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Performance of some soybean *Glycine max* (L.) Merrill. cultivars under salinity stress to germination characters

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Key words: Soybean cultivars, salinity levels, final germination percentage, mean germination time, germination index, energy of germination and seedling vigor index.

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Abstract

In order to examine the effect of osmotic stress on six soybean cultivars i.e. Giza 21, Giza 22, Giza 35, Giza 82, Giza 83 and Giza 111 at germination stage to salinity stress i.e. 0, 3, 6, 9, 12 and 15 dSm^{-1} NaCl and to confirm seedling germination to examine a range of genetic variability for salinity tolerance among soybean cultivars. A laboratory experiment was conducted at Giza Central Seed Testing Laboratory of Central Administration for Seed Certification (CASC), Ministry of Agriculture, Egypt during the period of April to June 2014. The results clearly showed that soybean cultivars significantly varied in averages of final germination percentage, mean germination time, germination index, vigor index and energy of germination. Results indicated that Giza 82 and Giza 111 cultivars exceeded other studied cultivars in germination percentage and energy of germination. Results showed that Giza 21 cultivar exceeded other studied cultivars in seedling vigor index. Moreover, Giza 35 cultivar recorded highest values of mean germination time. Results clearly showed that increasing salinity levels from 0 to15 dSm^{-1} significantly decreased germination percentage, germination index, and seedling vigor index. The control treatment recorded the highest averages of these characters except mean germination time. Final germination percentage, mean germination time, seedling vigor index and energy of germination significantly affected by the interaction between soybean cultivars and salinity concentrations. It could be summarized that for maximizing soybean germination characters of studied soybean cultivars under salinity stress are producing by using Giza 22 and Giza 82 cultivars These cultivars were more tolerant to salinity and recommended to use in breeding program for enhancing soybean production in newly reclaimed soils of Egypt.

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Introduction

Soybean (Glycine max (L.) Merrill) is the main source of supplying protein and oil plant, which can provide complete protein, containing essential amino acids for human health. In order to reduce the gap between oil production and its consumption in Egypt which reach 10% from our production only. Recently interest has improved in the potential of rising soybean in the new reclaimed areas outside the Nile valley, where diverse environments of agricultural may be available. The global warming climate change ongoing to confine not only the expansion of the cultivated area, but also the stability of the current agricultural production under reclaimed soil. So, this study was conducted to study enhancement of some soybean cultivars under different salinity levels in North Egypt. The total area harvested in Egypt was about 8000 ha with total of seed yield 23000 ton with an average 2.3 ton/ha of seed yields (FAO, 2013). Essa (2002) concluded that increasing salinity levels decreased all studied characters under all cultivars and Lee cultivar was less affected by salinity stress than Coquitt cultivar. At 8.5 dSm^{-1} a significant reduction in seedling height was found in all three cultivars. Neto *et al.* (2004) reported that salinity effects on germination of four cultivars *i.e.* Pioneira, Conquista, Xingu and Pintado of soybean they were contrasted in relation to germination when seeds were submitted to water stress induced by mannitol or sodium chloride. Water stress affected seed germination. Sadeghi, *et al.* (2011) concluded that different osmotic potential duration had significant effect on germination percentage, mean germination time, germination index, and the time to get 50% germination, seed vigor and electrical conductivity of seeds. Yan *et al.* (2012) concluded that the three cultivars WDD1812 Jindou23 and Jinyi38 were showed high salt tolerance at the germination stage. Jindou23 cultivar was more salt tolerant than the control. The excellent salt tolerance germplasm screened in this study provides the genetic materials for soybean breeding to improve salt tolerance. Kondetti *et al.* (2012) reported that increasing salinity levels decreased all studied characters under all cultivars. They added that PalamSoy and Pusa-16 cultivars were salt tolerant. Ahmadvand *et al.* (2012) showed that Sahar cultivar was superior to Gorgan-3 cultivar in germination and emergence percentage. In addition, Ndifon (2013) showed that salt stress caused much reduction in germination percentage of TGX849-313D cultivar.

