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Enhancement Onion Seed Germination and Seedling Vigor Traits through Magneto-Priming Techniques

Zalama, M.T.[1*] and F. H. Fathalla [2]

[1]Seed Technology Research Department, Field Crops Research Institute, ARC, Giza, Egypt
[2]Onion Research Section, Field Crop Research Inst., A.R.C., Egypt

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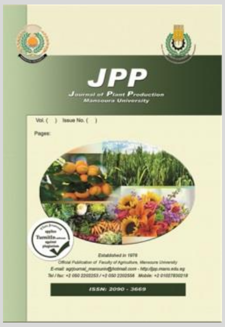

ABSTRACT

Standardization of magneto-priming technique treatments on seed and seedling vigor traits of onion cultivar *Giza Red*, under growth chamber and nursery conditions during 2018/2019 and 2019/2020 seasons. Therefore, a laboratory and nursery experiments were conducted in a Completely Randomized Design and Split-Split Plot Design with three replicates, respectively, consisted of; seed priming techniques vis., ordinary-priming and magneto-priming, chemical solutions vis., zinc sulfate ($ZnSo_4$, 500 mgL^{-1}), ascorbic acid (ASA, 50 mgL^{-1}) and distilled water (control treatment), along with durations time of seed priming vis., 12, 18 and 24 hours. It be concluded that, magneto-priming, ASA and $ZnSo_4$ solutions and 24 hours of seed priming treatments presented the highest significance increases compared to the other treatments in both of the two experiments. Furthermore, the combination between magneto-priming and ASA reveled the highest rated upon the control treatment, which were 50.4% for coefficient of velocity of germination, 36.7% for seedling length, 27.7% for seedling dry weight, 58.2% and 48.7% for seedling vigor index (I & II) and minimized mean germination time by 19.3%. Likewise, concerning the nursery experiment, the combination between magneto-priming and $ZnSo_4$ presented the highest increases over control by 24.7% for speed of emergence in the first season and 28.3% & 18.2% for seedling length in both seasons. While, the combination between magneto-priming and ASA detected the highest increases by 16% & 14% for field emergence, 34.4% & 38.5% for seedling dry weight, 56% & 58% for seedling vigor index and 36% & 37.5% for total amino acids in both seasons.

Keywords: Onion, Magneto-priming, Zinc sulphate, Ascorbic acid, Seed vigor, field emergence, seedling growth.

INTRODUCTION

Seed priming has emerged as an effective technique for improving seed quality during the pre-germinative metabolism that involved antioxidant functions and DNA repair operations, also enhancing germination synchronization, seedling growth and field establishment under adverse environmental conditions (Saranya *et al*., 2017). Low-vigor seeds can be enhanced through a wide range of treatments, some of them categorized as hydropriming, osmopriming and hormopriming (Araújo *et al*., 2016). In the context of seed technology, physical methods have demonstrated several features upon classic seed priming protocols. The application of magnetic fields (MFs) have been noted as eco- friendly, cheap, and non-invasive technique (Efthimiadou *et al*., 2014). One of the most investigated physical pre- sowing seed treatments is magneto priming which based on magnetic fields. Magneto-priming techniques recently considered as one of the most significantly pre-sowing seed treatments, which noninvasive dry seeds, utilize for promoting seed vigor, seedling growth and field performance under appropriate conditions or environmental stress conditions (Bilalis *et al*., 2013). Physical treatments effects in plants depend on various factors: radiation or MF (e.g., type, total dose, and dose rate) and exposure period, and plant features, such as species, cultivar, age, ploidy, and complexity of the target organ or tissue (De Micco *et al*., 2014).

Water is a good solvent and is oftentimes referred as the universal solvent. It is a diamagnetic molecule; however, its biophysical properties can be affected by magnetic field. The changes which taken place in the structure of liquid water induced by an external magnetic field are important in several applications, *e.g*., water treatment, biological and biotechnology. Magnetized water is the water exposed to the magnetic field in extremely low frequencies or passed through the magnetic device. Generated magnetized water molecules are restructuring into a very smaller, accurate and uniform clusters, which simply pass through the membranes into the internal cells and these features make the magnetized water more bio-friendly for plants. The fast movement of magnetized water molecules was due to increases the number of hydrogen bonds in presence of magnetic fields, which controlled the size of the water molecules and resulted in change in behavior of the water molecules (Krishnaraj *et al*., 2017).

Zinc is a substantial element for the life of plants. It is the only metal which act in six groups of enzymes such as hydrolases, transferases, lyases, isomerases, ligases and oxidoreductases. It is also involved in many biochemical processes such as, metabolism of carbohydrates, proteins and lipids. Likewise, involved in many physiological processes such as, germination and photosynthesis (Tsonev

[*] **Corresponding author.**
E-mail address: dr.mtz1979@gmail.com
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and Lidon, 2012), stimulate seed germination, better seed viability and seedling vigor, higher yield and reduction of seed rate required for sowing.

Ascorbic acid (ASA) as a water soluble antioxidant, have a great function in plant development process, through hormone signaling and as coenzyme in reactions by which carbohydrates, proteins and fats are metabolized. ASA plays a specific role in plant growth processes such as cell division and the expansion of cell wall. There is evidence of a correlation among seed germination capacity and the ASA content, because mature orthodox seeds lack ASA (De Tullio and Arrigoni, 2003). Endogenous ASA can be increased by exogenous application of ASA through the rooting medium (Chen and Gallie, 2004). The use of ASA as seed priming pretreatment, is due to its properties which reduce oxidative stress damage and improve germination characteristics (Rafique *et al*., 2011).

