Impact of Seed Soaking Treatments on Seedlings Parameters of Some Maize Hybrids

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Abstract

At Mansoura University at Egypt's Faculty of Agriculture's Agronomy Department Seed Testing in May 2022, a laboratory experiment in the factorial investigation in completely randomized design using four replicates was carried out to study the effect of soaking treatment with some antioxidants and chitosan at various levels (control treatment; soaking in distilled water; 100, 150 and 200 ppm of ascorbic acid (AA); at 100, 150 and 200 ppm of salicylic acid (SA); 0.25, 0.50 and 0.75 % of chitosan) on seedlings parameters of some maize hybrids (SC-2031, synthetic cultivar Giza-2 and TWC-324). The highest values of radical length, plumel length, seedling vigor index and seedling's fresh and dry weight were recorded from sown SC-2031 hybrid, followed by synthetic cultivar Giza-2 and then TWC-324 hybrid. Soaking maize seeds in ascorbic acid at 200 ppm resulted in the highest values of radical length, plumel length, seedling vigor index and seedling's fresh and dry weight, followed by soaking maize seeds in ascorbic acid at 150 or 100 ppm or salicylic acid at 100 ppm. The descending order of other soaking seed treatments was as follows; salicylic acid (150 ppm) > salicylic acid (200 ppm) > distilled water > without (untreated "control treatment") > chitosan (0.75 %) > chitosan (0.50 %). To maximize the seedlings parameters of maize, it could be recommended to soak maize SC-2031 hybrid seeds (AA) at the rate of 200 ppm or (SA) at 100 ppm for 12 hours.

Keywords: Maize, hybrids, seed soaking, ascorbic acid, salicylic acid, chitosan, seedlings.

تأثير معاملات نقع التقاوى على صفات البادرات لبعض هجن الذرة الشامية

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المستخلص

أجري هذا البحث لدراسة تأثير معاملة النقع ببعض مضادات الأكسدة والشيتوزان بمستويات مختلفة على صفات البادرات لبعض التراكيب الوراثية للذرة الشامية تحت الظروف المعملية. أجريت تجربة معملية بقسم المحاصيل، كلية الزراعة، جامعة المنصورة، مصر، خلال شهر مايو 2022 م. نفذت التجربة فى تجربة عاملية فى تصميم التام العشوائية فى أربع مكررات. تضمنت التجربة عاملين، العامل الأول ثلاثة تراكيب وراثية مختلفة من الذرة الشامية (هجين فردى أبيض هاى تك–2031، الصنف التركيبى الأبيض جيزة–2 وهجين ثلاثى أبيض–324)، العامل الثانى احتوى على إحدى عشر معاملة لنقع التقاوى فى بعض مضادات الأكسدة والشيتوزان بمستويات مختلفة على النحو التالي: بدون نقع "معاملة المقارنة"، النقع فى الماء المقطر، النقع في حمض الأسكوربيك بتركيز 100، 150 و200 جزء في المليون، حمض الساليسيليك بتركيز 100، 150 و200 جزء في المليون والشيتوزان بتركيز 0.25، 0.50 و0.75٪. نتجت أفضل القيم لصفات طول الجذير، طول الريشة، معدل قوة البادرات الوزن الغض والجاف للبادرات من زراعة هجين فردى أبيض هاى تك–2031، يليه الصنف التركيبى الأبيض جيزة–2 ثم أخيراً هجين ثلاثى أبيض–324. أدى نقع التقاوى في حمض الأسكوربيك بمعدل 200 جزء في المليون الى تسجيل أفضل القيم لطول الجذير، طول الريشة، معدل قوة البادرات الوزن الغض والجاف للبادرات يليه النقع في حمض الأسكوربيك بمعدلات 150 أو 100 جزء في المليون أو حمض الساليسيليك بمعدل 100 جزء في المليون. من أجل تعظيم صفات البادرات للذرة الشامية يوصى بنقع تقاوي هجين فردى أبيض هاى تك2031 في حمض الأسكوربيك بمعدل 200 جزء في المليون أو حمض الساليسيليك بمعدل 100 جزء في المليون لمدة 12 ساعة.

الكلمات المفتاحية: الذرة الشامية ,نقع البذور، حمض الأسكوربيك والسالسيليك، الشيتوزان، صفات البادرات.

Introduction

The most significant cereal grain in the world, after wheat and rice, is maize *Zea mays* L., which nourishes people and animals. Maize is a major element in industrial goods and is extremely important for human and animal nutrition. Moreover, maize is fed to animals as grains, silage, or fresh feed. The grains are also used in various industrial processes, including textiles and polymers. Hence, to close the consumption-production gap, it is crucial to focus on increasing maize productivity by increasing the cultivated area, enhancing germination and seedlings parameters, and increasing the production per area.

