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GERMINATION PARAMETERS ENHANCEMENT OF MAIZE GRAIN WITH SOAKING IN SOME NATURAL AND ARTIFICIAL SUBSTANCES

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Abstract- Two laboratory experiments were conducted at Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt, during May 2014 to enhance germination parameters of grain maize hybrid TWC 352 of both old and new harvested grains by soaking in different times in some natural and artificial substances. Every grain types experiment was carried out in factorial experiment in completely randomized design (CRD). The results revealed that new harvested maize grains significantly exceeded old harvested maize grains in most germination parameters. Soaking maize grains in ascorbic acid (AA) at the rate of 100 ppm significantly increased germination parameters. Highest germination parameters were produced from soaking maize grains in different substances for 18 hours. In order that maximize germination parameters of both old or new harvested grains maize hybrid TWC 352, it could be recommended that soaking grains in antioxidant substances such as ascorbic acid or citric acid or salicylic acid or natural substances such as yeast extract at the rate of 100 ppm of each one for 18 hours.

Keywords- Maize, Soaking treatments, GA_3, IAA, Salicylic acid, Ascorbic acid, Citric acid, Yeast extract, Times of soaking, Germination parameter

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Introduction

In Egypt, maize is considered as one of the main cereal crops, comes the third after wheat and rice. A great attention should be paid to raise maize productivity either by increasing the cultivated area or maximizing yield per unit area in order to reduce the gap between its production and consumption.

It is unquestionable that proper seed treatment measures can substantially improve the quality of seed and significantly increase the yield. Farmer's saved seeds provide lower germination rate, however, upon treatment significant increase in seed germination rate. It indicates that there is a scope of up gradation of farmers to saved seeds through treatment.

Seed germination and rapid germination are essential processes in seedling establishment. Seed soaking technique have been used to increment germination, improve germination uniformity, enhancing seedling establishment and encourage vegetative growth in more field crops such as maize [1]. The successful soaking process in the natural and artificial substances was depend on the time was taken.

Gibberellic acid (GA_3) is the most important growth regulator, which breaks seed dormancy, encourages germination, intermodal length, hypocotyls growth and cell division in cambial zone and increases leaves size. GA_3 stimulates hydrolytic enzymes that are needed for the degradation of the cells surrounding the radicle and thus speeds germination by promoting seedling elongation growth of cereal seeds [2]. Indole acetic acid (IAA) is the common natural auxin that shows all auxin doing actions and extensively affects plant's physiology and seed germination [3]. Anosheh et al. [4] found that seed priming with optimal concentrations of plant growth hormones (IAA, GA_3, abscisic acid, and ethylene) has proven that germination performance as well as growth and yield of many crop species under both normal and stress conditions could be improved effectively.

Salicylic acid (SA) is considered as a hormone like substance, which acting an important role in regulating a number of physiological processes such as ion uptake and transport, reserve of ethylene biosynthesis, transpiration, photosynthesis, nitrate metabolism, stress tolerance and plant growth [5]. Thus, application of SA stimulated tolerance in plants to many biotic and abiotic stresses chilling, salinity, drought and heat [5]. Tonel et al. [6] found that the salicylic acid (SA) application has minimized damages induced by salt stress to maize seed germination by favoring their germination percent. On the other hand, without SA was not able on maintaining seed viability.

Ascorbic acid (AsA) is one of the most important antioxidant at cellular processes including cell division and expansion, and at metabolism activity when germination started [7], cell detoxification, protecting cell from reactive oxygen species and preventing death cell [8]. Pre-sowing treatment with ascorbic acid is widely used and improves performance and stand establishment at different external factors such as high salinity [9].

Citric acid is widely used as an antioxidant and as an acidifier in food and drinks especially in lemonade, but also in for example confectionery, desserts, meat products and baby food. Citric acid is an organic compound belonging to the family of carboxylic acids. It presents in practically all plants. It is one of a series of compounds involved in the physiological oxidation of fats, proteins and carbohydrates to CO_2 and water [10].

Yeast is natural source of cytokinins and has stimulatory effects on plants [11]. Furthermore, yeast extract was recommended to participate in a beneficial role on cell division and extension, protein and nucleic acid synthesis and chlorophyll formation [12].

Thus, this investigation was established to enhance grains germination of grain maize hybrid TWC 352 of both old and new harvested parameters by soaking in different times in some natural and artificial substances.

Materials and Methods

This investigation was conducted at Agronomy Department Laboratory of Seed Testing, Faculty of Agriculture, Mansoura University, Egypt, during May 2014. The objective of this investigation was to enhance germination parameters of grain maize hybrid TWC 352 of both old and new harvested grains by soaking in different times in some natural and artificial substances. Grain maize hybrid TWC 352 of both old or new harvested grains) were produced and obtained from Experimental Farm of Gemmeiza Agriculture Research Station, Agricultural Research Center (ARC), Egypt.