Salinity is one of the major obstacles in increasing production in soybean growing areas. Salinity is known to workout depressing effects on germination percentage, length of shoot and root, fresh and dry weight of shoot and root. Salinity is an a biotic hazard, persuades numerous disorders in seeds and propagules during germination, it either completely inhibits germination at higher levels or induces a state of dormancy at lower levels (Khan and Ungar, 1997). Khajeh-Hosseini *et al.* (2002) found that salinity had adverse effects on germination characters. Germination decreased at Nacl concentration of 330 mMolal Nacl (81% germination) and above at 420 mMolal NaCl, only 40% of seeds germination and at 500 mMolal Nacl there was no germination. Thus, soybean seeds were more tolerance of salinity during germination than in the seedling phase. Essa (2002) and Neves *et al.* (2005) found that salinity had adverse effects on germination percentages. Blanco *et al.* (2007) reported that emergence and growth of soybean were reduced by water salinity and the crop was more tolerant during the emergence (ECi = 2.7 dSm^{-1}) than in the initial development (ECi = 1.0 dSm^{-1}) stage. Aghaei *et al.* (2008) reported that under salt stress the proline content increased. Farhoudi and Tafti (2011) concluded that salt stress led to decrease germination seedling fresh weight; seedling growth and seedling K^+ percentage in dry matter but increase mean germination time and seedling Na^+ percentage. Ahmadvand *et al.* (2012) reported that increasing salinity levels from 0, 4, and 8 dSm^{-1} induced by sodium chloride decreased final germination percentage. Furthermore, Ndifon (2013) found that increasing salinity levels had adverse effects on germination percentage.

There are an allocation of information about the interaction effect between soybean cultivars and salinity concentration that affecting seed germination characters. In this connection, Neves *et al.* (2005) showed that salinity stress reduced seed germination percentage. The germination percentage of the control group was 61% in average, while for the higher salt concentration (200 Mm) was reduced to 5%. Xu *et al.* (2011) showed that when exposed to 100 mMolal/L NaCl, the mean germination times of Lee 68 and N 2899 cultivars were delayed by 0.3 and 1.0 d, respectively compared to the controls. Under salt stress, this period was 3.5 and 6.5 d, respectively. There were many more abnormally germinated N 2899 seeds compared to Lee 68. It could be suggested that 100 mMolal/L NaCl affected soybean seed germination, especially in N 2899. However, moderate salt stress intensity only delayed germination time and did not have a severe impact on the final germination percentage. Furthermore, Ndifon (2013) showed that salt stress caused much reduction in germination percentage of TGX849-313D cultivar. This cultivar seems to be most susceptible to ionic effect (salt stress) in terms of reduction in germination. The other two cultivars of Samsoy-2 and TGX923-2E cultivars were at Par cultivar in terms of percentage reduction in germination. The effect of ionic stress was highly significantly different for all the three cultivars. The objectives of this research were aimed to study the performance of cultivars and salinity stress and their interactions on germination parameters of soybean plants under laboratory conditions.

Materials and methods

The experiment was conducted at Giza Central Seed Testing laboratory of Central Administration for Seed Testing and Certification, Ministry of agriculture, Egypt during the period of April to June 2014 to study the response of some soybean (Glycine max (L.) Merrill) cultivars to germinate under salinity concentrations.

Treatments and Experimental Design

The experiment was arranged in factorial experiment in Randomized Complete Block Design in four replications. The experiment include two factors, the first soybean cultivars which included six soybean cultivars *i.e.* Giza 21, Giza 22, Giza 35, Giza 82, Giza 83 and Giza 111 which were obtained from legume section, Field Crops Research Institute, ARC, Ministry of Agriculture, Egypt. All studied cultivars were stored under normal conditions in paper bags. The second factor included six salt concentrations of NaCl dSm^{-1} includes 0, 3, 6, 9, 12 and 15 dSm^{-1} NaCl. Fifty seeds of uniform size in each treatment for each cultivar were allowed to germinate on a filter paper in 9 cm diameter Petri dishes. Seeds were allowed to germinate in a germination chamber at 20 – 25°C **(ISTA Rules, 2013).** Each filter paper was moistened with a water solution at six different NaCl concentrations. Thus, the whole experiment comprised 144 Petri dishes.