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The only way to increase crop yield and productivity is to employ high-quality seeds and effective management techniques. Besides their genetic and physical purity, high-grade seeds have strength, homogeneity, and structural soundness. Several scientists have created new "Seed Enhancing Methods" to produce seeds of more excellent quality. His method's primary goal is to enhance the utilisation of seed treatment products by raising the technical quality of seeds.

Many studies have shown that the genetic component significantly impacts the survival of maize seeds and other crops. Maize genotypes' chemical and hormonal composition vary genetically, influencing physiological performance throughout the germination and growth stages (Tiryaki and Andrews, 2001). Al-Fahd (2017) indicated that several maize genotypes (Sarah, Baghdad-3, Al-Maha and Fajr-1) grown from seeds under typical laboratory germination circumstances performed differently regarding the fresh and dry weight of the seedlings and overall performance. Zalama and Kishk (2017) found that Hitech 2031 produced the best maize hybrid outcomes. In contrast, Giza 352 and Giza 130 had the worst, respecting seedling growth indices, i.e. seedling vigor index (SVI), plumule length, extreme length, and seedling fresh and dry weights. Kandil *et al.* (2019 b) indicated that T.W.C. 310 hybrid acquired the maximum shoot and root length, fresh weight, dry weight, and seedling vigour index. Yagiz and Konuskan (2020) indicated that seedling growth properties such as; root length and root fresh weight varied significantly depend on maize hybrids. Al-Omairi and Al-Hilfy (2021) found that both maize cultivars (Baghdad 3 and Buhoth 5018) significantly differed in root and the plumule length and seedling dry weight.

Ascorbic acid (AA) is one of the ubiquitous non-enzymatic antioxidant molecules that have a role in detoxifying reactive oxygen species (ROS) and meditating various critical processes in plants under both stress and normal circumstances. Nevertheless, ascorbate, a crucial water-soluble antioxidant molecule in biological systems, is its physiologically active form (Akram *et al.,* 2017). Kandil *et al.* (2015 a) revealed that soaking maize grains in 100 ppm of (AA) markedly improved all examined seedling characteristics. Chi *et al.* (2021) stated that vitamin seed treatment could be valuable for promoting maize seed germination and seedlings growth. Kadhim and Hamza (2021) concluded that soaking maize seeds in ascorbic acid (100 mg L^{-1}) for 18 hours improved the properties of seedlings.

Salicylic acid (SA) plays a role in controlling most biological plant activities, including photosynthesis, nitrogen metabolism, antioxidant defence system, proline metabolism and protection against abiotic stressors (Khan *et al.,* 2015). Eisvand *et al.* (2015) showed that priming maize seeds might be possible to increase the emergence percentage by using 100 ppm of (SA) and 100 ppm of (AA), ascorbic acid and salicylic acid at 100 ppm of grown root dry weight. Nimir *et al.* (2015) pointed out that priming seeds with salicylic acid improved seedling growth. Kandil *et al.* (2019 b) reported that seedling vigour index, percentages of seedling height reduction, shoot and root length, shoot and root fresh weight, shoot and root dry weight, and relative dry weight were all significantly higher after priming maize seeds in 100 ppm of ascorbic acid and salicylic.

As a result of chitin's deacetylation, chitosan is a naturally occurring polymer. Chitin may be obtained easily from shellfish waste produced during food preparation. Due to its fungicidal activities and ability to trigger defensive mechanisms in plant tissues, the high molecular weight, non-toxic, bioactive chemical known as chitosan has gained recognition as a valuable substance. Chitosan creates a semi-permeable coating that controls gas exchange, lowers the rate of respiration and transpiration, and delays the ripening processes (Terry and Joyce, 2004). Peykani and Sepehr (2018) found that soaking the seeds with chitosan enhanced root length, increased the number of root branches, and resulted in a considerable rise in dry seedling weight and reduced malondialdehyde content. At the same time, Al-Omairi and Al-Hilfy (2021) found that using 100 or 500 mg L^{-1} of chitosan did not give significant results on seedling characters.

This study may be used to prove that applied sciences are highly significant in life because of their various applications in the present and the past (This study may be used to prove that applied sciences are highly significant in life because of their various applications in the present and the past (Abido and Zsombik, 2018, Abido and Zsombik, 2019 and Abido *et al.,* 2021). Consequently, this study was established to assay the effect of soaking treatment with some antioxidants and chitosan at various levels on seedlings parameters of some maize hybrids under laboratory conditions.

Experimental design and treatments

In May 2022, An experiment was conducted in a lab at Mansoura University's Agronomy Department Seed Testing College of Agriculture, Egypt. This laboratory investigation aimed to assay the influence of soaking treatments with some antioxidants and chitosan at various levels on seedlings parameters of some maize hybrids.