Each type of maize grain of both old or new harvested grains was performed in separate experiment. Old harvested maize grains were resulted from 2012 growing season, whereas new harvested maize grains were resulted from 2013 growing season and both were examined for germination in May 2014.

Every experiment of grain types was carried out in factorial experiment in completely randomized design (CRD). The first factor included seven soaking grain treatments in some natural and artificial substances beside control treatment (untreated "without soaking") as follows:

- Soaking maize grains in distilled water.
- Soaking maize grains in gibberellic acid (GA_3-) at the rate of 100 ppm.
- Soaking maize grains in indol acetic acid (IAA) at the rate of 100 ppm.
- Soaking maize grains in salicylic acid (SA) at the rate of 100 ppm.
- Soaking maize grains in ascorbic acid (AA) at the rate of 100 ppm.
- Soaking maize grains in citric acid (CA) at the rate of 100 ppm.
- Soaking maize grains in yeast extract (YE) at the rate of 100 ppm.

Gibberellic acid (GA-) and indol acetic acid (IAA) as artificial growth regulators and salicylic acid (SA), ascorbic acid (AA) and citric acid (CA) as antioxidants were produced by El-Nasr Pharmaceutical Chemicals Co., Egypt, and obtained from El-Gomhouria Company for Trading Pharmaceutical Chemical & Medical.

Yeast extract (YE) as natural biostimulants was prepared by using a technique allowed yeast cells (pure dry yeast) to be grown and multiplied efficiently during conducive aerobic and nutritional conditions. Thus method allowed to produce denovo beneficial bioconstituent, (carbohydrates, sugars, proteins, amino acids, fatty acids, hormones, etc.), then these constituents could release out of yeast cells in readily form. Active dry yeast were dissolved in water at rate 1 g/L followed by adding sugar at ratio 1:1 and kept overnight for activation and reproduction of yeast and two cycles of freezing and thawing for disruption of yeast cells and releasing their content. Such technique for yeast preparation was modified by [13].

The second factor included three times of soaking treatments as follows:

- Soaking for 6 hours.
- Soaking for 12 hours.
- Soaking for 18 hours.

Standard Germination Test

Random sample of 400 grains per each treatment were sown on top filter paper in sterilized Petri-dishes (14 cm diameter). Each Petri-dish contain 25 grains, and four Petri-dishes kept close together and assessed as though they were one 100 - grains replication under the environmental conditions of Laboratory for Seed Testing in Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt at 14th May 2014 as the rules of International Seed Testing Association [14].

Dishes were inspected daily and distilled water added as required. Grains are considered physiologically germinated when the radical pierced the coleorhiza and reach approximately 2 to 3 mm long.

The germinated grains were counted and first count defined as the number of germinated grains at the fourth day. Then, every 24 hours the number of germinated grains were counted until end of germination test (7 days). Grains were categorized as germinated (radical 2 mm long), hard (no imbibitions or swelling) or nonviable (abnormal, dead or infected seeds) as described [14].

Germination Parameters

Final Germination Percentage (FG %): Normal seedlings of each replicate were counted after 7 days from planting and expressed as percentage according to the following equation described by [14]:

$$FG\% = \frac{\text{Number of normal seedlings}}{\text{Number of total grains}} \times 100$$

Speed Germination Index (SGI): It was calculated by following formula [14]:

$$SGI = \frac{\text{No. of germinated grains}}{\text{Days to first count}} + \frac{\ldots\ldots}{\ldots\ldots} + \frac{\text{No. of germinated grains}}{\text{Days to first count}}$$

Germination Index (GI): It was calculated according to the following equation [15]:

$$GI = \frac{\text{Germination percentage in each treatment}}{\text{Germination percentage in control treatment}}$$

Co-efficient of Germination (CG): It was calculated using the following formula according [16]:

$$CG = \frac{100(A_1 + A_2 + \ldots\ldots + A_n)}{A_1 T_1 + A_2 T_1 + \ldots\ldots + A_n T_n}$$

Where; A = Number of seed germinated, T = Time (days) corresponding to A, n = No. of days to final count.

Mean Germination Time (MGT): It was calculated based on the following equation of [17]:

$$MGT = \frac{\sum Dn}{\sum n}$$

Where (n) is the number of grains, which were germinated on day, D is number of days counted from the beginning of germination.

Energy of Germination (EG): It was the percentage of germinating grains at the first count (4 days after sowing) relative to the total number of tested grains [18].