Studied characters

Five germination characteristics namely final germination percentage, mean germination time, germination index, seedling vigor index and energy of germination were estimated.

1-Final Germination Percentage (FGP): Seed germinated count was taken after 8 days from sowing date and expressed as percentage according to the following equation described by (Ellis and Roberts, 1981& Ruan *et al.* 2002).

$$\textbf{FGP} = \frac{\text{Number of germinated seeds}}{\text{Total Number of seed tested}} \times 100$$

2-Mean germination time (MGT): It was determined according to the equation of (Ellis and Roberts 1980):

$MGT= \sum dn \div \sum n$

Where (n) is the number of seeds, which were germinated on days (d), and (d) is the number of days counted from the beginning of germination.

3-Germination Index (GI): Germination Index was calculated according to the following equation, Karim *et al.* (1992).

$$GI = \frac{\text{Germination \% in each treatment}}{\text{Germination \% in the control}} \times 100$$

4- Seedling vigor index (SVI): Seedling vigor index was calculated as the following equation according to Abdel Baki and Anderson (1973).

$$SVI = (\text{Average shoot length} + \text{Average root length}) \times \text{Germination \%}$$

5- Energy of germination (EG): Energy of germination was recorded at the fourth day as the percentage of germinated seeds four days after sowing relative to the number of seeds tested according to Ruan *et al*., (2002).

$$EC = \frac{\text{Number of germinated seeds after four days}}{\text{Number of germination days}} \times 100$$

Statistical Analysis

All data of this study were statistically analyzed according to the technique of variance (ANOVA) for the factorial Randomized Complete Block Design as published by Gomez and Gomez (1991). Least Significant Difference (LSD) method was used to test the differences between treatment means at 5% and 1% levels of probability as described by Snedecor and Cochran (1980). The data were analyzed statistically following RCBD design by MSTAT-C computer package developed by Russel (1986).

Results and discussion

A. Cultivars Performance

The six tested cultivars of soybean significantly varied for averages of final germination percentage, mean germination time, germination index, seedling vigor index and **e**nergy of germination as showed in Table 1. Results clearly showed that Giza 111 and Giza 82 cultivars exceeded other studied cultivars in germination percentage and energy of germination. However, the lowest percentages of final germination was recorded from sown Giza 22 cultivar. It could be noticed that Giza 82 cultivar exceeded Giza 22, Giza 21, Giza 35, Giza 83 and Giza 11 cultivars in final germination percentage by 15.84, 4.44, 2.76, 2.04 and 0.24 %, respectively. Results showed in Table 2 revealed that Giza 35 cultivar gave highest mean germination time**,** which was 5.87 day, followed by Giza 21 and Giza 83 cultivars came in the second rank, which were 5.44 and 5.38 day, respectively without significant differences between them. However, the lowest mean germination time was obtained from Giza 111 and Giza 82 cultivars, which were 4.70 and 4.72 day, respectively without significant differences between them. It could noticed that Giza 35 exceeded Giza 21, Giza 22, Giza 82, Giza 83 and Giza 111 in mean germination time by 7.3, 14.1, 19.5, 8.3 and 19.9 %, respectively. In addition, results indicated that Giza 22 cultivar exceeded other studied cultivars in germination index, which was 89.29%. Giza 35 and Giza 82 cultivars came in the second rank without significant differences between them, which were 87.97 and 85.05%, respectively. However, the lowest percentage of germination index was obtained from Giza 21 and Giza 83 cultivars without significant differences between them, which were 82.97 and 83.32 %, respectively. The differences in germination index due to soybean cultivars might be due to the genetical factors and heredity variation among the six soybean studied cultivars. It could be noticed that Giza 22 cultivar surpassed Giza 35, Giza 82, Giza 111, Giza 83, and Giza 21 cultivars in germination index by 1.47, 4.74. 4.96, 6.68 and 7.07 %, respectively. Results showed that Giza 21 cultivar surpassed other studied cultivars in seedling vigor index, which was 2171.4. Giza 82 and Giza 83 cultivar came in the second rank without significant differences between them, which were 2044.4 and 1986.5, respectively. However, the lowest seedling vigor index was produced from Giza 35 cultivar, which was 1767.8. It could be observed that Giza 21 cultivar exceeded Giza 22, Giza 35, Giza 82, Giza 83 and Giza 111 cultivars in seedling vigor index by 15.15, 18.58, 5.84, 8.51 and 16.02%, respectively. Regarding energy of germination, results clearly indicated that Giza 111 cultivar exceeded other cultivars in energy of germination, which was 67.50% and Giza 82 came in the second rank, which was 64.16 %. However, the lowest percentages of energy of germination was obtained from Giza 35 and Giza 83 cultivars without significant differences between them, which were 52.20 and 52.87 %, respectively. It could be concluded that Giza 111 cultivar surpassed Giza 82, Giza 21, Giza 22, Giza 83, and Giza 35 cultivars in energy of germination by 4.95, 12.1, 20.74, 21.67, and 22.66 %, respectively. Rao *et al.* (2002) found that some cultivars may have a degree of salt adaptation due to water retention capacity, membrane permeability and osmo-protection and or genetical and morphological factors. These results are in good accordance with those obtained by Farhoudi and Tafti. (2011), Xu *et al.* (2011), Ahmadvand *et al.* (2012), Kandil *et al.* (2012a) on wheat, Kandil *et al.* (2012b) on rice, and Kandil *et al.* (2012c) on chickpea and Kandil *et al.* (2012d) on forage sorghum Kondetti *et al.* (2012) and Ndifon (2013).