The laboratory experiment was conducted in a completely randomized design (CRD) using four replications. The investigation included two factors. The first factor comprised three maize hybrids: Single Cross 2031 (SC-2031), Synthetic cultivar Giza-2 and three-way cross 324 (TWC-324). The studied maize white single cross hybrid's HYTECH-2031 (SC-2031) seeds are produced and obtained from Misr Hytech Seed International Company. In comparison, the seeds of studied maize hybrids synthetic white cultivar Giza-2 and three-way cross white-24 (TWC-324) were generated and acquired from Egypt's Agricultural Research Center's (ARC) Maize Division, Experimental Farm of Gemmeiza Agriculture Research Station. The second factor included eleven soaking treatments of maize hybrids seeds in some antioxidants and chitosan at various levels, i.e. control treatment; distilled water, soaking in 100, 150 and 200 ppm of ascorbic acid (AA); 100, 150 and 200 ppm of salicylic acid (SA); and 0.25, 0.50 and 0.75 % of chitosan. All grains were soaked for 12 hours.

Ascorbic acid (AA) and salicylic acid (SA) as antioxidants and chitosan were created by the Egyptian company El-Nasr Pharmaceutical Chemicals Co., using materials from El-Gomhouria Company for Trading Pharmaceutical Chemical & Medical. Poly-(1.4-B-D-glucopyranosamine; 2-Amino-2-deoxy-(1-4)-B-D-glucopyranose, also known as chitosan powder, was created by properly dilution in 5% acetic acid solution.

400 random seeds for each treatment were planted in sterile Petri plates on top of filter paper (14 cm diameter). According to the regulations of the International Seed Testing Association, the Laboratory for Seed Testing in the Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt, will assess four Petri dishes that each contain 25 grains as if they were one Petri dish containing 100 seeds during the first week of May 2022. (ISTA, 1996). Every day, dishes were checked, and distilled water was added as necessary. After the radical has pierced the coleorhiza and the seed has grown to a length of about 2 to 3 mm, it is said to have physiologically germinated. The number of seeds that germinated on the fourth day was the initial count of the germinated seeds. Once the germination test was complete, the number of seeds germinating every 24 hours was tallied (7 days). According to ISTA (1996), seeds were divided into three categories: viable (abnormal, dead, or diseased seeds), complex (no imbibitions or swelling), and germinated (radical 2 mm long).

- Seedling characters:

Ten seedlings were randomly chosen from each treatment to estimate the following parameters; Radical length (cm); Plumel length (cm); Seedling vigor index (SVI). It was computed using the formula presented by AbdulBaki and Anderson (1970):

$$\text{SVI} = \frac{(\textbf{radical + plumel length}) \times \textbf{Germination percentage}}{100}$$

Seedlings fresh weight (g). According to ISTA (1996), the weight of 10 new seedlings was recorded and reported in gram (g) each duplicate; Seedlings dry weight (g): After oven drying at 70 o C until consistent weight, the weight of 10 seedlings at random per replicate was recorded and reported in gramme (g) (Agrawal, 1986).

statistically analysis

Data were statistically analysed using the analysis of variance (ANOVA) approach for the factorial experiment in a randomised completely with four replications (Gomez and Gomez, 1984). The differences between treatment means at the 5% probability level were examined using the least significant difference (LSD) technique, according to Snedecor and Cochran (1980).

Results and Discussion

Maize hybrids performance:

Three maize hybrids under study (SC-2031, Giza-2, and TWC-324) considerably varied in the seedling characteristics of radical length, plumel length, seedling vigour index (SVI), and seedling fresh and dry weight. The highest means of radical & plumel length, seedling vigor index (SVI) and seedling's fresh & dry weight were recorded from sown SC-2031 hybrid (Table 1). The second-best values of radical length, plumel length, SVI, fresh seedlings and fresh & dry weights resulted from sown synthetic cultivar Giza-2. However, the lowest values of radical & plumel length, seedling vigor index (SVI), and fresh & dry weights were produced from sown TWC-324

hybrid. The differences among studied maize hybrids in seedlings parameters of maize seedlings might be due to genetically vertical differences. These findings are in solid accord with those that were Al-Fahd (2017), Zalama and Kishk (2017), Kandil *et al.* (2019 b), Yagiz and Konuskan (2020) and Al-Omairi and Al-Hilfy (2021).

Effect of soaking treatment with some antioxidants and chitosan at various levels:

Regarding soaking treatment of maize hybrids seeds in some antioxidants and chitosan at various levels *i.e*. without soaking; soaking in distilled water; 100, 150 and 200 ppm of AA; 100, 150 and 200 ppm of SA and 0.25, 0.50 and 0.75 % of chitosan for 12 hours before germination test, the obtained results of this study indicated that there was a significant difference in radical length, plumel length, SVI and seedlings fresh & dry weights among all studied soaking treatment in some antioxidants and chitosan at various levels and the control treatment (untreated grains) as shown in Table 1.

