Zagazig J. Agric. Res., Vol. 42 No. (4) 2015

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

INFLUENCE OF SEED TREATMENTS ON LABORATORY VIABILITY AND VIGOUR MEASUREMENTS AND FIELD EMERGENCE OF SOME MAIZE (*Zea mays* L.) GENOTYPES

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ABSTRACT

This investigation was conducted in both laboratory and under field conditions to study the effect of some seed treatments on germination and seedling growth and to determine the relationship between viability and vigour measurements as well as their relationship with field emergence for six maize genotypes namely Giza 2, Sc 10 and 128 and Twc hybrids 321, 323 and 324. The seed treatments were included control, soaking in water, GA3, ascorbic acid, osmopriming operation (PEG 8000), soaking in zinc solution and gamma irradiation treatment. Field emergence experiments were conducted during both testing seasons (2012 and 2013) at Kafr El- Hamam Research Station on May, 15th, for the two years. The results indicated that Giza 2 variety followed by hybrid Twc 321 recorded higher values of most viability and vigour measurements included germination (%), good seedling (%), seedling length, tetrazolium potential (1-5) (%), and field emergence (%). However, hybrid Sc 10 obtained higher germination (%) in cold test. Soaking corn seed in ascorbic acid improved vigour and viability measurements whereas gave the higher good seedling (%), seedling vigour index and seedling length, as well as GA3 recorded longer seedling. The higher field emergence (%) was obtained by control treatment, soaking in zinc solution, soaking in GA3, osmopriming operation and soaking in ascorbic acid while seed soaking in water gave the higher field emergence index. On the other hand, seed irradiated by gamma rays recorded lower values of most viability and vigour measurements and field emergence. Highly significant correlation were observed between field emergence of maize and each of germination (%), good seedling (%), TZ-potential (%), TZ energy (1-2) (%) and field emergence index, on contrary, it was insignificantly correlated with electrical conductivity and cold tests.

Key words: Germination%, field emergence, GA3, ascorbic acid, PEG, Gamma rays, seed vigour, seed viability, maize.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most useful emerging crops having wider adaptability under varied agro-climatic conditions (FAO, 2010). Globally, maize is known as queen cereals because it has the highest genetic yield potential among the cereals (Guzobenli, 2010). It is cultivated on nearly 150 million hectares (ha) in about 160 countries having wider diversity of soil, climatic, biodiversity and management practices that contributes 36% in the global grain production (FAO, 2010).

Seed testing is often the first step in enhancing seed quality. Standard germination test, tetrazolium test, cold germination test and electrical conductivity test used to estimate seed viability and vigour to predict field emergence in most crops under adverse field conditions spurred further investigation for a more appropriate vigour measurement (Miller and McDonald, 1975).

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Germination of each seed is considered as one of the first and most fundamental life stages of a plant so that, the success in growth and yield production is also depending on this stage. Seed germination is a critical process in the life cycle of higher plants. During germination, the imbibed mature seed is highly sensitive to different environmental factors. So, fast and uniform germination are as important for superior crop production as is total germination, while slow, asynchronous and unreliable germination and emergence due to low vigour seeds leads to problems for successful crop production (Matthews, 1980). Seed invigoration treatments have therefore, been developed to improve seed performance during germination and emergence. Such seed treatments include soaking in water, gibberellic acid, ascorbic acid and zinc solution, osmopriming operation and seed irradiation with gamma rays. These sowing treatments improve germination or seedling growth or facilitate the delivery of seeds and other materials required at the time of sowing.

Plant growth regulators are organic compounds, which are produced in very small amount in plants and play an important role in germination, seedling growth and development and yield of crops and are becoming quite popular in field of agriculture. Gibberellic acid (GA3) is the most important growth regulator, which breaks seed dormancy, promotes germination, intermodal length, hypocotyl growth and cell division in cambial zone and increases the size of leaves. GA stimulates hydrolytic enzymes that are needed for the degration of the cells surrounding the radical and thus speeds germination by promoting seedling elongation growth of cereal seeds (Rood *et al.*, 1990).

Siadat *et al.* (2011) showed that soaking maize seeds for 12 hr., in gibberellin solution gave good results for improvement of germination percentage of aged seeds and the highest germination (%) and shoot length was in control (non-aged) seeds treated for 12 hr., in 400 ppm gibberellin while, Ghodrat and Rousta (2012) revealed that Priming with GA3 had no effect on seed germination however in some concentrations, GA3 increased shoot length, root length, dry weight.

Mumiati (2010) indicated that ascorbic acid treatment improved germination percentage, speed of germination and vigor index, beside the increase in length of shoot. In addition, 55 mM ascorbic acid treatment increased seedling height, number of leaves but it had no effect on root length. However, germination percentage and speed of germination were significantly decreased by increasing of osmotic potential (PEG-6000).

Hesabi *et al.* (2014) found that the highest germination percentage was obtained from seeds primed with polyethylene glycol (PEG) while the least was obtained from hydropriming for maize seeds.

Borzouei *et al.* (2010) showed that root and shoot length and seedling dry weight decreased with increasing radiation doses but final germination percentage was not significantly affected by radiation doses.

Maiti *et al.* (2005) indicated that hybrids of maize showed a large variability in germination percentage on the 4th day (seed vigour), final count on the 7th day, final germination percentage and dry weight of a normal seedling on the 10th day (seedling vigour).

El-Abady *et al.* (2014) found that the standard germination, seedling measurements and seed vigor tests were significantly different in the studied maize hybrids lots. Highest correlations were observed between field emergence and standard germination followed by cold test.

Ali (1979) in his study on 20 seed lots of soybean found that the averages of TZ potential were 86.1, 75.3, 52.5 and 21.1% for EC grades A, B, C and D, respectively. The averages of TZ seed energy (vigour) were 67.1, 45.8, 26.7 and 8.6% for EC grades A, B, C and D, respectively.

The standard germination test was not a good indicator for field emergence percentage. However, cold and conductivity tests were the best predictor of field emergence than all the other laboratory tests (Aliloo and Shokati 2011).