Table 1. Means of final germination percentage (%), mean germination time, germination index (%), seedling vigor index and energy of germination as affected by soybean cultivars.

Treatments	Final germination percentage (%)	Mean germination time (d)	Germinatio n index (%)	Seedling vigor index	Energy of germination
Giza 21	79.6	5.44	82.97	2171.4	59.33
Giza 22	70.1	5.04	89.29	1842.3	53.50
Giza 35	81.0	5.87	87.97	1767.8	52.20
Giza 82	83.3	4.72	85.05	2044.4	64.16
Giza 83	81.6	5.38	83.32	1986.5	52.87
Giza 111	83.1	4.70	84.86	1823.4	67.50
F-Test	**	**	**	**	**
L.S.D. 5 %	2.7	0.27	3.26	124.8	5.29
L.S.D. 1 %	3.5	0.36	4.31	165.2	7.00

**, ** and NS mean significant and insignificant, respectively at levels of probability 0.05 and 0.01.*

2-Salinity stress effects

The results in Table 2 reported that final germination percentage, mean germination time, germination index, seedling vigor index and energy of germination. Highest averages of these characters were recorded with control treatment and highest salinity concentration of 15 dSm^{-1} NaCl recorded the lowest averages of these characters compared with control treatment. Increasing salinity concentration from 0 to 15 dSm^{-1} NaCl gradually decreased averages of final germination percentage, germination index, seedling vigor index, energy of germination, Vice verse, mean germination time were increased. Highest final germination percentage (93.5 %) was produced from the control treatment compared with other salinity concentrations. On the contrary, the lowest average of final germination percentage (61.0 %) was recorded with highest salinity levels of 15 dSm^{-1} NaCl. Increasing salinity levels decreased final germination percentage of seeds which is directly related to the amount of absorbed water by the seeds. It could be noticed that increasing salinity levels form 3, 6, 9, 12 and to 15 dSm^{-1} NaCl decreased final germination percentage by 3.6, 9.0, 17.5, 22.8 and 34.7%, respectively compared with the control treatment. Furthermore, highest average of mean germination time was recorded with highest salinity levels of 15 dSm^{-1}, which was 7.47 day. It could be observed that increasing salinity levels from 3, 6, 9, 12 and 15 dSm^{-1} NaCl decreased mean germination time by 1.23, 9.70, 24.52, 32.43 and 46.45%, respectively compared with the control treatment. Increasing salinity levels from 3 to 15 NaCl dSm^{-1} gradually decreased germination index. Highest germination index was obtained from the control treatment compared with other salinity levels, which was 100.0 %. On contrary, highest of salinity levels of 15 NaCl dSm^{-1} recorded the lowest germination