Soaking maize seeds in AA at 200 ppm before starting the germination test resulted in the highest means of radical & plumel lengths, SVI and seedling's fresh & dry weight. However, soaking maize seeds in AA at the rate of 150 or 100 ppm or SA at the rate of 100 ppm ranked after soaking maize seeds in ascorbic acid at the rate of 200 ppm (Table 1). Further soaking seed treatments were applied in the following order, decreasing intensity: salicylic acid (150 ppm) > salicylic acid (200 ppm) > distilled water > without (untreated "control treatment") > chitosan (0.75 %) > chitosan (0.50 %). Whilst, the lowest means of radical & plumel lengths, SVI and seedlings fresh & dry weight were resulted from soaking maize seeds in chitosan at the rate of 0.25 %.

Ascorbic acid-associated enzyme (ascorbate peroxidase), which plays a variety of roles such as the germination process, may be responsible for the useful effect of soaking seeds in (AA) prior to beginning the germination test on seedlings parameters. Additionally, it increased tocopherol synthesis, which guards the plant from being programmed.

Table 1. Radical & plumel lengths, seedling vigour index (SVI), seedling fresh & dry weights of maize as impacted by hybrids, soaking treatment with certain antioxidants and chitosan at various doses, and their interaction.

Characters / Treatments	Radical length (cm)	Plumel length (cm)	Seedling vigor index (SVI)	Seedlings fresh weight (g)	Seedlings dry weight (g)
A- Maize hybrids					
SC-2031	10.41	8.01	15.35	7.06	0.647
Giza-2	7.73	7.79	12.13	7.04	0.457
TWC-324	6.00	6.21	10.47	5.01	0.389
F. test	*	*	*	*	*
LSD at 5 %	0.72	0.75	1.01	0.45	0.037
B- Soaking treatment with some antioxidants and chitosan at various levels:					
Without	9.03	7.80	11.70	7.33	0.523
Distilled water	9.26	8.57	12.56	7.42	0.525
Ascorbic acid (100 ppm)	10.13	8.97	16.99	7.48	0.582
Ascorbic acid (150 ppm)	10.27	9.03	18.52	7.51	0.596
Ascorbic acid (200 ppm)	10.77	9.05	19.39	7.90	0.681
Salicylic acid (100 ppm)	10.15	9.05	18.52	7.78	0.610
Salicylic acid (150 ppm)	9.67	8.90	16.80	7.47	0.598
Salicylic acid (200 ppm)	9.65	8.80	14.99	7.44	0.587
Chitosan (0.25 %)	1.12	1.55	0.54	1.26	0.114
Chitosan (0.50 %)	2.17	2.58	1.58	2.57	0.218
Chitosan (0.75 %)	6.25	6.75	7.57	5.92	0.436
F. test	*	*	*	*	*
LSD at 5 %	1.38	1.16	1.95	0.86	0.071
C- Interaction (F. test)					
A × B	*	*	*	*	*

Cell death may also be responsible (Conklin and Barth, 2004). Salicylic acid also controls many biological processes in plants, including the photosynthesis process, nitrogen metabolism, antioxidant defence system, and protection from abiotic stressors (Khan *et al.,* 2015). These outcomes are quite consistent with those that were by Eisvand *et al.* (2015), Kandil *et al.* (2015 a), Nimir *et al.* (2015), Chi *et al.* (2021), Kandil *et al.* (2019 b) and Kadhim and Hamza (2021). On the other hand, Al-Omairi and Al-Hilfy (2021) observed that soaking maize seeds in chitosan-containing solutions at 100 and 500 mg L-1 did not produce any appreciable effect.

Effect of interaction

The obtained results of this investigation indicated that there was a significant effect due to the interaction between maize hybrids and soaking treatment with some antioxidants and chitosan at various levels on Radical length, plume length, seedling vigour index (SVI), and seedlings' fresh and dry weights are the criteria for seedlings. They are all included in Table 1. The statistical analysis of obtained data showed that the highest means of radical length (Fig. 1), plumel length (Fig. 2), seedling vigor index (Fig. 3) and seedlings fresh (Fig. 4) as well as dry weight (Fig. 5) were resulted from soaking maize SC-2031 hybrid seeds in (AA) at the rate of 200 ppm or (SA) at the rate of 100 ppm. Soaking maize SC-2031 hybrid seeds in (AA) at the rate of 150 ppm or (SA) at the rate of 150 ppm ranked after previously mentioned interaction treatments and followed by soaking maize SC-2031 hybrid seeds in (AA) at the rate of 100 ppm or (SA) at the rate of 200 ppm. On the contrary, the lowest means of radical & plumel lengths, SVI and seedling's fresh & dry weight were obtained when soaking maize TWC-324 hybrid seeds in 0.25 % of chitosan for 12 h.