This study aimed to evaluate the effect of magneto-priming technique under various of seed priming and durations of priming treatments for estimating germinability, seedling vigor, traits under laboratory and nursery conditions and field emergence to achieve a good performance of onion seedling, cultivar *Giza Red*.

MATERIALS AND METHODS

Seeds of onion (*Allium cepa* L.) cultivar *Giza Red* were obtained from Onion Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Seeds were taken from the harvested season of 2018 and 2019, with an initial seed moisture content of 7±0.4 %. The magnetic water generating device with funnel shaped of 450 Gauss magnetic power and 41.66 ml/sec flow rate was produced by Magnetic Technologies L.L.C., Dubai, UAE. The laboratory experiment was conducted at the laboratory of Seed Technology Research Unit, Mansoura City, Dakhalia Governorate. While, the nursery experiment was taken place at Gemmeiza Agriculture Research Station Farm (Gharbeia Governorate) Egypt.

A Completely Randomized Design (CRD) with three replicates was taken place containing three factors with combinations of 54 treatments including control treatment. The first factor was mobilized with seed priming techniques; 1) Ordinary priming, seeds were primed by means of selective chemical substances solutions in their ordinary instance. 2) Magneto-priming, seeds were primed by the magnetized solutions of the respective chemical substances. The second factor was assigned to chemical solutions included; Zinc sulfate ($ZnSo_4$, 500 mgL^{-1}) and Ascorbic acid (ASA, 50 mgL^{-1}), along with distilled water (DW) as control treatment. The third factor mobilized with durations of seed priming (hours) i.e.,12, 18 and 24 hours.

A 500 mgL^{-1} of $ZnSo_4$ and 50 mgL^{-1} of ASA solutions were prepared separately by dissolving 500 mg of $ZnSo_4$ or 50 mg of ASA completely in a small quantity of absolute distilled water and mixed thoroughly, then distilled water was added to make the volume one litre to get standard solutions of $ZnSo_4$ (500 mgL^{-1}) and ASA (50 mgL^{-1}).

Magnetic water device with funnel shaped was used to prepare the magnetized respective solutions by passing each of distilled water, $ZnSo_4$ and ASA solutions, through the funnel of the magnetic device for five cycles to generate magnetized solutions of distilled water, $ZnSo_4$, (500 mgL^{-1}) and ASA (50 mgL^{-1}).

For priming procedure, onion seeds were surface-sterilized with 0.1% mercuric chloride solution for one minute and then rinsed twice with autoclaved distilled water (Khan *et al*., 2004). Then, freshly 100 ml solutions of distilled water, $ZnSo_4$ (500 mgL^{-1}) and ASA (50 mgL^{-1}) in its ordinary or magnetized instance were isolated and added to a weighted quantity of 5 grams' dry seeds. Every one hour, the solutions containing immersed seeds were blown to prevent smothering of the seeds in the solution. Three durations of 12, 18 and 24 hours were taken place to proceed seed priming treatments in the dark conditions at a constant temperature of 20 °C. At the end of priming processes, the seeds were removed, rinsed in distilled water and shade dried at 25 °C for 72 hours until close to original moisture content was reached. Then after, primed seeds were sealed in polyethylene bags and stored in a refrigerator until used.

Seed germination tests were carried out according to ISTA (1999). Three replicates of 100 seeds per each treatment were sown between two moistened filter papers (Whatman No.1) in Petri dishes (15 cm diameter). Each Petri-dish filled with 25 seed, every four Petri-dishes were kept close together and counted as one replication, then dishes were placed in growth chamber (20 °C and 80% RH) in the dark conditions, filter papers were moistened with 7.0 ml of distilled water when needed to avoid drying. Daily observation for emerging seedlings continued for 14 days after sowing to measure germination parameters.

- Germination percentage (G%) was calculated by counting only normal seedlings after 14 days of planting, as follow;

$$\textbf{G \%} = \frac{\text{Total number of germinated seeds}}{\text{Total number of seeds evaluated}} \times 100$$

- Coefficient of velocity of germination (CVG %) as another index of seed germination speed and velocity was calculated by the following formula as described by (Scott *et al*., 1984):

$$\textbf{CVG\%} = \frac{(G1+G2+G3+\cdots+Gn)}{(1\times G1)+(2\times G2)+\cdots+(n\times Gn)} \times \mathbf{100}$$

Where,

G1, G_2, G_3 and Gn are the numbers of germinated seeds from the first, the second, the third, … and the last day.

- Mean germination time (MGT, day) was calculated according to Ellis and Roberts (1981) formula;

$$\textbf{MGT} = \frac{\sum(\mathbf{D \times n})}{\sum \mathbf{n}}$$

where

n, is the number of seeds germinated on day D, and D is the number of days counted from the beginning of the test.

After the final count of 14 days from sowing, 30 normal seedlings were selected randomly from all replications (10 seedlings/1 replicate) to estimate seedling parameters.

- Seedling length (SL, cm) was measured as the total length of radicle and plumule (AOSA, 1983).
- Seedling dry weight (SDW, mg) was determined by drying the seedlings in a hot-air oven at 70 ºC for 72 h until constant weight was reached (Agrawal, 1986).
- Seedling vigor index (SVI-I) and (SVI-II) were calculated using the following equations, according to Abdul-Baki and Anderson (1970) and Abdul-Baki and Anderson (1973), respectively.

$$\text{SVI-I} = \text{Seedling length (cm)} \times \text{Germination percentage}$$

$$\text{SVI-II} = \text{Seedling dry weight (mg)} \times \text{Germination percentage}$$

A field experiment was taken place on onions growth in its nursery phase during the 10th of October in 2018 and 2019 seasons. The experiment was laid out in Split-Split Plot Design (SSPD) with three replicates. The main plot factor was assigned to seed priming techniques (ordinary priming and magneto priming). The subplot factor was mobilized within seed priming solutions ($ZnSo_4$, 500 mgL^{-1}, ASA, 50 mgL^{-1}, along with distilled water as control treatment). The sub-subplot factor was occupied with durations of seed priming (12, 18 and 24 hours).

