is also essential for respiratory processes in germinating seeds. Oxygen uptake by seeds can be measured shortly after the beginning of imbibition. The rate of oxygen uptake is an indicator of germination progress and has been suggested as a measure of seed vigor. Oxygen supply is limited when excessive water is present in the substrate.

Carbon dioxide is a product of respiration; under conditions of poor aeration, carbon dioxide can accumulate in the soil. At deeper soil depths, increased CO_2 might inhibit seed germination to some extent, but it usually plays a minor role in maintaining dormancy.

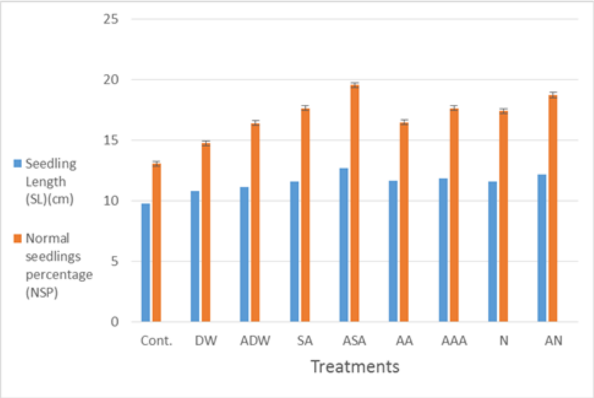

Figure 5. Histogram showing the average of seedling length (SL, cm) and normal seedling percentage (NSP) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

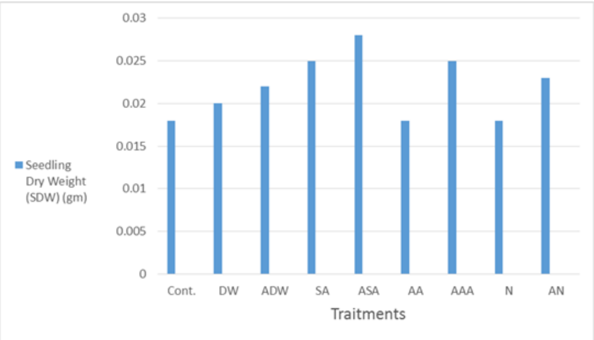

Figure 6. Histogram showing the average of seedling dry weight (SDW) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

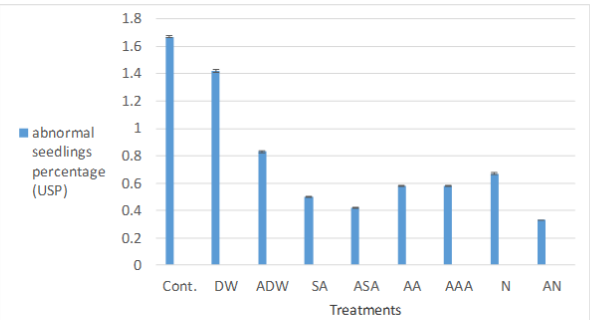

Figure 7. Histogram showing the average of abnormal seedlings percentage (USP) of onion (*Allium cepa* L.) seeds subjected to soaking treatments.

CONCLUSIONS

The treatment of seeds with aerated solutions stimulated germination and increased their relative growth rate. Further studies are warranted to determine the effects of treatment with aerated mediums on old seeds that have lost their vitality of other crops, as well as on genetic resources that have been stored for a long time. The treatments used in our study improved seedling strength in the laboratory; however, whether they increase the ability of the resulting plants to withstand adverse environmental conditions under field conditions, as well as whether they can be used to obtain good-quality seedlings that show vigorous growth needs to be determined.

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تحسين الإنبات لبذور البصل (Allium cepa L.) وصفات قوة البادرة بمعاملات النقع

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تفقد بذور البصل (Allium cepa L.) حيويتها خلال سنة إلى سنتين وتقل فترة حياتها. تم تصميم التجربة بطريقة القطاعات العشوائية الكاملة في هذه الدراسة في ستة مكررات لتحديد آثار نقع البذور لمدة 24 ساعة في الماء المقطر (DW)؛ الماء المقطر مع التهوية (ADW)، 0.1٪ من كل (حمض السكسينيك (SA) ، حمض السكسينيك مع التهوية (ASA) ، حمض الأسكوربيك ، حمض الأسكوربيك مع التهوية ، النتروبين (N) ، و النتروبين مع التهوية nitroben (AN) كل على حدة ، والكنترول (التجربة الضابطة) حيث تم إنبات البذور على ورق ترشيح والمعاملة بماء مقطر فقط (DW)، وتحضينها على درجة حرارة ثابتة 20 درجة مئوية في الظلام ، حيث أظهرت البذور المنقوعة في ASA أعلى نسبة إنبات ، ومدلول سرعة الإنبات (SGI) ، ومدلول قوة الشتلات ، والوزن الجاف للبادرات ، وطول البادرة بالسم وقد وجد أيضا إرتفاع . مدلول سرعة الإنبات (SGI) في البذور التي تم نقعها في بذور النتروبين مع التهوية عنها في التى تم نقعها في النتروبين فقط دون تهوية وكذلك إرتفاع نسبة الإنبات وطاقة الإنبات. سجلت أعلى قيم من زمن الإنبات GT ، ونسبة البادرات الغير طبيعية ، ونسبة البذور الميتة مع التجربة الضابطة (الكنترول) . وهذا يؤكد لنا أن طرق الإنبات تؤثر بشكل عام على صفات الإنبات وكذلك نمو بادرات نبات البصل.

الكلمات المفتاحية: البصل (Allium cepa L.)، الإنبات ، النقع ، التهوية ، حمض الأسكوربيك ، حمض السكسينيك ، نيتروبين