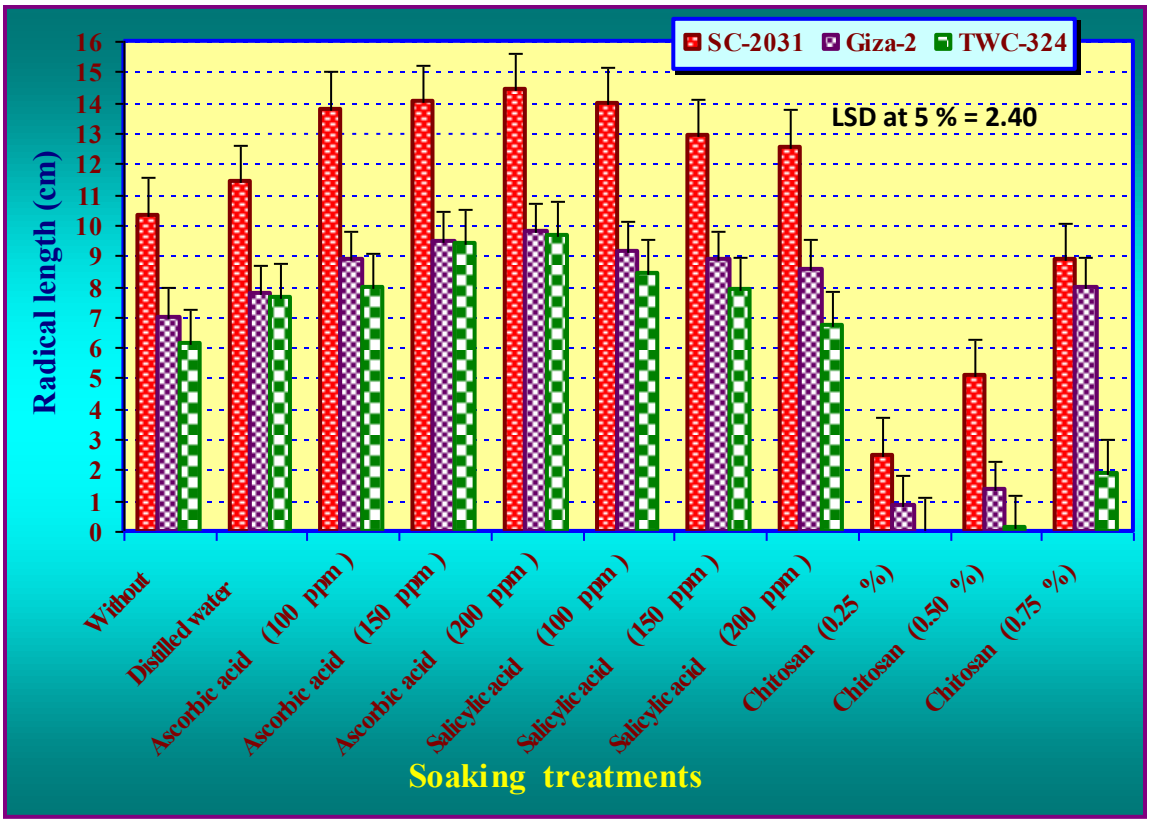

Figure 1. Radical length (cm) of maize seedlings as affected by the interaction hybrids and soaking treatment with some antioxidants and chitosan at various levels.