Nursery land area was well prepared, through two perpendicular ploughs, well leveling, ridging and dividing into units. Calcium super-phosphate (15.5 % P_2O_5) was soil incorporated during tillage operation at 30 kg P_2O_5/fed. Potassium Sulphate (48 % K_2O) at 24 kg K_2O/fed was applied immediately before the first irrigation. Each experimental plot area was kept at 12.6 m^2 (4.2m x 3m), included 5 ridges 60 cm width and 4 water furrows 30 cm width with 3 meter long for each. The height of raised seed beds was about 15 cm, along with 2-3 cm depth of beds. Prior to sowing, seeds are treated with fungal culture of Tendro 40 % FS (5 cm^3kg^{-1} seed) to avoid damage from damping-off disease. The surface of beds was smoothed and well flatten, then seeds were sown on the flat beds on the two sides of each row and covered with a fine layer of soil followed by light surface irrigation. Plots were moisturizing by water sprinkler as per the need till germination is completed. Nitrogen in the form of Ammonium Sulphate (20.5% N) at 100 kg N/fed were added into two portions, half being applied before the second irrigation, while the remaining portion was applied before the third irrigation. The field emergence and speed of emergence were measured after 14 days, while seedling vigor traits were measured after 50 days from sowing, as follow;

- Field emergence (FE%) was calculated as the percentage of seedlings established 14th day relative to number of seed sown. The seedlings appearing on the surface of soil were considered as emerged as follow;

$$\text{FE \%} = \frac{\text{Total number of emerged seeds}}{\text{Total number of seeds evaluated}} \times 100$$

- Speed of emergence (SPE%) was calculated according to Dadlani and Seshu (1990), as follow;

$$\text{SPE\%} = \frac{\text{Number of seedlings emerged after 5 DAS}}{\text{Number of seedlings emerged after 11 DAS}} \times 100$$

Twenty samples of normal transplants were selected randomly from the three inner lines of each experimental plot to estimate the following traits;

- Seedling length (SL, cm) was measured from the base of swelling sheath to the tip of longest tubular blades.
- Seedling dry weight (SDW, mg) was measured after oven drying of fresh transplant at 70 ºC for 72 hours.
- Seedling vigor index (SVI-I&II) were calculated using the following equations;

$$\text{SVI-I (Field)} = \text{Seedling length (cm)} \times \text{Field emergence percentage}$$

$$\text{SVI-II (Field)} = \text{Seedling dry weight (mg)} \times \text{Field emergence percentage}$$

- Total amino acids (TAA%) were measured based on alcoholic extracts of bulbs of each treatment according to AOAC (1990) method.

The raw data for estimated traits were statistically analyzed using analysis of variance (ANOVA) for a Completely Randomized Design (CRD) in the laboratory experiment and a Split-Split Plot Design (SSPD) in the nursery experiment, as described by (Gomez and Gomez, 1984), using "MSTAT-C" computer software package. To realize the significance among means of different variables, LSD test at 0.05 % level was conducted as mentioned by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Data in Table 1 pointed that, treatment of seed priming techniques significantly affected seed germination and vigor indices. Thus, applying magneto-priming significantly recorded the higher increases upon the ordinary seed priming by 6% for G (%), 20% for CVG (%), 14% for SL (cm), 12% for SDW (mg), 18% for SVI-I and 18% for SVI-II, in addition to decrease MGT in days by 15%.

Generally, seed priming significantly enhancing seed germination in onion seed (Parera and Cantliffe, 1994). Exposure seed to magneto-priming appeared to increase seed performance *i.e*., enhanced alpha-amylase, dehydrogenase and protease activities in magneto-primed seeds during imbibition. It's also have vital effects on the normal metabolisms and impacts cellular division (Dhawi *et al*., 2009), influence the synthesis of DNA, RNA and cellular propagation, activate the cellular stress response through encourage the expression of stress response genes (Ruediger, 2009), which led to alters gene expression, protein biosynthesis, enzyme activity, cell reproduction and cellular metabolism.

Data pointed in Table 1 indicated that, seed germination and seedling vigor indices were significantly affected by seed priming solutions of ASA (50 mgL^{-1}) followed by $ZnSo_4$ (500 mgL^{-1}) compared to distilled water as a control treatment. Furthermore, the superior increases over control were recorded by ASA (50 mgL^{-1}) treatment, which were 9% for G (%), 23% for CVG (%), 20% for SL (cm), 13% for SDW (mg), 29.6% for SVI-I and 22% of SVI-II, in addition to decrease MGT in days by 7%.

Applying $ZnSO_4$ (0.5 %) as seed priming treatment significantly enhanced seed germination, speed of emergence, seedling length, dry matter content and seedling vigor index of onion seed by 12%, 11%, 20%, 20% and 34% respectively, over control treatment (Saranya *et al*., 2017). Zinc has a physiological function during germination processes, which stimulating seed germination, enhancing seedling development and plant productivity, photosynthesis and in the preserve turgor of tissues (Tsonev and Lidon, 2012). Its represented in the activity of six categories of enzymes *i.e*., hydrolases, transferases, lyases, isomerases, ligases and oxidoreductases. Also, it has a vital role in many biochemical processes such as, metabolism of carbohydrates, proteins and lipids, synthesis of acid nucleic and stimulates tryptophan and auxin.