El-Galfy (2005) indicated that standard germination, cold test and tetrazolium test were best correlated with field emergence. This suggested the importance of conducting some viability and vigour tests in addition to commonly used standard germination to predict field emergence of maize seeds.

The aims of the present study were to examine the effect of some seed treatments on germination and seedling growth under field conditions and viability and vigour laboratory tests for hybrid maize concerning local ecological conditions and genetic materials. Fertherthrough, evaluate several viability and vigour tests looking to determine the relationship between laboratory tests and field emergence and in turn to identify vigour test which could predict field emergence for maize crop.

MATERIALS AND METHODS

Maize Genotypes

Six genotypes included Giza 2 open pollenated variety, single cross (Sc) hybrids 10 and 128 and three way cross (Twc) hybrids 321, 323 and 324 were used in this investigation. Seed lots were produced during the two summer seasons of 2011 and 2012 which obtained annually from Agricultural Research center, Field Crops Research Institute.

Seed Treatments

Seeds of maize genotypes were obtained without protecting or stimulate treatments then, the following pre-sowing seed treatments were conducted:

T_1- Control (dry seed)

T_2- Soaking in water, seeds were soaked in 100 ml from distilled water under room temperature (25°–30°C) (Bennet and Waters, 1987).

T_3- Soaking in gibberellic acid, seeds were soaked in GA3 solution with concentration of 400 ppm (Siadat *et al.*, 2011).

T_4-Soaking in ascorbic acid, seeds were soaked in ascorbic acid (vitamin C) solution with concentration of 100 ppm for 24 hr., (Hassanein *et al.*, 2009).

T_5-Osmopriming operation, seeds were primed by solution of Polyethylene Glycol (PEG) 8000. The osmotic potential solution was -0.5 MPa (Khan *et al.*, 1992).

T_6-Soaking in zinc solution, seeds were soaked in zinc sulphate heptahydrate solution with concentration of 7 g / liter (Afzal *et al.*, 2005).

Seeds were soaked in all seed treatments for 24 hr., then, seeds were washed thrice with distilled water and redried to original weight with forced air under shade (Sundstrom *et al.*, 1987).

T_7-Gamma irradiation treatment, maize seeds were irradiated at the recommended dose level of (100 Gy) at National Center for Radiation Research and Technology, (NCRRT), Nasr City, Cairo, Egypt. Irradiation facility used was Indian Gamma Cell Research Irradiator ($^{60}C_O$).

Labortary Tests

Laboratory tests were conducted for two successive seasons during 2012 and 2013 years, standard germination, tetrazolium and cold tests were carried out at Seed Laboratory, Agronomy Department, Faculty of Agriculture, Zagazig University, while Electrical conductivity test was carried out at Laboratory of Seed Technology, Research Department at Giza, ARC.

Standard Germination Test and its Measurements

In an attempt to identify more precisely the differences in performance among samples, four sup replications of 25 seeds of each seed lot replicate were germinated in rolled paper towels at temperature 27±-1°C. Other procedures were made according to AOSA (1981). Normal seedling were counted after 5 and 8 days from planting and expressed as the percentage germination. At final count, germinated seeds, good seedlings percentages were determined. In addition, seedling growth measurements included, seedling length "cm" and seedling vigour index: was calculated using the following formula outlined by Ruan *et al.* (2002): Seedling vigour index = SDW X GP

Where

SDW= seedling dry weight, GP=germination (%)

Tetrazolium (TZ) test

TZ procedures, ratings for potential germination and TZ vigour or energy (1-2) consisted of classifying individual seeds on the basis of embryo soundness as explained by Grabe (1970).

A representative sample of 300 seeds in three replications, 100 seeds each were used to evaluate the TZ staining patterns of each genotype seeds. In preparation for the test, seeds were preconditioned overnight at 35°C in water moistened paper towels. Then, seeds were prepared by bisecting the seed embryo rough without separate the two halves and the seeds were covered by the TZ solution and kept in darkness at 35°C for six hours. The solution was then discarded and the seeds rinsed in water. The stained seeds were submerged in water after rinsing and then refrigerated until time of evaluation.

Each seed was classified into one of eight possible categories. Categories one to five inclusive represented potentially germinative seeds. Categories six to eight inclusive represented non-germinative seeds (TZ potential 1-5). Level of seed vigour (TZ 1-2) was obtained by totaling the number of seeds in categories one and two.

Cold test

Seeds were placed in soil boxes and watered up to 70% of soil saturation then kept at 5°- 10°C for 7 days. After this period the seeds were removed from the cold temperature, placed in conditions favorable to warmer temperature, *i.e.* normally 25°C for germination to occur. After 8 more days, the number of normal seedlings was counted according to Byrd and Delouche (1971).

Electrical conductivity test "EC"

Conductivity tests are based on the premise that as seed deterioration progresses, the cell membranes become less rigid and more water-permeable, allowing the cell contents to escape into solution with the water and increasing its electrical conductivity.

Conductivity was measured on samples of 100 seeds for each replicate in four sup replicates, 25 seeds each, according to the procedures outlined by (ISTA., 1999).

The seeds were weighed and placed in Erlenmeyer flaskes (250 ml) containing 200 ml of deionised water and covered by aluminum foil. The flasks were then placed in an incubator chamber at 25°C for 24 hours. The conductivity of seed steep water was measured immediately after the removal of samples from the incubator with apipette-type conductivity cell attached to a bulk conductivity meter. The seed conductivity values were expressed as µmhos/g.

Field Experiments

Field emergence

Seeds were treated before sowing and were planted on 15th May, during both 2012 and 2013 summer seasons. The seven seed treatments were sown in rows, 20 cm apart and 10 cm between seeds within the row. Three replications of one m^2 for each plot were applied in a split plot design during both seasons. Maize genotypes were assigned to the main plots. The sub plots included seed treatments. Field emergence was recorded after the 10th day from planting.

Furthermore, field emergence index (FEI) was evaluated at the 10th day after sowing. In field emergence index, the higher value, the better field condition until FEI=1.0, so that FE = SG (ideal).The producer used by Egli and Tekrony (1995 and 1996) according to the following formula:

$FEI = \frac{FE}{SG} X\ 100$ Where: FEI=field mergence index, FE = mean seedling field emergence, SG = mean standard germination.

