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USE OF OSMO-HARDENING TECHNIQUE TO IMPROVE GERMINATION AND SEEDLING VIGOR OF TWO SORGHUM CULTIVARS

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ABSTRACT : A laboratory experiment was carried out under the laboratory natural conditions of Seed Technology Laboratory, Department of Field Crops, College of Agriculture, University of Anbar, Iraq, during year of 2017, to study the effect of seed priming (concentrations of potassium chloride solution KCl *i.e.* 0, 15, 20, 25 and 30 mg L^{-1}) on germination and seedling vigor of two sorghum cultivars (Rabih and Inkath). The experiment was carried out in factorial experiment in completely randomized design (CRD) with four replications. The main results of this study were as follow; Rabih cultivar significantly superior Inkath cultivar and resulted in the highest values of germination speed and final germination percentages, radical length and seedling vigor index. While, Inkath cultivar resulted in the highest values of plumel length. Germination and seedling vigor parameters were significantly enhanced as increasing concentration of potassium chloride (KCl) as seed priming from 0 to 15 and 20 mg L^{-1}. Conversely, increasing concentration of KCl as seed priming from 25 to 30 and 20 mg L^{-1} significantly decreased germination and seedling vigor parameters. It could be concluded that priming seeds of Rabih sorghum cultivar in 20 mg KCl L^{-1} for 24 hours to enhance germination and seedling vigor characters.

Key words : Sorghum, cultivars, varieties, Osmo-hardening, seed priming, osmopriming, germination, seedling vigor.

INTRODUCTION

Sorghum, *Sorghum bicolor* (L.) Moench, is the fifth most important cereal crop after rice, wheat, maize and barley (Smith and Frederiksen, 2000) and it contributes significantly to the protein and energy requirements of millions of people, especially the poor in Africa and Asia (Elkhier and Hamid, 2008). Sorghum is mainly important for people in the semi-arid tropics as a food crop because it is adapted to a wide range of ecological conditions and can tolerate adverse conditions such as; hot, dry, wet and water logged conditions. It can also adapt to poor fertility and high salinity soils (FAO, 2012). In developing countries, more than 35% of sorghum grain is grown primarily for human consumption, while the rest is used for feeding animals, brewing alcohol among other uses (Amir *et al*, 2009). Cereal grains like sorghum can constitute major energy sources and starch as raw materials for several end uses such as in baking, brewing, poultry and livestock industries.

Crop genotypes affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under different climatic conditions and play a dominant role in crop production systems. In this concern; Razmi *et al* (2013) showed that germination of sorghum genotypes responded differently to low temperatures, which it seems that KFS2 and Speedfeed cultivars were the most tolerant and sensitive genotypes to low temperature. Ali and Idris (2015) indicated that sorghum cultivars (Barbarei, Tabat and Wad-Ahmed) were significantly differed in seed germination and seedling characteristics. Al-baldawi and Hamza (2017) showed that significant differences were detected among sorghum cultivars (Inqath, Kafier and Rabeh) in germination at first count (%),germination at final count (%), length of radical and length of plumule. Kandil *et al* (2017) reported that the highest germination percentage and seedling vigor index were obtained from sown Mecca hybrid. While, the maximum germination index was obtained from sown Giza 15 cultivar.