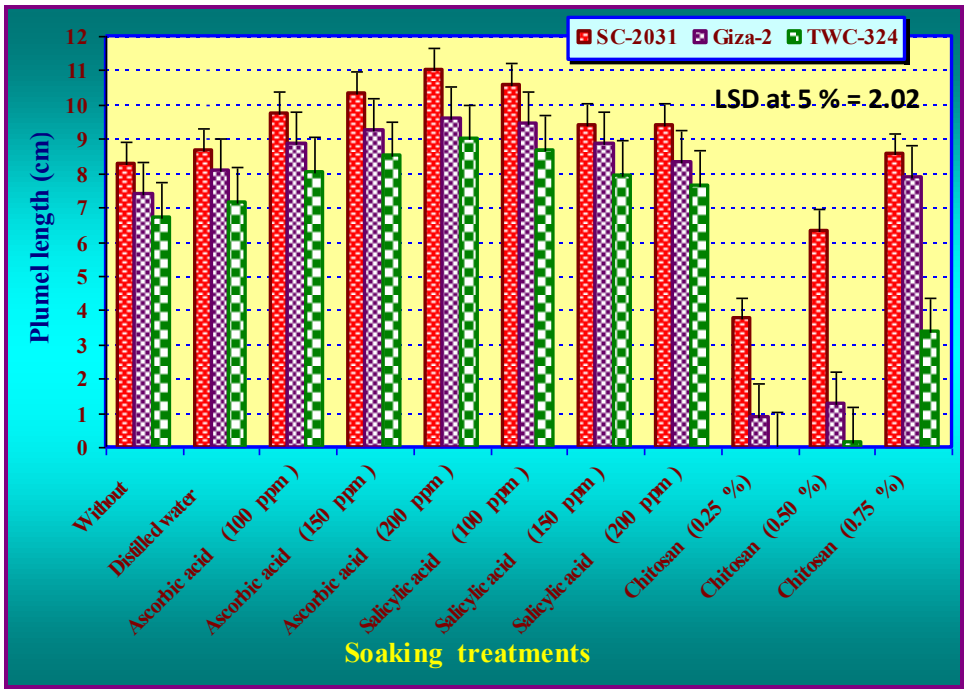

Figure 2. Plumel length (cm) of maize seedlings as influenced by the interaction of certain antioxidants with chitosan at different concentrations during soaking treatment.

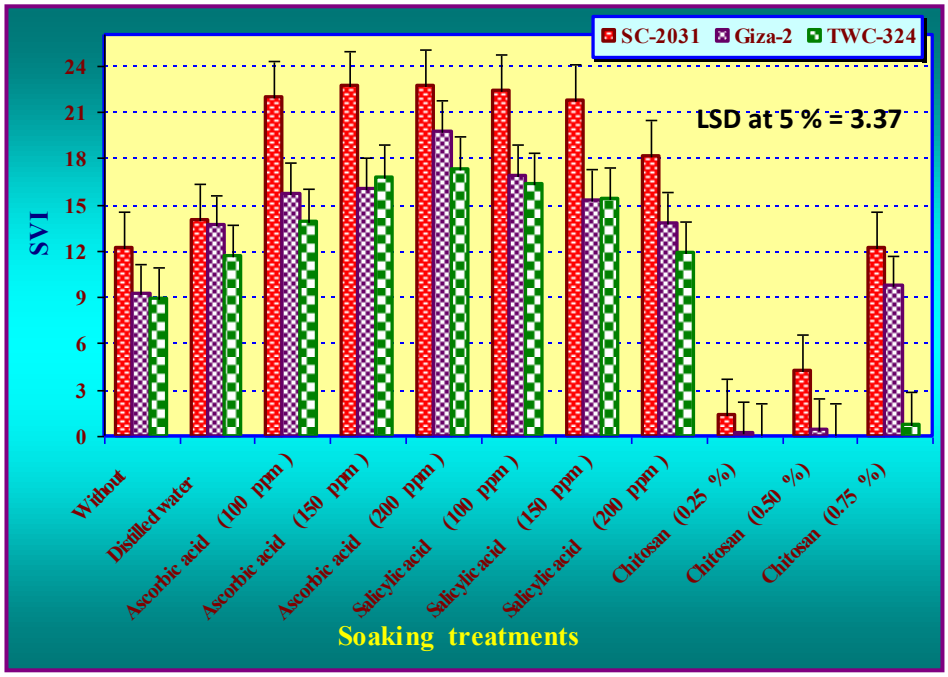

Figure 3. The interaction between hybrids and soaking treatment with some antioxidants and chitosan at various levels influences the SVI of maize.