Analysis of Variance

Split plot design with three replicates was used in field emergence experiment and Factorial completely randomized block design was used for laboratory tests. All collected data in each year were subjected to statistical analysis as prescribed by Snedecor and Cochran (1967) for comparison among means. Means having the same letters are not significantly different.

The combined analysis was made for the data of the two seasons. Before conducting a combined analysis, error variances were tested for homogeneity by using Bartlett test.

The important significant interactions between studied factors, regarding combined results would be tabulated and discussed following the main effects table and its discussion. Through interaction tables capital and small letters were used for comparison among means of rows and columns, respectively.

Comparison and correlation study

For the correlation study between seed viability and vigour tests as well as their relationships with field emergence results, the correlation coefficients among all possible test results and measurements were calculated.

RESULTS AND DISCUSSION

Laboratory Tests

Standard germination test (viability and vigour parameters)

Germination percentage

Germination percentages of maize genotypes and seed treatments in both years of investigation and its combined are presented in Table 1. Genotype results showed that TWC 321 variety and Giza 2 achieved higher germination percentages followed by TWC 323 as compared with other three genotypes. These results confirmed significantly during both years and the combined. These differences among maize genotypes could be attributed to genetical effects on germination potential of maize seed. In this connection, Maiti *et al.* (2005) indicated that maize hybrids showed a large variability in seedling traits studied included seeds germinated on the 4th day and germination percentage at the final count. Furthermore, El-Abady *et al.* (2014) found that seedling measurements were significantly different in the studied maize hybrids.

Respecting the influence of seed treatments on germination percentage, the results in Table 1 showed that control treatment gave higher germination (%) followed by soaking in ascorbic acid without significant differences. However, the lower germination percentages were recorded with irritiated seed and soaking in water treatments. Generally soaking corn seed in ascorbic acid appeared to be improved germination percentage (first year) and these results are in accordance with those reported by Mumiati (2010) and Ahmad *et al.* (2012) who concluded that early germination, emergence and seedling establishment were improved by seed priming with ascorbic acid. Also, Pauli and Stikler (1961) stated that germination of seed and final emergence were not affected by gibberllic acid treatment. On the other side, Siadat *et al.* (2011) showed that soaking corn seed in GA solution gave good results for improvement of germination percentage of aged seed. In addition, Soleimanzadeh (2013) showed that zinc sulphate alone or in combination with KH and KNO increased germination rate. Borzouei *et al.* (2010) indicated that germination percentage was not significantly affected by radiation doses.

The significant interaction effects between genotypes and seed treatments (Table 1-a) concerning the combined results indicated that Giza 2 and TWC 321 appeared to give higher germination percentages with control, soaking in ascorbic acid and osmopriming operation. However, TWC 323 achieved higher germination percentage with control and soaking in GA3 treatments. On the other direction, irradiated seed almost recorded lower germination percentages with most genotypes investigated. In this manner, Mabhaudhi and Modi (2010) reported that maximum germination percentage for both hybrid varieties of maize was achieved in the unprimed treatment.

Good seedling percentage

Good seedling percentages as a seed vigour measurements presented in Table 1. The results revealed highly significant differences during both years and the combined either among genotypes or seed treatments.

Giza 2 variety appeared to produce the highest good seedling % (49.26) which followed by TWC 321, SC 10, TWC 324 and SC 128 in descending order. On contrast, TWC 323 recorded the lowest good seedlings (%) (17.52). These results almost followed the same patterns of germination (%) (Table 1) indicated that maize genotypes differed significantly in viability and vigour potentiality which should be respecting in determine seeding rate or improved seed quality of lower vigour genotypes. These results are in a good connection with those reported by Maiti *et al.* (2005) and El-Abady *et al.* (2014).

Table 1. Germination (%) and good seedlings (%) of maize as influenced by genotype differences and seed treatments during two successive years (2012 and 2013) and their combined

Main effect and interaction	Germination (%)			Good seedlings (%)		
	1st year	2nd year	Combined	1st year	2nd year	Combined
Genotypes (G)						
Giza 2	95.47 b	95.85 a	95.66 a	48.76 a	49.76 a	49.26 a
SC 10	89.04 d	91.47 b	90.26 c	31.23 c	30.14 b	30.69 c
SC 128	86.76 e	92.33 b	89.54 c	23.78 e	27.33 c	25.56 e
TWC 321	97.28 a	94.71 a	96.00 a	34.61 b	30.95 b	32.78 b
TWC 323	96.61 ab	91.95 b	94.28 b	21.23 f	13.81 d	17.52 f
TWC 324	92.81 c	86.66 c	89.73 c	29.28 d	25.90 c	27.59 d
F- test	**	**	**	**	**	**
Seed treatments (S)						
Control	94.56 ab	96.33 a	95.19 a	35.72 b	24.27 c	30.00 d
Soaking in water	89.22 d	91.88 c	90.55 d	41.72 a	28.66 c	35.19 b
Soaking in GA3	93.33 bc	89.50 d	91.41 cd	34.72 b	25.16 d	29.94 b
Soaking in ascorbic acid	95.27 a	94.00 b	94.63 ab	35.83 b	44.44 a	40.13 a
Osmopriming operation	92.88 c	91.33 c	92.11 c	30.75 c	28.66 c	29.70 d
Soaking in zinc solution	93.61 bc	93.83 b	93.72 b	24.00 d	39.05 b	31.52 c
Gamma irradiation	92.61 c	88.27d	90.44 d	17.66 e	17.27 d	17.47 e
F- test	**	**	**	**	**	**
Interaction G x S	**	**	**	**	**	**

Table 1-a. Germination (%) of maize as affected by the interaction between maize genotypes and seed treatments (combined data)