Seed priming is a technique applied before germination, which involves uptake of water by the seed to the point where germination processes begin, but radical emergence does not occur. Seed were then dried back normally to the initial moisture content (McDonald, 2000 and Ashraf and Foolad, 2005**)**. Seed priming improves the longevity of low vigor seeds (Basu, 1994) and increasing the germination rate, germination percentage and the uniformity and speed of germination (Farooq *et al*, 2007). Seed osmotic conditioning technique referred as priming or osmoconditioning (Heydecker *et al*, 1975) has promising results for cereals. After osmotic conditioning, the seed can be dried back to the initial moisture content and stored until next sowing season. This technique used for maintaining beneficial seed characters, without quality loss resulted from rapid seed deterioration, improvement of germination, speed of germination, seedling vigor establishment and yield (Chiu *et al*, 2002 and Talebian *et al*, 2008) under a broad range of adverse environmental conditions (Kaya *et al*, 2006). Most cultivars of sorghum have low field emergence as common problem. However, seed priming with KCl at the rate of 40 mg L^{-1} improved field emergence of sorghum under wide range of environmental conditions **(**Al-baldawi and Hamza, 2017). Moradi and Younesi (2009) found that osmo or hydro priming seed led to reduce rate of emergence time and improved germination percentage of grain sorghum. Esmeilli and Heidarzade (2012) found that the highest germination percentage, germination rate, root length, shoot length, and total dry weight of rice were obtained from osmopriming using KNO_3. Dawood (2014) revealed that percentage of normal seedling at final count, speed of germination, length of radical and dry weight of seedling were increased when sorghum seeds soaked in 40 mg KCl L^{-1}. Ruttanaruangboworn *et al* (2017) showed that priming rice seeds with 1.0% KNO_3 improved seed germination and increased both the speed and uniformity of seed germination than priming with 2.0% KNO_3.

Therefore, the objective of this study was to evaluate the effect of seed priming in various concentrations of potassium chloride on germination and seedling vigor of two sorghum cultivars.

MATERIALS AND METHODS

A laboratory experiment was carried out under the laboratory natural conditions of Seed Technology Laboratory, Department of Field Crops, College of Agriculture, University of Anbar, Iraq, during year of 2017. The purpose of the experiment was to assess the effect of seed priming in potassium chloride solution on germination and seedling vigor of two sorghum cultivars.

The studied factors were; a) Sorghum cultivars *i.e.* Rabih and Inkath, which were relatively low in germination percentage (64 and 62%, respectively) and stored under normal storage conditions. B) Osmo-hardening technique by seed priming in different concentrations of potassium chloride (KCl) solution *i.e.* 0, 15, 20, 25 and 30 mg L^{-1}. The experiment was conducted in factorial experiment in completely randomized design (CRD) with four replications.

Seed samples of each sorghum cultivar were mixed well before working for homogenization and soaked for 24 hours in different concentrations of potassium chloride (KCl) solution under at room temperature (25 ^{o}C ± 3). After expiration of soaking period, the treated seeds were dried back (after washed with tap water) to their original moisture content (12%) at room temperature (25^{o}C).

Laboratory tools and workplaces were sterilized with pure medical alcohol 99%. Samples of 400 seeds per each treatment were sown in sterilized sand culture (with a 0.8 mm diameter) in sterilized Petri-dishes (14 cm diameter). Each Petri-dish contain 25 seeds, and four Petri-dishes kept close together and assessed as though they were one 100 – seed replication under germination cabinet at 25 ± 0.5^{o}C and 80% ± 1 of relative humidity as the rules of International Seed Testing Association (ISTA, 1996).

Procedures for recording data

Germination was observed daily according to the ISTA rules (1996) to study the following characters :

I- Germination parameters

1- Germination speed percentage (GS %) : The germination percentage at the first count (after 4 days from planting) was considered a guide to speed of germination, where normal seedlings of each replicate were counted after 4 days from planting and expressed as percentage according to the following equation described by ISTA (1996):

$$GS\ \% = \frac{\text{Number of normal seedlings at the first count}}{\text{Number of total seeds}} \times 100$$

2- Final germination percentage (FG %) : Normal seedlings of each replicate were counted at the final count (after 10 days from planting) and expressed as percentage according to the following equation described by ISTA (1996):

$$FS\ \% = \frac{\text{Number of normal seedlings at the first count}}{\text{Number of total seeds}} \times 100$$

II. Seedling parameters

3- Radical length : Averages of radical length of ten seedlings taken by random per each replicate from the grain to the tip of the radical and recorded and expressed in centimeters (cm) as the radical length at the end of standard germination test (AOSA, 1988).