Ascorbic acid has particular characteristics because it`s activity, which accord after a few hours from the onset of imbibition, which finally influenced seed germination and seedling vigor (De Tullio and Arrigoni, 2003). ASA plays a vital role in many physiological processes *i.e*., accelerates cell division, cell wall expansion and other plant growth development processes, stimulate seed germination and seedling growth (Tavili *et al*., 2009), ion intake to roots (Gonzalez-Reyes *et al*., 1994), regulating photosynthetic pigments (Foyer and Lelandais, 1993), respiration, senescence, increasing nucleic acid and protein synthesis and raising antioxidant enzyme activities (Ejaz *et al*., 2012).

With respect to seed priming durations (hours), data in Table 1 clarified significant variation ($P<0.05$) due to duration time of seed priming treatment on all seed germination and seedling vigor indices, except G (%) and SVI-I were not affected. Growing time of seed priming from 12 h passing by 18 h to 24 h slightly enhanced the mean values. Therefore, the high mean values were recorded by 24 h of seed priming duration, which were 92.2% for G (%), 35.0% for CVG (%), 14.1 for SL (cm), 28.1 for SDW (mg), 1309 for SVI-I and 2597.5 for SVI-II, in addition to low MGT by 5.5 day. While, 12 h of seed priming duration recorded the low mean values, as shown in Table 1.

Our results are homogenized with those reported by Caseiro *et al*. (2004). They cleared that, hydro-priming was most effective for improving seed germination of onion compared to the unprimed seed, especially when the seeds were hydrated for 96 hours compared to 24 and 48 hours. In seed imbibition stage, the water content raises up to reach high level and slightly changes until radicle emergence. For this point, priming up substantially enhanced seeds germination behaviors, while longer priming duration may have negative effects (Bradford, 1986). Earlier studies investigated the effect of duration time of seed priming treatments i.e., 12, 24 and 36 hours on wheat, on fenugreek (Soughir *et al*., 2012), on safflower. They indicated that, different priming treatments and duration have significant effect on total germination percentage, germination index, mean germination time and seedling vigor upon the unprimed seed.

Table 1. Germination percentage (G%), coefficient of velocity of germination (CVG%), mean germination time (MGT, day), seedling length (SL, cm), seedling dry weight (SDW, mg) and seedling vigor index (SVI-I and SVI-II) of onion seeds, as affected by seed priming techniques, solutions treatments and seed priming durations, as well as their interactions.

Treatments / Traits	G (%)	CVG (%)	MGT (day)	SL (cm)	SDW (mg)	SVI-I	SVI-II
Seed priming techniques (A)							
Ordinary priming (Control)	88.6	30.4	6.0	13.2	26.0	1179.0	2315.9
Magneto-priming	94.0	36.6	5.1	15.0	29.1	1391.2	2734.0
F test	*	*	*	*	*	*	*
LSD (5%)	2.58	0.71	0.08	0.04	0.48	35.0	69.85
Seed priming solutions (B)							
Distilled water (Control)	86.2	30.2	5.8	12.6	25.8	1091.3	2237.0
Zinc sulfate (500 mgL^{-1})	93.8	33.3	5.6	14.4	27.9	1350.0	2615.0
Ascorbic acid (50 mgL^{-1})	93.8	37.0	5.4	15.1	29.1	1414.0	2723.0
F test	*	*	*	*	*	*	*
LSD (5%)	3.15	0.87	0.10	0.05	0.60	42.75	85.56
Seed priming durations (C)							
12 hours	90.0	31.8	5.7	13.9	27.1	1257.2	2448.1
18 hours	91.5	33.7	5.6	14.0	27.5	1298.2	2529.1
24 hours	92.2	35.0	5.5	14.1	28.1	1309.0	2597.5
F test	Ns	*	*	*	*	NS	*
LSD (5%)	--	0.86	0.10	0.05	0.59	--	85.50
Interactions							
A x B	*	*	Ns	*	*	*	*
A x C	Ns	Ns	Ns	*	Ns	Ns	Ns
B x C	Ns	Ns	Ns	Ns	Ns	Ns	Ns
A x B x C	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Data revealed that, the binary interaction among seed priming technique and chemical solutions treatments significantly ($P<0.05$) indicated highly variation rates on seed vigor traits, except mean germination time which was not affected, in contrast to the other interactions treatments, as shown in Table 1. Moreover, the highest increases rates upon the control treatment goes to the combination between magneto-priming and ASA (50 mgL^{-1}), which were 50.4% for CVG (%), 36.7% for SL (cm), 27.7% for SDW (mg), 58.2% for SVI-I and 48.7% for SVI-II, as well as the largest decrease by 19.3% of MGT in days under control treatment, while the combination between magneto-priming and $ZnSo_4$ (500 mgL^{-1}) recorded the highest increases by 20% for G (%), as shown in Table 2.

Table 2. Germination percentage (G%), coefficient of velocity of germination (CVG%), mean germination time (MGT, day), seedling length (SL, cm), seedling dry weight (SDW, mg) and seedling vigor index (SVI-I and SVI-II) of onion seeds, as affected by the binary interaction between seed priming techniques and seed priming solutions.