index, which was 65.75 %. It could be stated that increasing salinity levels form 3, 6, 9, 12 and 15 dSm^{-1} NaCl decreased germination index by 3.41, 9.03, 17.21, 22.63 and 34.25%, respectively compared with the control. Increasing salinity levels from 3 to 15 dSm^{-1} NaCl gradually decreased seedling vigor index. The control treatment recorded highest seedling vigor index, which was 3181.9. On contrary, the lowest average of seedling vigor index (538.4) was recorded with highest salinity levels of. 15 dSm^{-1}. Increasing salinity levels from 3, 6, 9, and 12 and to 15 dSm^{-1} NaCl decreased seedling vigor index by 17.38, 26.41, 48.63, 58.78 and 83.07%, respectively compared with the control. Highest energy of germination was obtained from the control treatment compared with other salinity levels, which was 91.00. On the other hand, highest of salinity levels of 15 NaCl dSm^{-1} recorded the lowest energy of germination, which was 15.20. It could be noticed that increasing salinity levels form 3, 6, 9, 12 and 15 dSm^{-1} NaCl decreased energy of germination by 5.86, 25.27, 46.02, 55.40 and 83.29 %, respectively compared with the control treatment. **Ghoulam and Fares (2001)** reported that higher levels decreasing the final percentage of seed germination and seedling characters such as shoot, root length, shoot and root fresh and dry weight as well as vegetative plant growth is suppressed under saline conditions. Munns (2002) concluded that soluble salts leads to osmotic stress, which results in specific ion toxicity and ionic imbalance and the consequences of these, can be plant demise. These results in good agreement with those obtained by Shereen *et al.* (2001), Shereen and Ansar (2001), khajeh-Hosseini *et al.* (2005), Neves *et al.* (2005), Blanco *et al* (2007),Yan (2008), Amirjani (2010), Muhammad *et al.* (2010), Sadeghi *et al.* (2011), Farhoudi and Tafti (2011), Xu *et al.* (2011), Ahmadvand *et al.* (2012) and Kondetti *et al.* (2012).

Table 2. Means of final germination percentage (%), mean germination time, germination index (%), seedling vigor index and energy of germination as affected by salinity concentrations.

Treatments	Final germination percentage (%)	Mean germination time (d)	Germination index (%)	Seedling vigor index	Energy of germination
0 dSm^{-1}NaCl	93.5	4.00	100.00	3181.9	91.00
3 dSm^{-1}NaCl	90.1	4.05	96.59	2628.6	85.66
6 dSm^{-1}NaCl	85.0	4.43	90.97	2341.4	68.00
9 dSm^{-1}NaCl	77.1	5.30	82.79	1634.3	49.12
12 dSm^{-1}NaCl	72.1	5.92	77.37	1311.3	40.58
15 dSm^{-1}NaCl	61.0	7.47	65.75	538.4	15.20
F-Test	**	**	**	**	**
L.S.D 5 %	2.7	0.27	3.26	124.8	5.29
L.S.D 1 %	3.5	0.36	4.31	165.2	7.00