Seed treatments / Genotypes	Control	Soaking in water	Soaking in GA3	Soaking in ascorbic acid	Osmopriming operation	Soaking in zinc solution	Gamma irradiation
	A	BC	BC	AB	AB	AB	C
Giza 2	97.66 a	95.00 a	94.83 a	96.33 ab	96.33 a	96.33 a	93.16 a
	A	CD	CD	BCD	BC	AB	D
SC 10	93.66 b	88.50 b	89.00 b	90.00 c	91.00 a	92.16 b	87.50 c
	AB	D	C	A	D	BC	B
SC 128	92.00 b	85.50 c	88.33 b	93.83 b	85.16 e	90.83 b	91.16 ab
	A	B	A	A	AB	A	B
TWC 321	97.66 a	93.66 a	96.33 a	97.83 a	95.33 ab	97.50 a	93.66 a
	A	BC	AB	B	C	B	D
TWC 323	98.50 a	94.16 a	96.00 a	95.00 b	92.00 c	95.83 a	88.50 c
	BC	EF	F	A	AB	CD	DE
TWC 324	91.66 b	86.50 bc	84.00 c	94.83 b	92.83 bc	89.66 b	88.66 bc

Concerning the effect of seed treatments on good seedlings (%), the results showed that soaking in ascorbic acid achieved the highest good seedling (40.13%) which followed by soaking in water, soaking in zinc solution and lastly both control and osmopriming operation treatments in descending order. However, irradiated seed gave the lowest good seedling (17.47%). In other words, soaking maize seed in ascorbic acid enhanced good seedling (%) which could be attributed to stimulate the early metabolic processes through germination stage resulted in vigour seedling. The results are in accordance with those reported by Mumiati (2010) and Ahmad *et al.* (2012) who suggests that seed priming with ascorbic acid may improve the speed of germination of maize seed and benefit seedling growth.

Finally the significant interaction effects between genotypes and seed treatments on good seedling (%) (Table 1-b) revealed that Giza 2 cultivar tended to produce higher good seedling (%) when soaked in ascorbic acid or untreated as dry seed. On the other direction, the lowest value of good seedling (7.66%) was obtained by TWC 323 when irradiated by gamma rays.

Seedling vigour index (SVI)

Seedling vigour index as a vigour measurement are given in Table 2. The obtained results revealed highly significant differences through years or the combined for either genotypes or seed treatments.

According to maize genotypes, higher values of SVI were given by Twc 323 and Twc 324 and Giza 2 variety without significant differences between those three maize genotypes. However, the lowest SVI (16.55) was produced by Sc 10 compared with other maize genotypes investigated. The results confirmed the superiority of Giza 2 variety in the most seed and seedling vigour measurements indicated its higher genetical potential in this respect compared with other genotypes investigated. In this connection Maiti *et al.* (2005) reported that maize genotypes showed large variability in seedling vigour index.

Concerning the influence of seed treatments on SVI, the results showed that seed soaking in ascorbic acid and control treatments appeared to record the higher values in this respect which followed by soaking in water and gamma irradiated seed treatments as compared with other seed treatments. However, the lowest SVI value (22.58) was recorded by seed soaking in GA3. These results almost followed the same patterns of a formermentioned seed vigour measurements confirmed the superiority of soaking seed in ascorbic acid in improve seed viability and vigour of maize. In this connection Stickler and Pauli (1961) indicated that treating wheat seed with GA3 reduced seedling vigour.

In respecting to the significant interaction effects between maize genotypes and seed treatments of SVI (Table 2-a), the results showed that Giza 2 variety gave higher values with control and soaking in ascorbic acid treatments while TWC 324 obtained higher SVI with control treatment. On the other direction, SC 10 appeared to recorded lower SVI values with the all seed treatments.

Seedling length "cm"

Seedling length of maize genotypes and seed treatments results indicated highly significant differences through both years and the combined as could be seen in Table 2.

Meanwhile, Giza 2 variety gave the longest seedling which followed by TWC 321 and SC 10 compared with other genotypes investigated (combined results). These results followed the same patterns of germination (%) (Table 1) stated the superiority of Giza 2 variety and TWC 321 on other maize genotypes respecting seed viability and vigour potentiality. The obtained results are in accordance with those reported by Molina *et al.* (1992).

Concerning the influence of seed treatments on seedling length of maize, longer seedlings were achieved by soaking seeds in GA3 (25.44 cm) and ascorbic acid (24.86 cm) followed by osmopriming operation (23.49 cm). At contrast, the shortest seedling of 19.56 cm was recorded by irradiated seeds by gamma rays. The favority of soaked seed in ascorbic acid was noticed in the most formermentioned viability and vigour measurements. In this connection, Wu and Peterson (1979) found that seed soaking in GA3 increased seedling length, while, Khodarahmpour (2012) showed that PEG decreased seedling length.

Table 1-b. Good seedlings (%) of maize as affected by the interaction between maize genotypes and seed treatments (combined data)

Seed treatments / Genotypes	Control	Soaking in water	Soaking in GA3	Soaking in ascorbic acid	Osmopriming operation	Soaking in zinc solution	Gamma irradiation
	A	B	B	A	C	C	D
Giza 2	65.00 a	49.33 a	50.66 a	66.50 a	41.50 a	38.83 a	33.00 a
	C	C	B	B	A	AB	D
SC 10	23.66 c	23.16 e	36.83 b	36.33 c	40.16 a	37.66 ab	17.00 b
	B	B	C	A	B	C	C
SC 128	27.33 b	28.83 d	21.83 e	34.66 c	26.75 c	21.50 e	18.00 b
	F	B	E	A	D	C	G
TWC 321	21.16 cd	43.00 b	26.00 d	56.50 b	30.16 b	35.00 b	17.66 b
	C	A	E	D	E	B	F
TWC 323	20.50 d	28.33 d	13.66 f	17.00 e	11.00 d	24.50 d	7.66 d
	D	A	BC	BC	C	B	E
TWC 324	22.33 cd	38.50 c	30.66c	29.83 d	28.66 bc	31.66 c	11.50 c

Table 2. Seedling vigour index and seedling length (cm) of maize as influenced by genotype differences and seed treatments during two successive years (2012 and 2013) and their combined