Abnormal Seedlings Percentage (AS %): It was counted and expressed by the percentage of abnormal seedlings after 7 days according to [14].

Hard Grains Percentage (HG %): It was counted and expressed by the percentage of hard grains after 7 days according to [14].

Data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) for the factorial completely randomized design to each experiment (grain types), then combined analysis was done between grain types experiments as published by [19] by using "MSTAT-C " computer software package. Least significant of difference (LSD) method was used to test the differences between treatment means at 5 % level of probability as described by [20].

Results and Discussion

Effect of Old or New Type of Harvested Maize Grains

From obtained results in [Tables-1] & [Tables-2], it could be noticed that there were significant differences in germination parameters *i.e.* final germination percentage (FG %), speed germination index (SGI), germination index (GI), mean germination time (MGT), energy of germination (EG) and hard grains percentage (HG %) between types of maize grains of both old or new harvested grains. While, the differences in co-efficient of germination (CG) and abnormal seedlings percentage (AS %) did not reached level of significance at 5% due to types of maize grains (old or new harvested grains).

New harvested maize grains significantly exceeded old harvested maize grains in final germination percentage, speed germination index, germination index, mean germination time and energy of germination, which recorded the highest values of these characters and increased its by 2.72, 2.78, 2.19, 2.92 and 2.72 %, respectively as compared with old harvested maize grains. Whereas, Germinated new harvested grains of maize associated with the lowest percentage of hard grains (HG %), but germinated old harvested grains of maize accompanied with the highest percentage of HG %. The reduction in HG% due to using old or new harvested grains reached about 55.60%. The reduction in germination parameters as a result of using old harvested grains might be due to a series of metabolic defects which effects embryonic and non-embryonic parts of the grains [21], starting respiration and consequently decrease in grain matter, functional and nutritional properties of the grains [22] and also the decrease in total carbohydrate and increase in lipid peroxidation [23]. These results are in good accordance with those found by [22,24].

Table 1- Final germination (FG) percentage, speed germination index (SGI), germination index (GI) and co-efficient of germination (CG) as affected by types of maize grain, soaking grain treatments and times of soaking as well as their interactions.

Treatments	Final Germination (FG %)			Speed Germination Index (SGI)			Germination Index (GI)			Co-efficient of Germination (CG)		
	OG	NG	Com	OG	NG	Com	OG	NG	Com	OG	NG	Com
Soaking grain treatments												
Untreated (control)	79	83	81	4.98	5.13	5.05	0.999	1	0.999	24.56	24.7	24.63
Distilled water	88.6	91	89.8	5.53	5.67	5.6	1.096	1.122	1.109	24.95	24.95	24.95
Gibberellic acid (GA_3)	88.6	92.6	90.6	5.54	5.78	5.66	1.116	1.122	1.119	25	24.97	24.98
Indol acetic acid (IAA)	89.3	92	90.6	5.57	5.76	5.67	1.108	1.13	1.119	24.97	24.97	24.97
Salicylic acid (SA)	92.6	96	94.3	5.79	5.99	5.89	1.157	1.173	1.164	25	24.97	24.99
Ascorbic acid (AA)	97.6	99.3	98.5	6.1	6.2	6.15	1.197	1.236	1.216	25	25	25
Citric acid (CA)	95.3	96.6	96	5.95	6.04	6	1.165	1.206	1.185	25	25	25
Yeast extract (YE)	91	93.6	92.3	5.68	5.87	5.77	1.128	1.151	1.14	25	24.97	24.98
F. test	*	*	*	*	*	*	*	*	*	NS	NS	NS
LSD at 5 %	1.4	1.3	1	0.09	0.09	0.09	0.015	0.018	0.012	-	-	-
Times of soaking												
6 hours	88.4	91.4	89.9	5.52	5.71	5.61	1.101	1.119	1.11	24.97	24.95	24.96
12 hours	92.1	94.2	93.2	5.75	5.9	5.82	1.135	1.166	1.151	25	24.99	24.99
18 hours	95.1	97.7	96.4	5.94	6.1	6.02	1.177	1.204	1.19	25	25	25
F. test	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.9	0.8	0.6	0.06	0.06	0.04	0.01	0.012	0.007	0.03	0.03	0.02
Means of grain types	91.9	94.4		5.74	5.9		1.138	1.163		24.99	24.98	
F. test	*			*			*			NS		
C- Interactions (F. test)												
Grain types × Soaking treatments			NS			NS			*			NS
Grain types × Soaking times			NS			NS			NS			NS
Soaking treatments × Soaking times			*			*			*			*
Grain types× Soaking treatments × Soaking times			*			NS			*			NS

OG: Old grains; NG: New grains; Com: Combined

Table 2- Mean germination time (MGT), energy of germination (EG), abnormal seedlings (AS) percentage and hard grains percentage (HG %) as affected by types of maize grain, soaking grain treatments and times of soaking as well as their interactions.