Interaction treatments (A×B)		G (%)	CVG (%)	MGT (day)	SL (cm)	SDW (mg)	SVI-I	SVI-II
Ordinary priming	DW (Cont.)	80.0	26.0	6.2	11.7	23.8	936.3	1906.0
	$ZnSO_4$ (500 mgL^{-1})	91.5	30.4	6.1	13.7	26.5	1254.5	2430.4
	ASA (50 mgL^{-1})	94.2	34.7	5.8	14.2	27.8	1346.0	2611.1
Magneto priming	DW(Cont.)	92.4	34.4	5.3	13.5	27.8	1246.3	2567.1
	$ZnSO_4$ (500 mgL^{-1})	96.0	36.2	5.0	15.0	29.2	1445.3	2799.2
	ASA (50 mgL^{-1})	93.3	39.1	5.0	16.0	30.4	1482.1	2834.8
LSD (5%)		4.5	1.23	0.14	0.07	0.84	60.47	121.0

The increases due to the combinations between magneto-priming and ascorbic acid or zinc sulphate treatments might be the principal reason for improving seed germination and seedling vigor traits of onion. The changes which taken place in the structure of liquid water induced by an external magnetic field are important in several applications, e.g., water treatment, biological and biotechnology.

Earlier studies ensured the positive effects of magnetized water on seed germination, germination rate, speed of germination, mean germination time, seedling vigor index of onion seed (Kubisz *et al*., 2012; Hozayn *et al*., 2015), radical and shoot length, fresh and dry mass of weight seedling growth and productivity of onion (Ghaffoor *et al*., 2003). Magnetized water had stimulatory effects *i.e*., the higher activities of hydrolyzing enzymes in liquid water (Ijaz1 *et al*., 2012), activation and production process of antioxidants enzymes activity and hormones, enhanced level of the seed-store auxin, increases in the total carbohydrates, protein and amino acids, proline and phenol contents, inorganic minerals contents and total chlorophyll and carotenoids in all plant parts, which resulted in initial stimulation, improvement on seed germination and vigor, rooting, vegetative growth and yield (Elshokali and Abdelbagi, 2014).

The statistical analysis of data pointed in Table 3 revealed that, significant differences ($P<0.05$) were detected with respect to field emergence percentage (FE%), speed of emergence (SPE%), seedling length (SL, cm) and seedling dry weight (SDW, mg), as affected by seed priming techniques, priming solutions and duration of seed priming (h) under nursery conations. Magneto-priming treatment was the most beneficial treatment to obtain better values over ordinary priming treatment. More, the increases due to applying magneto-priming upon ordinary priming were 6.4% & 6.2% for FE (%), 8.1% & 5.5% for SPE (%), 15% &12% for SL (cm), and 18% & 20% for SDW (mg) in the 1st & 2nd seasons, respectively.

Seed priming solutions of $ZnSo_4$ (500 mgL^{-1}) and ASA (50 mgL^{-1}) showed converging mean values of field emergence and seedling vigor traits, which were very close to each other. While, they significantly showed positive impacts compared to the control treatment. The highly increases due to applying $ZnSo_4$ (500 mgL^{-1}) upon control treatment were, 11.6% for SPE (%) in 1st season, 9% & 4% for SL (cm) in 1st & 2nd seasons and 11% for SDW (mg) in 2nd season. While, the high increase over control treatment due to applying ASA (50 mgL^{-1}) were, 6.6% & 5.5% for FE (%) in 1st & 2nd seasons, 7.7% for SPE (%) in 2nd season and 12.5% for SDW (mg) in 1st season, as shown in Table 3.

Table 3. Field emergence percentage (FE%), Speed of emergence (SPE%), seedling length (SL, cm) and its dry weight (SDW, mg) of onion seedlings, as affected by seed priming techniques, solutions treatments and seed priming durations, as well as their interactions, during 2018/2019 and 2019/2020 seasons.

Treatments	FE (%)		SPE (%)		SL (cm)		SDW (mg)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Seed priming techniques (A)								
Ordinary priming	81.5	79.1	68.3	62.1	26.6	24.6	124.5	109.6
Magneto-priming	86.7	84.0	73.9	65.5	30.6	27.5	146.5	131.4
F test	*	*	*	*	*	*	*	*
LSD (5%)	0.80	0.72	1.58	0.57	1.08	1.86	5.97	4.79
Seed priming solutions (B)								
DW (Cont.)	80.6	78.8	66.3	61.3	27.3	25.3	125.3	111.7
$ZnSo_4$ (500 mgL^{-1})	85.7	82.4	74.0	64.1	29.7	26.4	140.3	124.2
ASA (50 mgL^{-1})	85.9	83.1	73.0	66.0	28.8	26.3	141.0	125.0
F test	*	*	*	*	*	*	*	*
LSD (5%)	1.42	0.97	0.92	0.84	0.63	0.59	1.98	1.90
Seed priming durations(C)								
12 hours	82.7	80.3	69.0	62.5	27.7	25.3	131.2	117.3
18 hours	83.8	81.3	71.3	64.1	28.3	26.1	136.0	119.8
24 hours	85.6	82.6	73.1	65.0	29.8	27.0	139.3	123.7
F test	*	*	*	*	*	*	*	*
LSD (5%)	1.08	1.45	0.64	0.80	0.43	0.44	1.59	1.82
Interactions								
A x B	*	*	*	*	*	Ns	*	*
A x C	Ns	Ns	Ns	Ns	Ns	Ns	*	*
B x C	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
A x B x C	Ns	Ns	Ns	Ns	Ns	Ns	Ns	*

Prior researches pointed that, Zinc treatment was the superior over the other micronutrients, which proved to be the highly effective for the number of leaves/plant, bulbs diameter and weight and yield, they demonstrated that zinc micronutrient caused healthy and vigorous root growth in onion throughout the life cycle of plant might and translocated effectively from leaves in to the bulbs. Also, zinc has a physiological function during seed germination and seedling development stages, which lead up to enhancing plant productivity.