Main effect and interaction	Seedling vigour index			seedling length (cm)		
	1st year	2nd year	Combined	1st year	2nd year	Combined
Genotypes (G)						
Giza 2	27.05 b	28.90 b	27.97 ab	25.06 a	24.09 a	24.57 a
SC 10	16.82d	16.29 d	16.55 c	23.56 b	23.46 a	23.51 b
SC 128	24.77c	26.00 c	25.38 b	21.04 c	21.12 b	21.08 c
TWC 321	27.21b	25.61 c	26.41 b	23.92 b	24.39 a	24.16 ab
TWC 323	26.61 b	30.32 a	28.46 a	21.89 c	20.57 b	21.23 c
TWC 324	29.28 a	26.42 c	27.85 ab	21.53 c	21.35 b	21.44 c
F- test	**	**	**	**	**	**
Seed treatments (S)						
Control	28.44 a	27.76 b	28.10 a	23.48 bc	20.02 d	21.75 c
Soaking in water	26.28 b	24.52 c	25.40 b	19.78 d	23.48 bc	21.63 c
Soaking in GA3	22.64 d	22.52 c	22.58 c	28.58 a	22.30 d	25.44 a
Soaking in ascorbic acid	26.03 b	31.61 a	28.82 a	23.14 c	26.57 a	24.86 a
Osmopriming operation	24.00 c	24.00 c	24.00 bc	24.24 b	22.73 cd	23.49 b
Soaking in zinc solution	24.44 c	24.03 c	24.23 bc	19.93 d	23.92 b	21.92 c
Gamma irradiation	25.18 bc	24.70 c	24.94 b	20.69 d	18.43 e	19.56 d
F- test	**	**	**	**	**	**
Interaction G x S	**	**	**	**	**	**

Table 2-a. Seedling vigour index of maize as affected by the interaction between maize genotypes and seed treatments (combined data)

Seed treatments / Genotypes	Control	Soaking in water	Soaking in GA3	Soaking in ascorbic acid	Osmopriming operation	Soaking in zinc solution	Gamma irradiation
	A	AB	B	A	AB	AB	AB
Giza 2	31.48 a	28.25 a	23.83 a	29.02 b	27.27 ab	28.02 a	27.94 a
	A	A	A	A	A	A	A
SC 10	19.52 b	17.08 b	15.22 b	15.98 c	16.37 c	15.42 b	16.27 b
	A	AB	AB	AB	B	AB	AB
SC 128	28.37 a	24.90 a	23.70 a	26.30 b	22.73 b	25.11 a	26.56 a
	A	A	A	A	A	A	A
TWC 321	28.86 a	27.17 a	24.94 a	26.02 b	26.33 ab	26.30 a	25.27 a
	B	BC	C	A	C	C	BC
TWC 323	28.94 a	27.69 a	23.49 a	26.63 a	23.28 ab	23.87 a	25.34 a
	A	AB	B	AB	AB	AB	AB
TWC 324	31.42 a	27.32 a	24.29 a	28.96 b	28.02 a	26.69 a	28.27

Tetrazolium Results (TZ)

Tetrazolium potential (%) (1-5)

The TZ test was used as a rapid test to evaluate the differences among maize genotypes in terms of TZ- potential (1-5) and TZ-energy (1-2) (Table 3). TZ- potential represent seeds that are capable of producing normal seedling under favorable germination conditions as a viability test.

TZ-potential results revealed highly significant differences between maize genotypes in both years of investigation and the combined. Meanthrough, Giza 2 variety achieved the highest TZ-potential (97.33%) which followed by TWC 321 (96.00) and TWC 323 (94.00) compared with other maize genotypes which recorded lower TZ-potential of 93.33, 92.66 and 92.00% for SC 128, TWC 324 and SC 10 in the same following order concerning the combined results. These results almost followed the same patterns of other viability and vigour measurements former discussed indicated the superiority of Giza 2 variety in seed quality potential compared with other maize genotypes investigated. Varietal differences concerning TZ-potential were detected by El-Galfy (2005), Asiedu *et al.* (2007) and Eraky *et al.* (2010).

Tetrazolium energy (1-2)

Vigour percentages (Seed Energy (1-2) %) represent seeds that are reasonably soundbut show minor imperfections which considered capable of germination under a rather wide range of environmental conditions.

TZ-energy (1-2)% as a vigour test included the best two reasonably sound seed grades of maize genotypes are given in Table 3. The results showed highly significant differences through both years and the combined where likely, Giza 2 variety achieved the highest TZ-energy (1-2) (61.66%) which followed by SC 128 (30.16) and SC 10 (29.33), however, the lowest TZ (1-2) (24.50%) was recorded by TWC 323, concerning the combined results. Generally, TZ-energy (1-2) % was ranged from

Table 3. Tetrazolium potential (1-5) and Tetrazolium-energy (1-2) of maize genotypes during two successive years (2012 and 2013) and their combined

Genotypes	Tetrazolium potential (1-5) (%)			Tetrazolium-energy (1-2) (%)		
	1st year	2nd year	Combined	1st year	2nd year	Combined
Giza 2	97.33 a	97.33 a	97.33 a	69.33 a	56.0 a	61.66 a
SC 10	90.66 b	93.33 bc	92.00 c	30.66 cd	28.00 b	29.33 bc
SC 128	90.66 b	96.00 ab	93.33 c	33.00 c	27.33 b	30.16 b
TWC 321	98.00 a	94.00 bc	96.00 ab	37.33 b	17.00 c	27.16 c
TWC 323	95.33 a	92.66 cd	94.00 bc	33.33 c	15.66 c	24.50 d
TWC 324	95.33 a	90.11 d	92.66 c	29.33 d	25.00 b	27.16 c
F- test	**	**	**	**	**	**

29.33–69.33, 15.66–56.00 and 24.50–61.66% among maize genotypes in the both following years of investigation and their combined, respectively. Such wide range of the TZ energy indicated that maize genotypes varied much longer in the vigour potential which it might be due to the genetic structures differences beside their interactions with the environmental conditions throughout seed development and maturity. Likely, the results followed the same patterns of other viability and vigour measurements evaluated in this investigation. These results are in accordance with those reported by Eraky *et al.* (2010).

Cold test germination percentage

This seed vigour test was developed to provide a method of predicting the performance of seed lots when planted in early spring in cold, wet soils.