Treatments	Mean germination time (MGT)			Energy of germination (EG)			Abnormal seedlings (AS) percentage			Hard grains percentage (HG %)		
	OG	NG	Com	OG	NG	Com	OG	NG	Com	OG	NG	Com
Soaking grain treatments												
Untreated (control)	20.25	20.75	20.5	75	79	77	9	8	8.5	13	8	10.5
Distilled water	22.16	22.75	22.45	88	90.3	89.1	6	4.66	5.33	6.33	3	4.66
Gibberellic acid (GA_3)	22.16	23.16	22.66	88.6	92.3	90.5	5.33	5	5.16	6.33	2.66	4.5
Indol acetic acid (IAA)	22.33	23.08	22.7	89	92	90.5	6	6.66	6.33	3.66	2	2.83
Salicylic acid (SA)	23.16	24	23.58	92.6	95.6	94.1	2.66	3.33	3	4	1.33	2.66
Ascorbic acid (AA)	24.41	24.83	24.62	97.6	99.3	98.5	0.33	0.66	0.5	1.66	0.33	1
Citric acid (CA)	23.83	24.16	24	95.3	96.6	96	2	1.66	1.83	2.66	1.33	2
Yeast extract (YE)	22.75	23.5	23.12	91	93.6	92.3	3.66	3.66	3.66	5.33	2.66	4
F. test	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.36	0.4	0.27	1.5	1.4	1	1.86	1.63	1.22	2.29	1.86	1.46
Times of soaking												
6 hours	22.1	22.89	22.5	88	90.8	89.4	6	5.28	5.64	6.28	2.85	4.57
12 hours	23.03	23.6	23.32	92.1	94.2	93.2	3.42	3	3.21	4.28	2.28	3.28
18 hours	23.78	24.42	24.1	95.1	97.7	96.4	1.71	2.71	2.21	2.28	0.57	1.42
F. test	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.23	0.26	0.18	1	0.9	0.6	1.22	1.07	0.8	1.5	1.22	0.95
Means of grain types	22.97	23.64		91.7	94.2		3.71	3.66		4.28	1.9	
F. test	*			*			NS			*		
C- Interactions (F. test)												
Grain types × Soaking treatments			NS			NS			NS			NS
Grain types × Soaking times			NS			NS			*			NS
Soaking treatments × Soaking times			*			*			NS			NS
Grain types× Soaking treatments × Soaking times			NS			NS			NS			NS

OG: Old grains; NG: New grains; Com: Combined

Effect of Soaking Grains Treatments

Regarding to soaking maize grains treatments in some natural and artificial substances *i.e.* soaking maize grains in distilled water, gibberellic acid (GA_3-), indol acetic acid (IAA), salicylic acid (SA), ascorbic acid (AA), citric acid (CA) and yeast extract (YE) at the rate of 100 ppm of each one, results clearly show that there was a significant differences in germination parameters *i.e.* final germination percentage (FG %), speed germination index (SGI), germination index (GI), mean germination time (MGT), energy of germination (EG), abnormal seedlings percentage (AS %) and hard grains percentage (HG %) among all studied treatments and control treatment (untreated grains) for old, new grains and combined between them [Tables-1] & [Tables-2]. On the other hand, co-efficient of germination (CG) insignificantly affected by soaking maize grain treatments before germination test in some natural and artificial substance for both old or new grains and combined data.

maize grains in antioxidant substances such as ascorbic acid (AA) at the rate of 100 ppm before starting germination test significantly increased final germination percentage (FG %), speed germination index (SGI), germination index (GI), mean germination time (MGT), energy of germination (EG) and resulted in the highest values, in addition increased these characters by (23.54, 19.64 and 21.60%), (22.49, 20.86 and 21.78%), (19.82, 23.60 and 21.72%), (20.54, 19.66 and 20.10%) and (30.13, 25.70 and 27.92%) as compared with the control treatment for both old or new grains and combined data, respectively.

However, soaking maize grains in antioxidant substances such as citric acid (CA) at the rate of 100 ppm ranked after aforementioned treatment and followed by soaking maize grains in salicylic acid (SA) at the rate of 100 ppm. The other soaking grain treatments could be arranged as follows; soaking maize grains in natural substances such as yeast extract (YE), indol acetic acid (IAA), gibberellic acid (GA_3), distilled water and untreated grains (control treatment) concerning its effect on FG %, SGI, GI, MGT and EG for old, new grains and combined data.