4- Plumel length : Averages of plumel length of the ten seedlings taken by random per each replicate from the grain to the tip of the leaf blade were recorded and expressed in centimeters as the plumel length at the end of standard germination test (AOSA, 1988).

5- Seedling vigor index (SVI) : It was calculated according to the formula as suggested by AbdulBaki and Anderson (1973):

$$SVI = \frac{(\text{Radical length} + \text{Plumel length}) \times \text{Germination percentage}}{100}$$

Statistical analysis

All obtained data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) for the factorial experiment in completely randomized design (CRD) as published by Gomez and Gomez (1984) by means of "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 Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

A. Cultivars performance

The obtained results showed that the two studied sorghum cultivars *i.e.* Rabih and Inkath were significantly differed in germination (germination speed and final germination percentages) and seedling vigor (radical length, plumel length and seedling vigor index), as shown in Table 1.

It could be observed that Rabih cultivar significantly superior Inkath cultivar and resulted in the highest values of germination speed (70.35%), final germination (78.75%), radical length (11.34 cm) and seedling vigor index (21.34) and the lowest values of plumel length (10.41 cm). This means that Inkath cultivar had greater germination and seedling vigor than Inkath cultivar. On the other side, Inkath cultivar resulted in the lowest values of germination speed (66.40%), final germination (77.00%), radical length (10.60 cm) and seedling vigor index (19.72) and the highest values of plumel length (14.65 cm), as presented in Tables 3 and 4.

These results might be related to genetic factors which resulted from genetic makeup relations in addition the difference in the speed changes that get to the level of chromosome and nucleus, which in turn affect the overall physiological and biological processes of enzymes, such as enzymatic activity, growth regulators, etc., according to the genetic mechanism controlling each cultivar (Al-Silawi, 2011). These results are partially agreement with those found by Razmi *et al* (2013), Ali and Idris (2015), Al-baldawi and Hamza (2017) and Kandil *et al* (2017).

B. Effect of osmo-hardening technique by seed priming in potassium chloride (KCl) concentrations

The osmo-hardening technique by seed priming in potassium chloride (KCl) concentrations had significant effect on germination (germination speed and final germination percentages) and seedling vigor (radical length, plumel length and seedling vigor index) as shown in Table 2. Germination and seedling vigor parameters were significantly enhanced as increasing concentration of potassium chloride (KCl) as seed priming from 0 to 15 and 20 mg L^{-1}. Conversely, increasing concentration of KCl as seed priming from 25 to 30 and 20 mg L^{-1} significantly decreased germination and seedling vigor parameters. Where, the highest values of germination speed (82.75 %), final germination (91.75 %), radical

Table 1 : Means of germination speed (GS) and final germination (FG) percentages, radical length, plumel length and seedling vigor index (SVI) as inflected by sorghum cultivars and Osmo-hardening technique *i.e.* seed priming in potassium chloride (KCl) concentrations.

Characters / Treatments	Germination speed (GS %)	Final germination (FG %)	Radical length (cm)	Plumel length (cm)	Seedling vigor index (SVI)
A- Cultivars					
Rabih	70.35	78.75	11.34	10.41	21.34
Inkath	66.40	77.0	10.60	14.65	19.72
F. test	*	*	*	*	*
B- Seed priming in potassium chloride (KCl) concentrations					
0 mg KCl L^{-1}	53.38	63.50	9.43	12.53	13.95
15 mg KCl L^{-1}	62.75	71.75	9.81	14.32	17.32
20 mg KCl L^{-1}	82.75	91.75	13.28	17.12	27.89
25 mg KCl L^{-1}	74.62	84.12	11.46	16.04	23.14
30 mg KCl L^{-1}	68.38	78.25	10.87	15.15	20.36
F. test	*	*	*	*	*
LSD (5%)	1.97	2.13	0.27	0.20	0.63
C- Interaction (F- test)					
A × B	NS	NS	NS	*	NS

Table 2 : Means of germination speed (GS) and final germination (FG) percentages, radical length, plumel length and seedling vigor index (SVI) as inflected by the interaction between sorghum cultivars and Osmo-hardening technique *i.e.* seed priming in potassium chloride (KCl) concentrations.