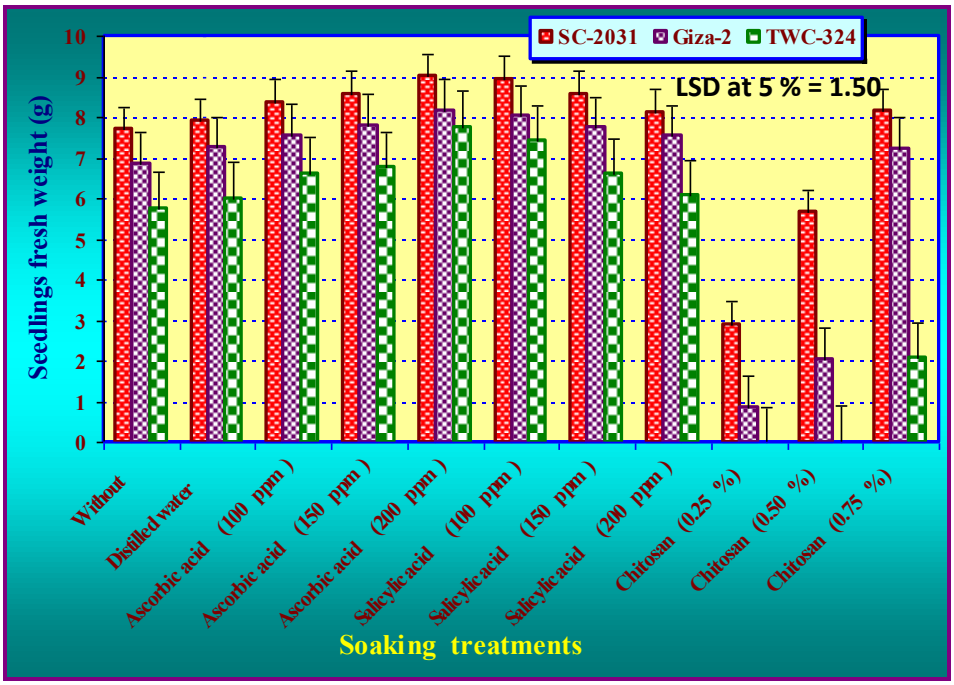

Figure 4. The seedling's fresh weight (g) of maize is affected by the interaction between hybrids and soaking treatment with some antioxidants and chitosan at various levels.

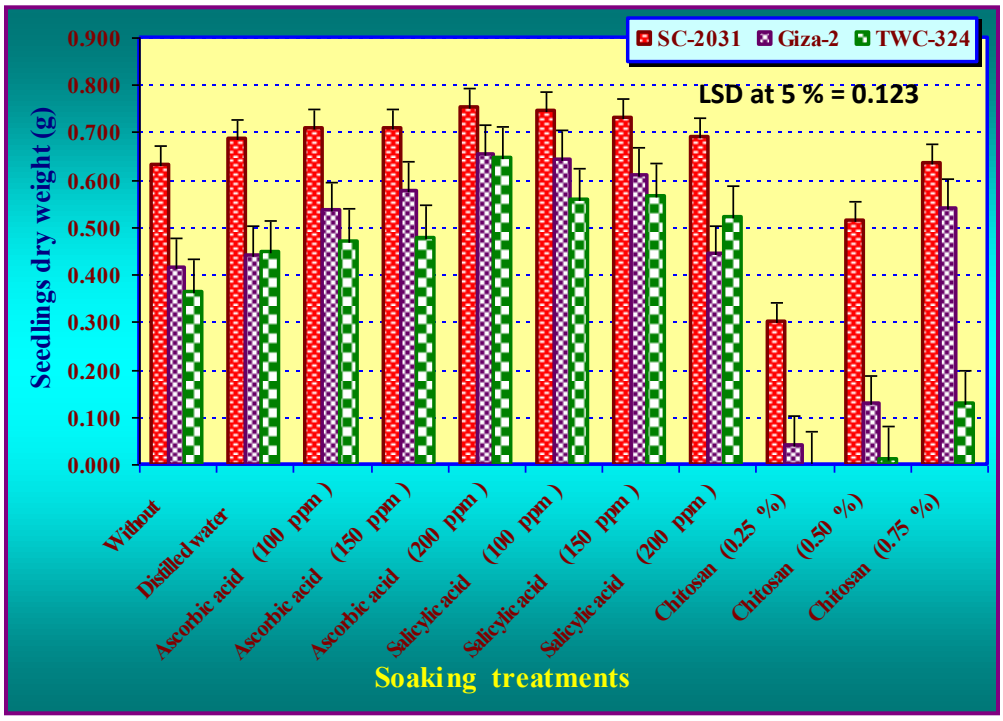

Figure 5. The seedling's dry weight (g) of maize is affected by the interaction between hybrids and soaking treatment with some antioxidants and chitosan at various levels.

Conclusion

Regarding the soaking treatment of maize hybrids seeds in some antioxidants and chitosan at various levels, *i.e*. without soaking; soaking in distilled water; 100, 150 and 200 ppm of AA; 100, 150 and 200 ppm of SA and 0.25, 0.50 and 0.75 % of chitosan for 12 hours before germination test, the obtained results of this study indicated that all germination parameter significantly increased due to seed soaking of maize SC-2031 hybrid seeds for 12 hours in either salicylic acid (SA) at 100 ppm or ascorbic acid (AA) at 200 ppm.

References

Abdul-Baki, A. A., & Anderson, J. D. (1970). Viability and leaching of sugars from germinating barley1. *Crop science*, 10(1), 31-34.

Abido, W. A. E., Dhurgham, S., Altai, K., Zsombik, L., Hadházy, Á., Allem, A., & Dulai, S. (2021). Pretreatment of seed with hydrogen peroxide for mitigating salt stress of some hungarian wheat landraces at seedlings stage. In *IOP Conference Series: Earth and Environmental Science (Vol. 923, No. 1, p. 012062).* IOP Publishing.

Abido, W. A. E., & Zsombik, L. (2018). Effect of water stress on germination of some Hungarian wheat landraces varieties. *Acta Ecologica Sinica*, 38(6), 422-428.