Soaking maize grains in ascorbic acid at the rate of 100 ppm before starting germination test significantly decreased abnormal seedlings percentage (AS %) and hard grains percentage (HG %) and resulted in the lowest percentages, by decreases estimated with (96.33, 91.75 and 94.12%) and (87.23, 95.88 and 90.48%) as compared with the control treatment for both old or new grains and combined data, respectively. The order of other soaking grain treatments concerning favourable effect on AS% and HG% was as follows; soaking in CA > soaking in SA > soaking in YE > soaking in IAA > soaking in GA_3 > soaking in distilled water > untreated (control treatment).

The favourable effect of soaking maize grains in ascorbic acid (AA) before starting germination test may be ascribed to ascorbic acid is consider as an important metabolite involved in many cellular processes, including cell division. In addition, ascorbic acid is utilized during the initial stages of germination by both zygotic and somatic embryos [25]. Besides, the desirable effect of citric acid may be owing its effective role in controlling seed-borne diseases and bacterial pathogens, also its antimicrobial properties resting primarily in the chelation of divalent cations [26]. In addition, the advantageous effect of salicylic acid may be due to salicylic acid significantly stimulated the activities of enzymes involved in germination [27]. The positive effects of applying yeast extract may be attributed to its stimulatory effect on cell division and enlargement, protein and nucleic acid synthesis [12]. The effective role of gibberellic acid (GA_3) in enhancing final germination percentage comparing with the control treatment may be due to GA_3 is the most important growth regulator, which breaks seed dormancy, promotes germination, intermodal length, hypocotyls growth and cell division in cambial zone. Moreover, GA_3 stimulates hydrolytic enzymes that are needed for the degradation of the cells surrounding the radicle and thus speeds germination by promoting seedling elongation growth of cereal seeds [2]. Finally, the efficient role of indole acetic acid (IAA) in enhancing final germination percentage comparing with the control treatment may be payable to indole acetic acid (IAA) is the common natural auxin that shows all auxin doing actions and extensively affects plant's physiology and seed germination [3]. These results are in good accordance with those reported by [28,29].

Effect of Times of Soaking

Times of soaking maize grain treatments before germination test in some natural and artificial substances at 6, 12 and 18 hours significantly affected all studied characters which were germination parameters *i.e.* final germination percentage (FG %), speed germination index (SGI), germination index (GI), Co-efficient of germination (CG), mean germination time (MGT), energy of germination (EG), abnormal seedlings percentage (AS %) and hard grains percentage (HG %) for both old or new grains and combined data [Tables-1] & [Tables-2].

Generally, increasing times of soaking significantly increased final germination percentage (FG %), speed germination index (SGI), germination index (GI), Co-efficient of germination (CG), mean germination time (MGT) and energy of germination (EG). Thus, the highest percentages of these characters were produced from soaking maize grains in different substances for 18 hours of both old or new grains and combined data. On the other hand, the lowest percentages of these characters were obtained when soaking maize grains in different substances for 6 hours of both old or new grains and combined data.

However, increasing times of soaking significantly decreased abnormal seedlings percentage (AS %) and hard grains percentage (HG %), consequently, the lowest percentages of these characters were resulted from soaked maize grains in different substances for 18 hours of old, new grains and combined between them. On the other direction, highest percentages of AS% and HG% were resulted from soaking maize grains in different substances for 6 hours of both old or new grains and combined data.

The favourable effect of increasing times of soaking maize grain treatments may be due to increase the quantity of soaking substances was obtained by grains, consequently shows best impact of these substances. These results in good agreement with those reported by [30].

Effect of Interactions

The results indicated that there was significant effect due the interaction between grain types X soaking grains treatments on germination index (GI). Highest GI values were resulted from soaking new harvested maize grains in ascorbic acid (AA) at the rate of 100 ppm [Fig-1].

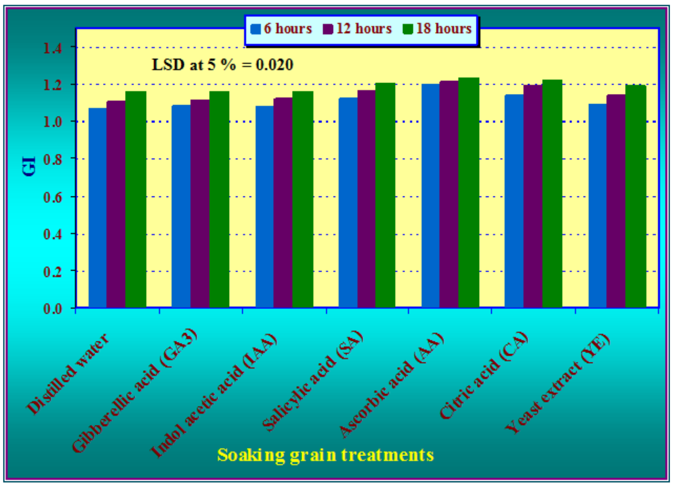

Fig. 1- Germination index (GI) as affected by the interaction between soaking treatments and times of soaking as combined over types of maize grains