Treatments	Characters	Germination speed (GS %)	Final germination (FG %)	Radical length (cm)	Plumel length (cm)	Seedling vigor index (SVI)
Rabih	0 mg KCl L^{-1}	54.50	64.50	9.68	12.91	14.57
	15 mg KCl L^{-1}	63.50	72.75	10.35	14.53	18.10
	20 mg KCl L^{-1}	85.75	92.50	13.69	17.30	28.66
	25 mg KCl L^{-1}	77.50	85.50	11.69	16.70	24.27
	30 mg KCl L^{-1}	70.50	78.50	11.30	15.59	21.11
Inkath	0 mg KCl L^{-1}	52.25	62.50	9.18	12.15	13.33
	15 mg KCl L^{-1}	62.00	70.75	9.28	14.11	16.54
	20 mg KCl L^{-1}	79.75	91.00	12.87	16.93	27.12
	25 mg KCl L^{-1}	71.75	82.75	11.24	15.37	22.02
	30 mg KCl L^{-1}	66.25	78.00	10.43	14.71	19.60
	F- test	NS	NS	NS	*	NS
	LSD (5%)	-	-	-	0.28	-

length (13.28 cm), plumel length (17.12 cm) and seedling vigor index (27.89). The second best treatment was priming sorghum seeds in KCl at the rate of 25 mg L^{-1}, followed by priming sorghum seeds in KCl at the rate of 30 mg L^{-1} and then priming sorghum seeds in KCl at the rate of 15 mg L^{-1}. However, the lowest values of germination speed (53.38 %), final germination (63.50 %), radical length (9.43 cm), plumel length (12.53 cm) and seedling vigor index (13.95). The enhancement in germination and seedling vigor traits by priming in KCl solution may be due to the completion of pre-germinative metabolic activities to the point of radical protrusion which make the seed germinate faster compared with untreated seed and repairs damages of seed cells and build up of germination metabolites (Bray, 1995). Besides, the important role of potassium in maintaining ionic balance within cells, building protein, enzymatic activation, equation of excess negative charges resulting from the presence of proteins and nucleic acids (Marschner, 2012), opening and closing of stomata and transport process in the phloem (Armengaud *et al*, 2004). Moradi and Younesi (2009), Esmeilli and Heidarzade (2012), Dawood (2014), Al-baldawi and Hamza (2017) and Ruttanaruangboworn *et al* (2017) confirmed these results.

C. Effect of interaction

The interaction between sorghum cultivars and osmo-hardening technique by seed priming in potassium chloride (KCl) concentrations significantly affected plumel length only, vice-versa concerning other studied germination and seedling vigor parameters (Tables 1). The tallest plumel (17.30 cm) was recorded when seed of Rabih cultivar primed in 20 mg KCl L^{-1}, followed by priming seed of Inkath cultivar in 20 mg KCl L^{-1}, then priming seed of Rabih cultivar in 25 mg KCl L^{-1}. While, the lowest plumel (12.15 cm) was given from soaking seed of Inkath cultivar on water without KCl (control treatment).

CONCLUSION

Results of this study indicate that osmo-hardening technique by seed priming in potassium chloride (KCl) enhanced sorghum cultivars seed quality and may be preempted the deterioration effects occurred during storage and resulted in preserve in seed quality as indicated by germination (germination speed and final germination percentages) and seedling vigor (radical length, plumel length and seedling vigor index) traits. Seed priming of sorghum Rabih cultivar in 20 mg KCl L^{-1} for 24 hours enhancing germination and seedling vigor traits.

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