Abido, W. A. E., & Zsombik, L. (2019). Effect of salinity on germination characters and seedlings parameters of Egyptian flax cultivars growing in Nyiregyhaza. *Acta Ecologica Sinica*, 39(1), 102-108.

Agrawal, P.K. (1986). Seed vigor: Concepts and Measurements. In: Seed Production Technology (Ed. J.P. Srivastava and L.T. Simarsk), *ICARDA, Aleppo, Syria pp: 190-198*.

Akram, N. A., Shafiq, F., & Ashraf, M. (2017). Ascorbic acid-a potential oxidant scavenger and its role in plant development and abiotic stress tolerance. *Frontiers in plant science*, 613.

Al-Fahd, A. J. A. (2017). Effect of storage period and seed size on growth, yield and quality of maize cultivars. Ph.D. Thesis. Dept. of Field Crops, College of Agriculture., University of Anbar.

Al-Omairi, A. A., & Al-Hilfy, I. H. (2021). Effect of soaking maize seeds with selenium and chitosan on improving germination, vigour and viability of seed and seedling. In *IOP Conference Series: Earth and Environmental Science*, 904(1), 012075). IOP Publishing.

Chi, Y. X., Yang, L., Zhao, C. J., Muhammad, I., Zhou, X. B., & De Zhu, H. (2021). Effects of soaking seeds in exogenous vitamins on active oxygen metabolism and seedling growth under low-temperature stress. *Saudi Journal of Biological Sciences*, *28*(6), 3254-3261.

Conklin, P.L. & Barth C. (2004). Ascorbic acid, a familiar small molecule intertwined in the response of plants to ozone, pathogens and the onset of senescence. *Plant Cell Environment,* 27, 959–971.

Eisvand, H. R., Fathi, N., & Goudarzi, D. (2015). Effects of some PGRs on seedling emergence and CAT and POD activity of maize under low temperature stress. *Iranian Journal of Plant Physiology*, 5(3), 1393-1402.

Gomez, K.A. & Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. 2nd Ed., Jhon Wiley and Sons Inc., New York, pp: 95-109.

International Seed Testing Association "ISTA" (1996). International Rules for Seed Testing. *Seed Science and Technology*, 21, 25-254.

Kadhim, J. J., & Hamza, J. H. (2021). Effect of maize seeds soaking with acids of ascorbic, citric and humic on field emergence. *The Iraqi Journal of Agricultural Science*, 52(4), 971-976.

Kandil, A. A., Sharief, A. E., Seadh, S. E., & Al-Hamery, J. J. K. (2015). Maize seedlings characters as affected by soaking in some natural and artificial substances. *International Journal of Advanced Research in Biological Sciences,* 2(5), 126-138.

Kandil, A. A., Sharief, A. E., & Ahmed, M. H. (2019). Effect of antioxidant and growth hormones on seedling parameters of new and aging seed of some maize hybrids. *Global Advance Research journal of Agricultural Sciences,* 8(3), 114-125.

Khan, M. I. R., Fatma, M., Per, T. S., Anjum, N. A., & Khan, N. A. (2015). Salicylic acid-induced abiotic stress tolerance and underlying mechanisms in plants. *Frontiers in plant science*, *6*, 462.

Nimir, N. E. A., Lu, S., Zhou, G., Guo, W., Ma, B., & Wang, Y. (2015). Comparative effects of gibberellic acid, kinetin and salicylic acid on emergence, seedling growth and the antioxidant defence system of sweet sorghum (*Sorghum bicolor*) under salinity and temperature stresses. *Crop and Pasture Science*, 66(2), 145-157.

Peykani, L. S., & Sepehr, M. F. (2018). Effect of chitosan on antioxidant enzyme activity, proline, and malondialdehyde content in *Triticum aestivum* L. and *Zea maize* L. under salt stress condition. *Iran. J. Plant Physiol*, *10*,(1) 2661-2670.

Snedecor, G. W. & Cochran, W. G. (1980). Statistical Methods. 7Th Ed. Iowa State University Press, Iowa, USA., PP. 507.

Terry, L.A. & Joyce, D.C. (2004). Elicitors of induced disease resistance in postharvest horticultural crops: a brief review. *Postharvest Biology and Technology*, 32, 1-13.

Tiryaki, I., & Andrews, D. J. (2001). Germination and seedling cold tolerance in sorghum: I. Evaluation of rapid screening methods. *Agronomy Journal*, 93(6), 1386-1391.

Yagiz, A. & Konuskan, O. (2020). Germination characteristics of maize seeds harvested at different maturity in accelerated aging tests. *Fresenius Environ. Bulletin,* 29(9A), 8047-8052.

Zalama, M. T., & Kishk, A. M. S. (2017). Evaluation of seed germin ability and field emergence of some maize (*Zea mays*, L.) Hybrids Under Salinity Stress Conditions. *Journal of Plant Production*, 8(5), 649-656.