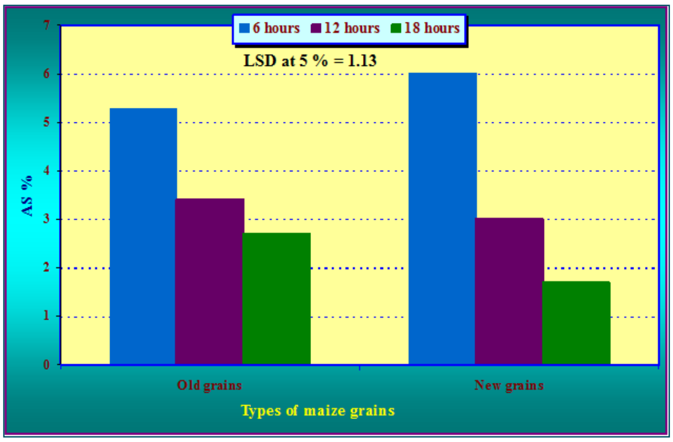

Fig. 2- Abnormal seedlings percentage (AS %) as affected by the interaction between types of maize grains and times of soaking as combined over soaking treatments

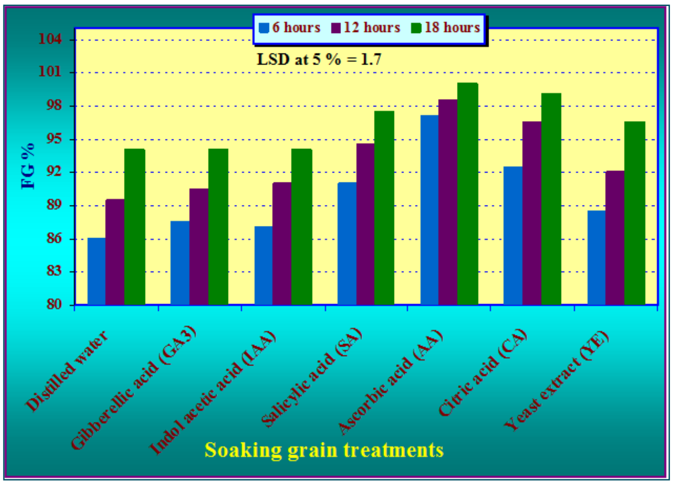

Fig. 3- Final germination percentage (FG %) as affected by the interaction between soaking treatments and times of soaking as combined over types of maize grains

Soaking new harvested maize grains in citric acid (CA) at the rate of 100 ppm ranked after previously mention interaction treatment, and followed by soaking new harvested maize grains in salicylic ascorbic acid (SA) at the rate of 100 ppm and then soaking old harvested maize grains in ascorbic acid (AA) at the rate of 100 ppm.

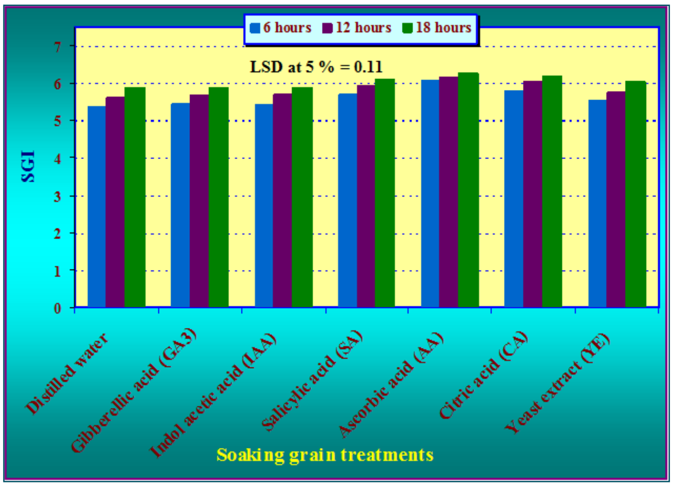

Fig. 4- Speed germination index (SGI) as affected by the interaction between soaking treatments and times of soaking as combined over types of maize grains