Cold-germination percentages of maize genotypes during two successive years and the combined are presented in Table 4. Meantrough, the results revealed highly significant differences among maize genotypes through years and the combined whears SC 10 had the higher cold germination percentage (88.66) which followed by TWC 321 (86.33) and Giza 2 variety (85.00), concerning the combined results. At contrast, TWC 323 and TWC 324 obtained the lower cold germination percentages as compared with other maize genotypes investigated. Therefore, wide range of variation could be noticed between maize genotypes which amounted to 61.33 – 90.66, 60.66 – 89.33 and 61.00 – 88.66 in the two following years and the combined in the same following order. The obtained results are in accordance with those reported by Aliloo and Shokati (2011), and Sulewska *et al.* (2014). However, Egli and Tekrony (1995) indicated that cold test varied from more than 80 % to near zero.

Electrical conductivity (EC) test "µs/g"

Electrical conductivity of maize genotypes during the two years and their combined are presented in Table 4. The presented data indicated highly significant differences among maize genotypes in both years and the combined where TWC 323 recorded the lower EC values of 2.886, 2.667 and2.776 µs/g through the two successive years and the combined, respectively. Giza 2 variety and TWC 321 gave middle values of EC, however the highest EC values of 8.544, 6.330 and 7.437 µs/g were recorded by SC 10 during both years and the combined, in the respecting order. These results mostly taken the reverse direction of the forms presented seed viability and vigour results included germination (%), good seedlings (%), TZ potential and vigour (%) as well as cold germination (%). Thus, these results indicated that low-EC genotypes have the higher viability and vigour percentages than the high-EC genotypes. The obtained results are in agreement with those reported by Aliloo and Shokati (2011). However, Ali (1979) reported that care should be taken in using EC test alone as a seed viability test.

Table 4. Cold test germination (%) and Electrical conductivity (µs/g) of maize genotypes during two successive years (2012 and 2013) and their combined

Genotypes	Cold test germination(%)-age			Electrical conductivity (µs/g)		
	1st year	2nd year	Combined	1st year	2nd year	Combined
Giza 2	80.66 c	89.33 a	85.00 b	4.493 c	3.125 c	3.809 c
SC 10	90.66 a	86.66 a	88.66 a	8.544 a	6.330 a	7.437 a
SC 128	90.00 ab	67.33 b	78.66 c	6.483 b	3.402 bc	4.942 b
TWC 321	87.33 b	85.33 a	86.33 ab	3.682 cd	3.525 bc	3.603 c
TWC 323	72.00 d	54.66 d	63.33 d	2.886 d	2.667 c	2.776 d
TWC 324	61.33 e	60.66 c	61.00 d	4.396 c	4.274 b	4.335 bc
F- test	**	**	**	**	**	**

Field Experiment

Field Emergence

Field emergence (%) at 10th day (FEP)

Field emergence (%) at 10th day as affected by maize genotypes and seed treatments during the two successive seasons are tabulated in Table 5. The results revealed highly significant differences during the two years and their combined.

With respect to maize genotypes, Giza 2 variety achieved highest field emergence percentages as compared with the other maize genotypes investigated which followed by TWC 321and TWC 323, regarding the combined data. At contrast, the lower FEP were recorded by SC 128 and TWC 324. These results almost followed the same patterns of germination (%) and seedling vigour index (Tables 1 and 2). The obtained results are in concurrence with those reported by Racz *et al.* (2007), Mabhaudhi and Modi (2010) and Aliloo and Shokati (2011). However, Racz *et al.* (2007) rported that maize varieties did not vary in field emergence percentages.

Concerning the influence of seed treatments on field emergence (%), the results showed that control (dry seed), soaking in zinc solution and soaking in GA3 gave higher FE (%) followed by osmopriming operation and soaking in ascorbic acid concerning the combined date. On the other side, irradiated seed gave the lowest FEP during both years. In this manner, several investigator reported various trends for seed treatments effects since Afzal *et al.* (2002) showed that maximum final germination percentage was recorded for control treatment, while Mahmoodi *et al.* (2011) indicated that seedlings from hydroprimed seeds emerged early than those from unprimed seeds. Also, Rao and Rao (1966) reported that the greatest germination percentage resulted from soaking in GA3, however Ghodrat and Rousta (2012) revealed thet priming with GA3 had no effect on seed germination. Generally, such reverse trends due to influence of seed treatments on field emergence might be attributed to the effect of environmental conditions special the edaphic factors.

The significant interaction effect between maize genotypes and seed treatments on FEP (Table 5-a) indicated that Giza 2 variety gave the higher FEP when soaked in ascorbic acid, osmopriming operation and zinc solution which followed by control and irradiated seed treatments. Meanthrough, TWC 321 gave higher FEP when soaked in GA3 and zinc solution, while TWC 323 recorded higher FEP when soaked in zinc solution. Contrary, the lowest FEP (23.82) was given by TWC 324 when the seed was irradiated by gamma rays. Generally, the interaction effects stated the superiority of Giza 2 variety under the different seed treatments as compared with other maize genotypes investigated regarding FEP.

Table 5. Field emergence percentage and Field emergence index (F.E.I) (%) on the 10th day from sowing of maize as influenced by genotype differences and seed treatments during two successive years (2012 and 2013) and their combined

Main effect and interaction	Field emergence (F.E.) (%) on 10th day			Field emergence index (F.E.I) (%) on 10th day		
	1st year	2nd year	Combined	1st year	2nd year	Combined
Genotypes (G)						
Giza 2	69.21 a	82.49 a	75.85 a	85.65 ab	91.86 a	88.76 a
SC 10	71.97 a	56.98 c	64.46 c	88.02 a	85.83 b	86.92 ab
SC 128	60.12 b	52.61 d	56.36 d	67.12 c	61.94 d	64.53 d
TWC 321	70.07 a	71.79 b	70.93 b	82.99 ab	86.67 b	84.83 b
TWC 323	62.93 b	70.34 b	66.63 bc	84.19 ab	87.34 ab	85.77 ab
TWC 324	70.79 a	53.10 d	57.25 d	80.89 b	74.53 c	85.77 ab
F- test	**	**	**	**	**	**
Seed treatments (S)						
Control	70.46 a	68.58 a	69.52 a	84.08 ab	84.08 ab	84.08 abc
Soaking in water	66.76 ab	62.71 b	64.74 b	87.88 a	86.00 ab	86.94 a
Soaking in GA3	70.73 a	63.68 b	67.20 a	77.38 cd	88.39 a	82.89 bc
Soaking in Ascorbic acid	64.68 bc	66.91 a	65.79 ab	79.65 bcd	82.31 b	80.98 c
Osmopriming operation	67.75 ab	64.26 b	66.01 ab	85.54 ab	86.72 ab	86.13 ab
Soaking in zinc solution	68.19 ab	69.28 a	68.73 a	81.94 abc	84.27 ab	83.10 abc
Gamma irradiation	60.39 c	54.18 c	57.28 c	73.87 d	57.77 c	65.82 d
F- test	**	**	**	**	**	**
Interaction G x S	NS	**	**	**	**	**