More, seed priming with ASA significantly increase ions uptake *i.e*., K^{+}, P^{+3}, Ca^{+2}, Mg^{+2}, Zn^{+2} and Fe^{+3} in shoots and roots, which resulted in high seedling vigor traits (Gonzalez-Reyes *et al*., 1994; Ahmed *et al*., 2016). Although, ASA led to increase the number of onion root primordia by increasing the number of cells that pass from the stage G1 (quiescent) to the S stage (transcriptional) in quiescent meristematic cells, which promoted and renewed the activity seedling growth (Liso *et al*., 1988).

Duration of seed priming treatment exposed to three different periods (12, 18 and 24 h) showed significant (P <

0.05) effects on field emergence and seedling vigor traits, as shown in Table 3. Seed priming duration of 24 hours presented the high mean values, which were 85.6 & 82.6 for FE (%), 73.1 & 65.0 for SPE (%), 29.8 & 27.0 for SL (cm) and 139.3 &123.7 for SDW (mg) in the 1st and 2nd season respectively. While, 12 hours' treatment of seed priming duration recorded the lowest mean values, which were 82.7 & 80.3 for FE (%), 69.0 & 62.5 for SPE (%), 27.7 & 25.3 for SL (cm) and 131.2 & 117.3 for SDW (mg) in the 1st and 2nd seasons, respectively, as shown in Table 3.

Isolated data in Table 4 presented that, treatment of seed priming technique cleared significant ($P < 0.05$) effects on seedling vigor index and total amino acids characters during the two growing seasons. Thus, applying magneto-priming treatment significantly permits the high increases upon the ordinary priming treatment by 21.6% & 18.2% for SVI-I, 25% & 27% for SVI-II and 13.6% & 13.7% for total amino acids (%), in the 1st & 2nd seasons, respectively.

Although, seed priming solutions significantly indicated positive effects, while compared to distilled water treatment (cont.). Treatment of ASA (50 mgL^{-1}) showed the high increases up on control treatment by 9.4% for SVI-I in 2nd season, 19% and 17% for SVI-II and 19.2% & 19.6% for total amino acids (%) in the 1st and 2nd seasons, respectively. While, $ZnSo_4$ (500 mgL^{-1}) treatment recorded the great increase over control by 14.5% for SVI-I in the 1st season (Table 4).

Table 4. Seedling vigor index (I & II) and total amino acids (%) of onion seedlings, as affected by seed priming techniques, solutions treatments and seed priming durations, as well as their interactions, during 2018/2019 and 2019/2020 seasons.

Treatments	SVI-I		SVI-II		Total amino acids (%)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Seed priming techniques (A)						
Ordinary priming	2179	1947	10175	8664	1.47	1.45
Magneto-priming	2649	2301	12702	11007	1.67	1.65
F test	*	*	*	*	*	*
LSD (5%)	70.00	169.13	565.46	292.18	0.05	0.03
Seed priming solutions (B)						
DW (Cont.)	2221	2002	10167	8865	1.40	1.38
$ZnSo_4$ (500 mgL^{-1})	2544	2181	12037	10241	1.64	1.61
ASA (50 mgL^{-1})	2476	2190	12110	10400	1.67	1.65
F test	*	*	*	*	*	*
LSD (5%)	56.57	47.75	217.31	184.97	0.02	0.01
Seed priming durations (C)						
12 hours	2299	2039	10897	9465	1.53	1.50
18 hours	2383	2130	11437	9777	1.57	1.55
24 hours	2559	2204	11981	10264	1.61	1.60
F test	*	*	*	*	*	*
LSD (5%)	48.21	56.46	185.82	230.21	0.02	0.01
Interactions						
A x B	*	*	*	*	Ns	*
A x C	Ns	Ns	*	Ns	Ns	Ns
B x C	Ns	Ns	Ns	Ns	Ns	*
A x B x C	Ns	Ns	Ns	Ns	*	*

Moreover, clarified significant variation ($P<0.05$) were observed with respect to duration of seed priming treatment. Growing time of seed priming from 12 h passing by 18 h to reach 24 hours slightly enhanced the mean values of seedling vigor index and total amino acids. Treatment of seed priming for 24 hours recorded the high mean values by 2559 & 2204 for SVI-I, 11981 & 10264 for SVI-II and 1.61% & 1.60% for total amino acids (%) in the 1st& 2nd seasons, respectively. While, 12 hours of seed priming treatment detected the low mean values by 2299 & 2039 for SVI-I, 10897 & 9465 for SVI-II and 1.53% & 1.50% for total amino acids (%), in the 1st & 2nd seasons, respectively (Table 4).

Previous researches obtained by Yadav and Yadav (2002) are homogenized with our results, they pointed that, Zinc is involved in many metabolic processes such as, many enzymatic reactions which control multiply biosynthetic pathways, biosynthesis of hormones and chlorophyll, which leading to improved growth, yield attributes and bulb yield in onion. Along with Sulphur, which have a great function in improving the bulb pungency, which is correlated with bulb quality.

Secluded data shown in Table 3 demonstrated significant ($P<0.05$) effects on field emergence and seedling vigor traits, as a result to the binary interaction between seed priming technique and seed priming solution treatments, while compared to the other interactions treatments. Regarding to the calculated increase rates, data in the Table 5 demonstrated that, the combination between magneto-priming technique and $ZnSo_4$ (500 mgL^{-1}) or ASA (50 mgL^{-1}) solutions were the superior interaction treatments compared to the other interaction treatments. Moreover, the combination between magneto-priming and $ZnSo_4$ (500 mgL^{-1}) showed the high increases over control treatment by 24.7% for SPE (%) in 1st season and 28.3% & 18.2% for SL (cm) in 1st & 2nd seasons. While, the combination between magneto-priming and ASA (50 mgL^{-1}) treatment showed the high increases which were,16% & 14% for FE (%), 34.4% & 38.5% for SDW (mg) in 1st & 2nd seasons, while recorded 13.3% for SPE (%) in 2nd season.