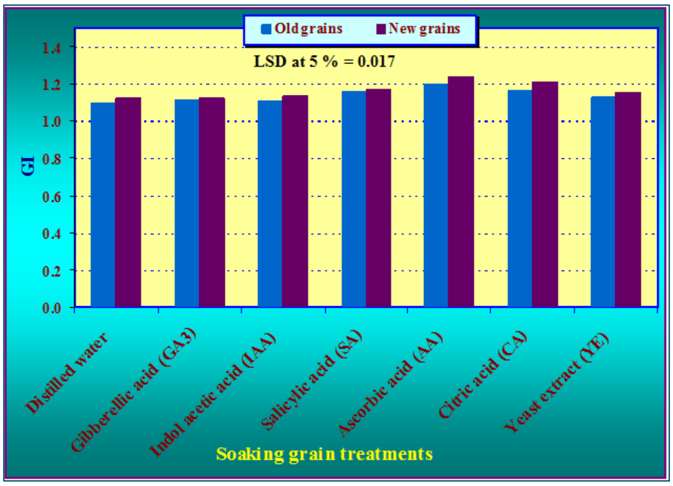

Fig. 5- Germination index (GI) as affected by the interaction between types of maize grains and soaking treatments as combined over times of soaking

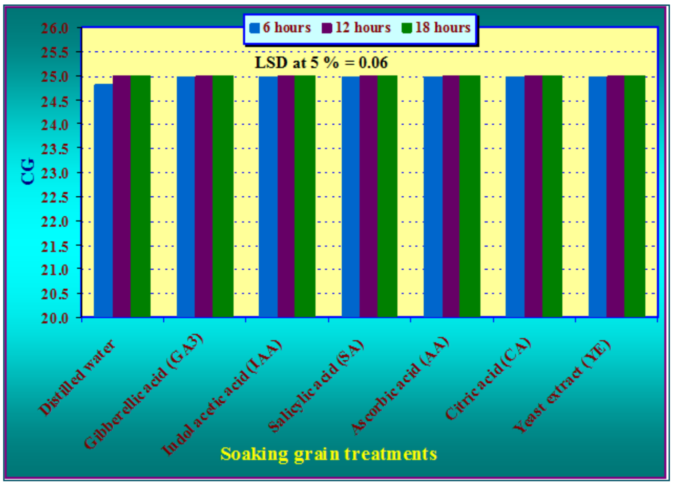

Fig. 6- Co. efficient of germination (CG) as affected by the interaction between soaking treatments and times of soaking as combined over types of maize grains

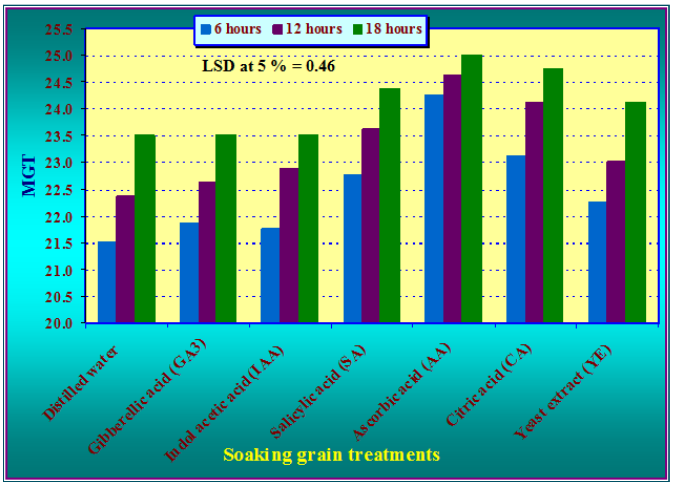

Fig. 7- Mean germination time (MGT) as affected by the interaction between soaking treatments and times of soaking as combined over types of maize grains

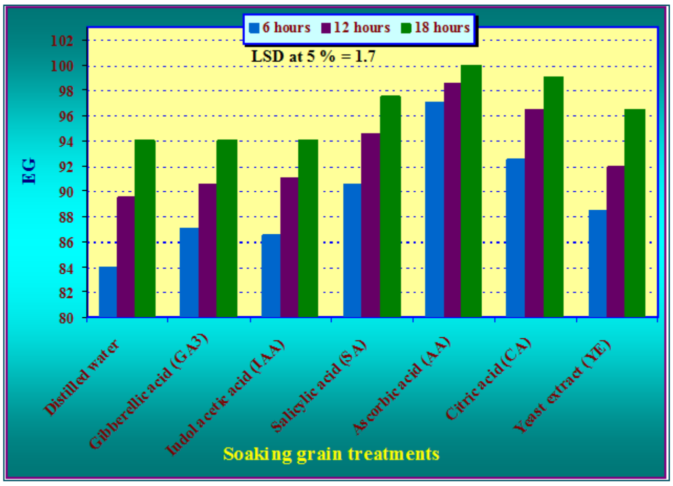

Fig. 8- Energy of germination (EG) as affected by the interaction between soaking treatments and times of soaking as combined over types of maize grains

The results showed that abnormal seedlings percentage (AS%) was significantly affected due to the interaction between grain types X soaking times. Highest AS percentages were resulted from soaking new harvested maize grains for 18 hours [Fig-2]. Soaking new harvested maize grains for 12 hours ranked after previously mention interaction treatment, and followed by soaking new harvested maize grains for 6 hours and soaking old harvested maize grains for 18 hours.