Table 5-a. Field emergence percentage on 10th day from sowing of maize as affected by the interaction between genotypes and seed treatments (combined data)

Seed treatments / Genotypes	Control	Soaking in water	Soaking in GA3	Soaking in ascorbic acid	Osmopriming operation	Soaking in zinc solution	Gamma irradiation
	A	AB	B	A	A	A	A
Giza 2	82.83 a	81.10 a	75.97 a	84.07 a	85.18 a	86.22 a	82.22 a
	AB	B	BC	A	C	A	A
SC 10	57.15 d	55.07 c	52.50 d	62.87 c	46.62 d	61.72 c	62.96 b
	A	BC	AB	C	BC	C	D
SC 128	63.45 c	54.56 c	59.50 c	53.20 d	54.06 c	51.25 d	32.21 d
	AB	C	A	AB	BC	A	C
TWC 321	73.73 b	65.92 b	77.15 a	72.96 b	70.36 b	77.52 b	64.89 b
	AB	CD	D	AB	BC	A	E
TWC 323	76.29 b	69.37 b	65.79 b	75.55 b	71.72 b	80.73 ab	52.95 c
	A	B	AB	AB	A	A	C
TWC 324	49.99 e	42.21 d	45.30 e	44.81 e	49.62 cd	50.24 d	23.82 e

Field emergence index (FEI) on 10th day

Field emergence index data as influenced by varietal differences and seed treatments during both seasons and their combined are presented in Table 5. Meanwhile, the results indicated highly significant differences where Giza 2 variety achieved the higher FEI (88.76) which followed by hybrids SC10 and both TWC 323, TWC 324 .then, by TWC 321 in descending order. However, the lowest value of FEI (64.53) was recorded by SC128, concerning the combined results. These results almost followed the same patterns of formermentiond viability and vigour measurements as well as field emergence on 10th day confirmed the superiority of Giza 2 variety in seed quality potential as compared with other maize genotypes investigated.

Such evaluated measurement (FEI) gave a clear idea about the relationship between field emergence and laboratory germination. Thus, the higher FEI values indicate the vigourous potential of such seeds and in turn the great relation between the laboratory germination and field emergence results under such conditions. In this connection, Lin (1982) reported that seeds with a high vigour index emerged better in the field than seed with low vigour index. Also, Andric *et al.* (2004) showed that seeds with optimum vigour (SG: %) had very similar SG and FE values. On the contrary, in seeds with reduced vigour (SG < 80%), the SG and FE values were very different, and there was a very great possibility of reduced FE, if we use such seed.

Respecting the influence of seed treatments on FEI, likely the results showed highly significant differences during both seasons and the combined. Meanthrough, the higher value of 86.94 was achieved by soaking in water which followed by osmopriming operation (86.13), control treatment (84.08), soaking in zing solution (83.10), soaking in GA3 (82.89) and soaking in ascorbic acid (80.98), concerning the combined results. However, the lowest value of FEI (65.82) was recorded by irradiated seed. Generally, no clear trends could be detected among seed treatments except those irradiated by gamma rays which gave the lowest value in this respect. In this connection, Afzal *et al.* (2002) showed that maximum final germination percentage was recorded for control treatment.

Concerning the significant interaction effects between maize genotypes and seed treatments on FEI (Table 5-b), the results showed that seed soaked in water almost gave higher values with most maize genotypes investigated in this respect. Therefore, the highest FEI (95.59) was achieved by SC 10 when the seed was soaked in water which followed by TWC 323 (94.66) with osmopriming operation and Giza 2 variety (92.77) with control treatment. At contrary, the lowest value of FEI (36.16) was recorded by TWC 324 when the seed was irradiated by gamma rays.

Correlation Study

Correlation between seed quality measurements and field emergence of maize (combined data)

To identify the relationship between seed viability and vigour measurements as well as their correlation with field emergence of maize, correlation coefficients were calculated for all possible combinations in the two years (combined data) and presented in Table 6. It could be clearly noticed that positive highly significant correlation coefficients were existed between field emergence of maize and each of germination (%), good seedling (%), TZ-potential (%), TZ energy (1-2) (%) and FEI with r= 0.346, 0.410, 0.527, 0.466 and 0.984 for the same followed order. However, it was insignificantly correlated with EC values (r = - 0.093) and cold test (r = 0.073). Likely, FEI highly significant correlated with each of good seedling (%), TZ-potential (%) and TZ energy (1-2) (%). Also, cold test germination (%) highly significantly correlated with EC values. However, it was significantly correlated with good seedling and TZ energy (1-2) (%). While, EC values showed negative highly significant correlations with germination (%) and TZ potential (%). Furthermore, TZ energy (1-2) (%) appeared to be highly significantly correlated with good seedling (%) and TZ potential (%) with r values of 0.988, and 0.518 in the same following order. Then, highly significant correlation coefficients were observed between TZ potential (%) and each of germination (%) and good seedling (%). Finally, germination index highly significant correlated with good seedling (%).