The enhancements due to the combinations between magneto-priming technique and ascorbic acid or zinc sulphate treatments might be due to their great function role, which resulted in improve field emergence and transplant growth of onion seedlings. With regard to the supplemental effects of magnetized water (higher solubility), earlier studies proved a positive relationship between magnetic field and responses of biochemical and biological material. Dunand *et al*. (1989) reported that, magnetically treated water is claimed to enhance the weight and growth of agricultural crops, as it increased the growth of onion by 67.6%, similar results obtained by El Sagan and Abd El Baset (2015) and Ali *et al*. (2017). Moreover, exposure water to magnetic field treatment is a recognize technique for achieving high water use efficiencies, which resulted in an increased capability to release of salts and consequently improve absorption of nutrients and fertilizers in plants during the vegetative growth stage (Maheshwari and Grewal, 2009).

Table 5. Field emergence percentage (FE%), speed of emergence (SPE%), seedling length (SL, cm) and its dry weight (SDW, mg) of onion seedlings, as affected by the binary interaction between seed priming techniques and seed priming solutions treatments, during 2018/2019 and 2019/2020 seasons.

Interaction treatments (A×B)		FE (%)		SPE (%)		SL (cm)		SDW (mg)	
		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Ordinary priming	DW (Cont.)	75.2	74.0	61.1	59.1	24.0	23.5	114.0	98.6
	$ZnSo_4$ (500 mgL^{-1})	84.7	81.5	71.8	62.1	28.5	25.1	130.9	115.5
	ASA (50 mgL^{-1})	84.4	82.0	72.0	65.1	27.4	25.2	128.3	113.3
Magneto priming	DW(Cont.)	86.0	83.6	71.5	63.6	30.6	27.1	136.6	124.8
	$ZnSo_4$ (500 mgL^{-1})	86.6	83.2	76.2	66.2	30.8	27.8	149.6	132.9
	ASA (50 mgL^{-1})	87.2	84.4	74.0	67.0	30.2	27.5	153.3	136.6
LSD (5%)		1.53	2.05	0.91	1.13	0.61	0.62	2.24	2.57

The binary interaction between seed priming techniques and chemical solution treatments significantly affected seedling vigor and total amino acids characters, while compared to the other interactions treatments (Table 4). The results in Table (6) pointed that, the combination between magneto-priming and ASA (50 mgL^{-1}) treatment obtained the great increases over control treatment while compared to other interaction treatments, which were 33.5% for SVI-I in 2nd season, 56% & 58% for SVI-II in 1st & 2nd seasons and 36% & 37.5% for total amino acids (%) in 1st and 2nd seasons, respectively. While, the increases by 48% for SVI-I in 1st season was recorded by magneto-priming and $ZnSo_4$ (500 mgL^{-1}) treatment (Table 6).

Magnetized water hardly enhanced bulb diameter, bulb height, bulb weight without leaves and No. and weight of green leaves, when compared with un-magnetized water of two onion cultivars (Ali *et al*., 2017). More, El Sagan and Abd El Baset (2015) reported that, magnetic water proved to be a good technology to increase plant height and weight, number of leaves/plant, bulb diameters and weight and marketable yield percentage of onion variety Giza Red, while compare to un-magnetized water. More, Elshokali and Abdelbagi (2014) reported that, expose onion seeds to magnetized water significantly increased the soluble contents of Zn concentration (0.126 mgL^{-1}), compared to the non-magnetized water (0.017 mgL^{-1}).

Some vital process be found due to applying magneto-priming *i.e*., substantially enhancing dissolving capacity of magnetized water repeatedly, increasing the leaching of excess soluble salts, dissolving the soluble minerals such as Fe, Mn, Zn and Cu (Shahin *et al*., 2016), acids and salts such as carbonates, phosphates and sulfates (Hilal and Hillal, 2000), increasing elements uptake such as N, P and K and increases the accumulation of Mg, Fe, Cu, Zn, P, K and Ca (Basant and Harsharn, 2009) and rising up the speed of chemical reactions. Which finally, irreversibly affects cell membrane permeability, thus increasing its availability to plants, which resulted in enhancing plant growth and productivity (Dhawi, 2014).

Table 6. Seedling vigor index (SVI-I & II) and total amino acids (%) of onion seedlings, as affected by the binary interaction between seed priming techniques and seed priming solutions treatments, during 2018/2019 and 2019/2020 seasons.

Interaction treatments (A×B)		SVI-I		SVI-II		Total amino acids (%)	
		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Ordinary priming	DW (Cont.)	1805	1738	8583	7298	1.30	1.28
	$ZnSo_4$ (500 mgL^{-1})	2415	2046	11099	9421	1.55	1.53
	ASA (50 mgL^{-1})	2314	2058	10841	9272	1.56	1.54
Magneto priming	DW(Cont.)	2636	2267	11750	10432	1.50	1.49
	$ZnSo_4$ (500 mgL^{-1})	2672	2316	12976	11060	1.73	1.69
	ASA (50 mgL^{-1})	2637	2321	13379	11528	1.77	1.76
LSD (5%)		68.19	79.85	262.8	325.5	0.03	0.02

As a result, it can be concluded that subjected onion seeds to magneto-priming technique led to activate a composition of seeds, reduce a growth period, enhance a reproduction of the seeds and increased the solubility of ascorbic acid and zinc sulphate. Therefore, the curing treatments of zinc sulfate and ascorbic acid solutions will be more efficient and attainable to be used in seed priming technique, when it is utilized as magnetized solution (higher solubility). Also, magneto-priming could be a promising technique for seeds that have low viability and on genetic resources that have been stored for a long time, as well as increasing the ability of the resulting plants to withstand adverse environmental conditions under field conditions, as well as whether they can be used to improving agricultural, but more researches is required for different crops.