With respect to the effect of the interaction between soaking grains treatments X soaking times, it was significant on final germination percentage [Fig-3], speed germination index [Fig-4], germination index [Fig-5], Co-efficient of germination [Fig-6], mean germination time [Fig-7], energy of germination [Fig-8]. Soaking maize grains in ascorbic acid (AA) at the rate of 100 ppm for 18 hours resulted in the highest values of these characters. Soaking maize grains in citric acid (CA) at the rate of 100 ppm from 18 hours ranked after previously mention interaction treatment, and followed by soaking maize grains in ascorbic acid (AA) at the rate of 100 ppm from 12 hours.

Concerning to the interaction among grain types X soaking grains treatments X soaking times, it exhibited significant effect on final germination percentage [Fig-9] and germination index [Fig-10]. The highest values of these characters were obtained from soaking new maize grains in ascorbic acid (AA) at the rate of 100 ppm for 18 hours, followed by soaking new maize grains in ascorbic acid (AA) at the rate of 100 ppm for 12 hours. The third best interaction treatments was soaking new maize grains in CA at the rate of 100 ppm for 18 hours.

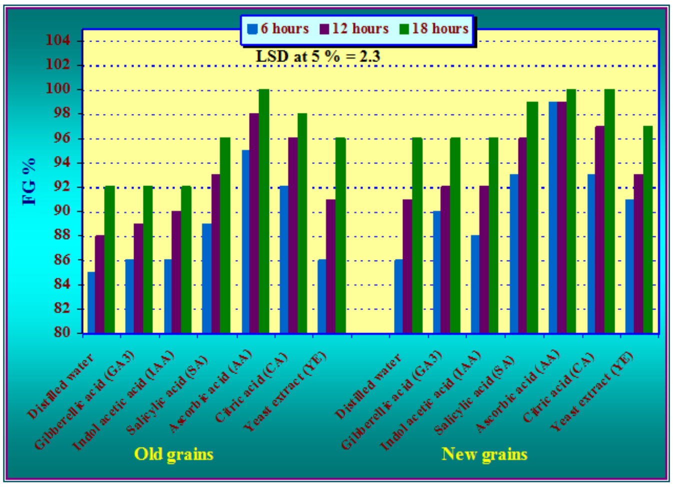

Fig. 9- Final germination percentage (FG %) as affected by the interaction among types of maize grains, soaking treatments and times of soaking

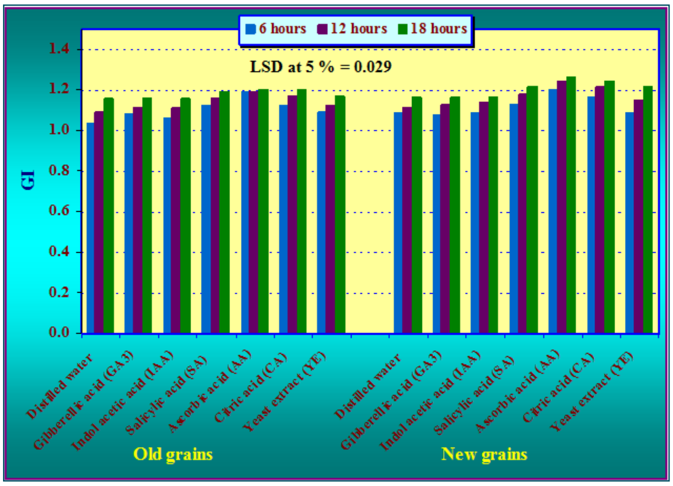

Fig. 10- Germination index (GI) as affected by the interaction among types of maize grains, soaking treatments and times of soaking

Conclusion

For maximizing germination and seedlings parameters of both old or new harvested grains maize hybrid TWC 352, it could be recommended that soaking in antioxidant substances such as ascorbic acid or citric acid or salicylic acid or natural substances such as yeast extract at the rate of 100 ppm of each one for 18 hours.

Conflicts of Interest: None declared.

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