Table 5-b. Field emergence index (F.E.I) (%) on 10th day from sowing of maize as affected by the interaction between genotypes and seed treatments (combined data)

Seed treatments / Genotypes	Control	Soaking in water	Soaking in GA3	Soaking in ascorbic acid	Osmopriming operation	Soaking in zinc solution	Gamma irradiation
	A	A	A	A	A	A	A
Giza 2	92.77 a	90.83 a	90.10 a	84.60 a	91.12 ab	85.32 a	86.53 a
	B	A	AB	AB	AB	AB	B
SC 10	82.82 b	95.59 a	87.70 ab	88.42 ab	87.84 ab	86.20 a	79.87 a
	A	A	A	A	A	A	B
SC 128	69.17 c	65.53 b	67.12 c	71.59 c	72.58 c	69.60 b	36.06 b
	A	A	B	AB	AB	AB	B
TWC 321	89.47 ab	91.47 a	78.90 b	85.20 a	85.79 ab	83.83 a	79.14 a
	BC	AB	ABC	BC	A	AB	C
TWC 323	81.78 b	90.84 a	86.25 ab	82.60 ab	94.66 a	87.05 a	77.14 a
	A	A	A	B	A	A	C
TWC 324	88.44 ab	87.36 a	87.21 ab	73.44 bc	84.76 b	86.59 a	36.16 b

Table 6. Correlation coefficients between all possible combinations of maize seed viability and vigour measurements as well as their correlation coefficients with field emergence for two years (combined data)

	Germination (%)	Good seedlings (%)	Tetrazolium potential (%)	Tetrazolium energy (1-2) (%)	Electrical conductivity	Cold test germination (%)	Field emergence index
Field emergence	0.346**	0.410**	0.527**	0.466**	-0.093	0.073	0.984**
Field emergence index	0.180	0.401**	0.422**	0.457**	0.035	0.099	
Cold test germination (%)	-0.080	0.381*	0.125	0.394*	0.481**		
Electrical conductivity	-0.625**	-0.031	-0.435**	0.004			
Tetrazolium energy (1-2) (%)	0.149	0.988**	0.518**				
Tetrazolium potential (%)	0.707**	0.492**					
Good seedlings (%)	0.130						

* Denotes significance at 5% probability level ** Denotes significance at 1% probability level

Such highly significant correlation coefficients existed between field emergence and laboratory measurements (SGT and TZ) expressed the important of TZ-test as a "quick test" and other viability and vigour measurements of SGT in evaluation of maize seed viability and vigour which could be used to predict field emergence and in turn determine the pest seed quality and seedling rates required for planting under the different conditions and safing the seed and practical processes could be required after sowing to establish optimum plant density and good stand.

TZ- tests for determing the extent to which a-24 hr., TZ- test could be predict the results of a 8 day standard germination test (correlation coefficient between G % and TZ- potential (%) = 0.707**) as well as predict FE % (r = 0.527**). Then, TZ test could be recommended for evaluating seed viability and vigour of maize seed for safing the time and geting the quick viability and vigour results for maize seed according to the results of this investigation.

Many investigators found laboratory germination tests to correlate well with field emergence like seed conductivity test (Khavari *et al.*, 2009), standard germination, cold test, tetrazolium test and speed of germination for corn (El-Galfy, 2005), cold and conductivity tests for corn (Aliloo and Shokati, 2011) and standard germination for corn (El-Abady *et al.*, 2014). Otherwise, other investigators observed that standard germination test was not well correlated with field emergence of maize Ilbi *et al.* (2009). However, Naderidarbaghshahi and Jalalizand (2013) reported that from total laboratory tests (germination speed test, seed electrical test and vigour index) only significant correlation coefficient was about standard germination test (r=0.75**) with field emergence.

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تأثير معاملات البذور على قياسات الحيوية والقوة المعملية والتكشف الحقلى لبعض التراكيب الوراثية فى الذرة الشامية

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أجرى هذا البحث فى المعمل والحقل خلال عامى ٢٠١٢ و ٢٠١٣ بهدف دراسة تأثير بعض معاملات البذور على الإنبات وقوة نمو البادرات وتحديد العلاقة بين حيوية وقوة البذور والتكشف الحقلى لستة تراكيب وراثية من الذرة الشامية هى الصنف جيزة ٢ ، هجين فردى ١٠ ، هجين فردى ١٢٨ ، هجين ثلاثى ٣٢١ ، هجين ثلاثى ٣٢٣ وهجين ثلاثى ٣٢٤، حيث تضمنت معاملات البذور الكنترول (بذور جافة)، النقع فى الماء، حامض الجبريلليك، حامض الأسكوربيك (فيتامين C)، البولى ايثيلين جليكول ٨٠٠٠ ، محلول الزنك وتشعيع البذور بأشعة جاما، ويمكن تلخيص أهم النتائج على النحو التالى: أوضحت النتائج وجود اختلافات معنوية بين التراكيب الوراثية المستخدمة فى كل الاختبارات المعملية وقياساتها وكذلك التكشف الحقلى، تفوق كل من الصنف جيزة ٢ وهجين ثلاثى ٣٢١ فى معظم قياسات حيوية وقوة البذور (النسبة المئوية للإنبات ،النسبة المئوية للبادرات الجيدة، أطوال البادرات، النسبة المئوية للتترازوليم (١-٥)، النسبة المئوية للتكشف الحقلى)، أظهرت النتائج أن نقع البذور فى حامض الأسكوربيك يمكن أن يعمل على تحسين أنبات البذور حيث أعطى أعلى نسبة للبادرات القوية ودليل قوة البذور واشترك مع الجبرلين فى إعطاء أعلى قيمه لطول البادرات بينما سجلت البذور المعاملة بأشعة جاما أقل قيم للصفات تحت الدراسة، أوضحت النتائج وجود ارتباط عالى المعنوية بين التكشف الحقلى ومعظم قياسات حيوية وقوة البذور خاصة مع اختبار التترازوليم بينما لم يكن الإرتباط معنويا بين التكشف الحقلى وكلا من اختبار البرودة والتوصيل الكهربى، وتؤكد الدراسة على وجود اختلافات وراثية فى القدرة الكامنة لحيوية وقوة البذور كما توصى بإمكانية استخدام اختبار التترازوليم لتقدير حيوية وقوة البذور كاختبار سريع (٢٤-٣٦ ساعة) للتنبؤ السريع للتكشف فى حقول الذرة الشامية.

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