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تحسين صفات قوة إنبات البذور وجودة بادرات البصل بإستخدام تكنولوجيا التهيئة المغناطيسية

محمد طه عبد الرحمن زلمه[1] و فتح الله حسن فتح الله[2]

[1]قسم بحوث تكنولوجيا البذور - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر.

[2]قسم بحوث البصل - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر.

أجريت هذه الدراسة بمعمل وحدة تكنولوجيا البذور بالمنصورة و بمزرعة محطة البحوث الزراعية بالجميزة (محافظة الغربية) خلال موسمى 2018 /2019, 2020/2019 بهدف معرفة تأثير تقنية تهيئة البذور مغناطيسياً على مؤشرات قوة البذور وصفات قوة الشتلات تحت ظروف الإنبات في غرفة النمو (20 ° مئوية ، 80 % رطوبة نسبية) وإنتاجية شتلات البصل في المشتل تحت الظروف الحقلية عند50 يوم من الزراعة، بإستخدام صنف جيزة أحمر. تحقيقا لهذه الغاية، أجريت تجربة معملية في تصميم تام العشوائية وأخري حقلية في تصميم القطع المنشقة مرتين بإستخدام ثلاث مكررات، حيث كانت معاملات تهيئة البذور: تهيئة البذور مغناطيسياً باستخدام جهاز مغنطة الماء (قوة مفناطيسية 450 غاوس - معدل تدفق 41.66 مل/ثانية)، تهيئة البذور بالطريقة الشائعة الاستخدام (بدون مغنطة)؛ ثلاث معاملات من محاليل المواد الكيميائية: كبريتات الزنك بتركيز 500 مليجرام/لتر، حمض الأسكوربيك بتركيز 50 ملليجرام/لتر والماء المقطر كمعاملة قياسية؛ ثلاث فترات زمنية لتهيئة البذور: 12، 18 و 24 ساعة. أظهرت نتائج مؤشرات قوة البذور والبادرات وصفات جودة الشتلات، أن تهيئة البذور مغناطيسياً قد أعطت أعلى القيم المعنوية لجميع صفات قوة البذور والبادرات مقارنة بتهيئة البذور بالطريقة الشائعة بدون مغنطة. ثبت أيضاً أن تهيئة البذور بواسطة النقع في محاليل حمض الاسكوربيك بتركيز 50 ملليجرام/لتر ثم كبريتات الزنك بتركيز 500 ملليجرام/لتر كانتا الأعلي تأثيراً وقيماً على التوالي مقارنةً بمعاملة الماء المقطر (المعاملة القياسية). أخيراً أظهرت معاملة تهيئة البذور لمدة 24 ساعة متبوعة بمعاملة 18 ساعة أعلي القيم مقارنة بتهيئة البذور لمدة 12 ساعة، تحت ظروف الإنبات المعملي والمشتل تحت الظروف الحقلية خلال موسمي الزراعة. أظهر التفاعل الثنائي بين تهيئة البذور مغناطيسياً والمعاملة بحمض الأسكوربيك (50 ملليجرام/لتر) أعلى الزيادات فوق معاملة الكنترول مقارنة بمعاملات التفاعل الأخري، حيث كانت هذه الزيادات 50.4 % لسرعة الإنبات (٪)، 36.7% لطول البادرات (سم)، 27.7% لوزن البادرات الجافة (مللجرام) و58.2 % لمؤشر قوة البادرات وأيضاُ أكبر انخفاض لمتوسط وقت الإنبات (يوم) بنسبة 19.3%، في حين جاءت معاملة تهيئة البذور مغناطيسياً بواسطة كبريتات الزنك (500 ملليجرام/لتر) تالياً بانخفاض بسيط، مقارنة بمعاملات التفاعل الأخري. أظهرت نتائج التجربة الحقلية، أن معاملتي تهيئة البذور مغناطيسياً بواسطة محلول حمض الأسكوربيك (50 ملليجرام/لتر) ثم محلول كبريتات الزنك (500 ملليجرام/لتر) تالياً كانتا الأعلي قيماً. كما سجل التفاعل بين تهيئة البذور مغناطيسياً ومحلول كبريتات الزنك أعلي الزيادات فوق معاملة الكنترول بنسبة 24.7% لسرعة الإنبثاق الحقلي (%) في الموسم الأول و28.3% & 18.2% لطول البادرات (سم) خلال موسمي الزراعة. في حين سجلت معاملة تهيئة البذور مغناطيسياً بواسطة حمض الاسكوربيك أعلي إرتفاع فوق معاملة الكنترول بنسبة 16% & 14% للإنبثاق الحقلي (٪)، 34.4% & 38.5% للوزن الجاف للبادرات (ملليجرام)، 56% & 58 % لمؤشر قوة البادرات و 36% & 37.5% للنسبة الكلية للأحماض الأمينية خلال موسمي الزراعة. وعليه يمكن التوصية بأن تهيئة بذور البصل بالتقنية المغناطيسية و بالنقع في حمض الإسكوربيك (50 ملليجرام / لتر) تؤدي إلي زيادة نسبة الإنبات، مؤشرات قوة البذور والبادرات وتحسين جودة شتلات البصل.