**, ** and NS mean significant and insignificant respectively at levels of probability 0.05 and 0.01.*

3- Interaction effects

Results illustrated in Figs 1 to 4 clearly showed that final germination percentage**,** mean germination time, energy of germination, significantly affected by the interaction between soybean cultivars and salinity concentration. Vice versa, averages of germination index (GI), seedling vigor index (SVI) did not reach the levels of significant, this mean that each factor acted separately. As shown in Fig 1 highest final germination percentage from sown Giza 22 cultivar under the control treatment. However, the lowest percentages of germination percentage from sown Giza 35 or Giza 82 cultivars under salinity level of 15 dSm^{-1} NaCl. Furthermore, As shown in Fig 2 highest mean germination time resulted from sown Giza 35, Giza 21 and Giza 83 cultivars under the control treatment. While, the lowest mean germination time produced from sown Giza 82, Giza 22 and Giza 111 cultivars at salinity level of 15 dSm^{-1} NaCl. In addition, as shown in Fig 3 highest energy of germination resulted from sown Giza 111 or Giza 22 cultivars under the control treatment. However, the lowest energy of germination was obtained from sown Giza 22 cultivar at the salinity of 15 dSm^{-1} NaCl. Abdelmajid (2009) showed that the relative salt tolerance of Amdoun genotype may be due to its K^+/Na^+ discrimination. This cultivar seems to be able to protect its photosynthetic apparatus against the toxic Na^+ and Cl^- ions, and to ensure an appropriate K^+ supply to the plants under salt stress. Xu *et al.* (2011) suggested that 100 mMolal/L NaCl affected soybean seed germination, especially in N 2899. However, moderate salt stress intensity only delayed germination time, and did not have a severe impact on the final germination percentage. Furthermore, Ndifon (2013) reported that the reduction in germination percentage due to salt stress. The effect may be due to the presence of efficient compartmentation of common salt ions. These results are in good accordance with those obtained by Shereen *et al.* (2001), Khajeh-Hosseini *et al.* (2005), Neves *et al.* (2005), Blanco *et al* (2007), Yan (2008), Amirjani (2010), Muhammad *et al.* (2010), Sadeghi *et al.* (2011), Farhoudi and Tafti. (2011), Xu *et al.* (2011), Ahmadvand *et al.* (2012) and Kondetti *et al.* (2012 and Ndifon (2013).

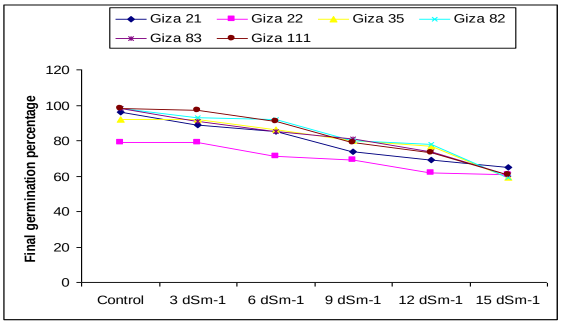

Fig. 1. Percentage of final germination as affected by the interaction between cultivars and salinity concentrations.

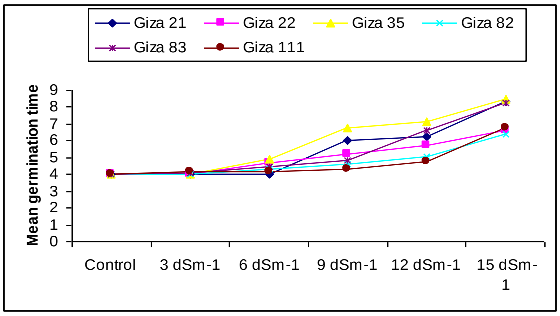

Fig. 2. Means of germination index as affected by the interaction between cultivars and salinity concentrations.

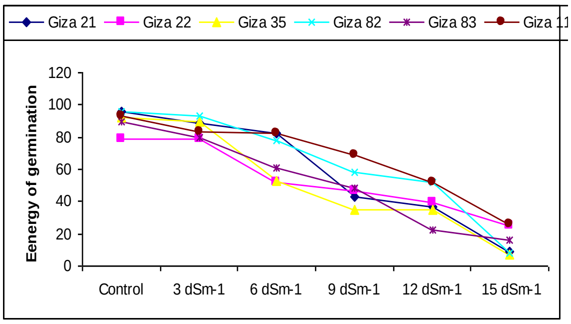

Fig. 3. Means of energy of germination as affected by the interaction between cultivars and salinity concentrations.

Conclusion

It could be concluded that for maximizing soybean germination characters of studied soybean cultivars under salinity stress are producing by using Giza 22 and Giza 82 cultivars These cultivars were more tolerant to salinity and recommended to use in breeding program for enhancing soybean production in newly reclaimed soils of Egypt.

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