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SEED PRE-TREATMENT WITH GIBBERELLIC AND SALICYLIC ACIDS TO TOLERATE DROUGHT STRESS IN SORGHUM CULTIVARS

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Abstract

A laboratory experiment was carried out in the laboratories of College of Agricultural Engineering Sciences, University of Baghdad in 2017. Three factors were studied; S*orghum bicolor* L. cultivars (Inqath, Rabeh and Buhoth70), primed and unprimed seed and osmotic potential (0, -5, -9, -13 bar). The aim was to improve germination and seedling growth under water stress. The results showed significant superiority of Buhoth 70 cultivar compared to others, significant superiority of primed seed compared to the unprimed, significant negative impact as long as increasing levels of osmotic potential and significant superiority of interaction treatment (Buhoth70 × primed seed × 0) compared to others in germination ratio, radicle and plumule lengths, dry seedling weight and seedling vigour index. A significant positive correlation found between all these traits. It can conclude that using seed priming technology before planting led to improve performance under drought stress conditions compared to the unprimed under the same level of stress. It can recommend to prim sorghum seeds before planting under drought stress or not.

Key words: abiotic stress, environmental stress, growth regulators, polyethylene glycol, seed priming, seed vigour, *Sorghum bicolor*.

Introduction

Water resources available in Iraq are changeable from one year to the next and deteriorate qualitatively as a result of storage and because of the polluted water taken from various agricultural, industrial and service activities. The neighbouring countries followed a water policy that caused major damage to Iraq's annual water allotment. It has become necessary to establish new management of water resources in order to optimise its use and not to waste and raise the efficiency of water use to obtain higher productivity with the lowest amount of water. The study of the effect of drought on plants by exposing the plant to relatively low humidity environments or by exposing the roots of the plant to low-water stress, this is done either by controlling the amount of irrigation water or the number of irrigation times or using some organic compounds to reduce the water stress. These compounds (polyethylene glycol or Mannitol), which are based on the principle of water withdrawal from the plant with a difference in the solution potential between the inner and outer medium depending on the concentration of the solution (Dami and Hughes, 1997, Skribanek and Tomcsányi, 2008, Fuller and Hamza, 2013). Seed priming technology is one of the ways to reduce the negative impact of drought by soaking it before planting with growth regulators for a certain period. Seed priming technique is one of the ways to improve the vitality of a relatively degraded seed that rely on seed saturated in water slowly without germination. Studies showed that this technology led to the acceleration and harmony of germination and field emergence under a wide range of environmental conditions and the benefits obtained from the priming process observed in different types of seed. Sedghi *et al*., (2010) stated that the main purpose of seed priming is to increase the germination rate, reduce the average time required for germination and improve seedling growth under a wide range of environmental conditions. The results obtained by Heydecker and Coolbear, (1977) showed that the primed seeds gave early emergence in the fields of wheat, barley, maize and sorghum crops. Harris, (1996) explained that seed priming of sorghum as a way to improve the field emergence of seedlings as it found that priming of seed reduced the

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length of germination as the priming period increases from 0 to 10-12 hours. This technique has increased the susceptibility of a small seed to bear stressful environments such as drought, salinity and extreme temperatures on sorghum (Ashraf *et al*., 2005; De Oliveira *et al*., 2010). Studies have been conducted in recent years to examine the possibility of improving the seed vigour to tolerate the abiotic stress, which may be affected by soaking seed in various nutritious solutions or growth regulators (Taiz and Zeiger, 2006; Javid *et al*., 2011). The results of Siadat *et al*., (2011) indicate that soaking of degraded maize seed by gibberellic acid has a positive impact on germination, the concentration 400 ppm and soaking for 12 h., gave best germination ratio compared with the control treatment (distilled water only) and the other concentrations used (50, 100, 200 and 800 ppm) of gibberellic acid and in different times of soaking (8 and 24 hours only). Alowan and Jaddoa, (2015) indicated that there was a significant increase in the percentage of field emergence in the seed of sorghum. The treatment of seed soaking with gibberellic acid achieved the highest mean of 77.8% for the spring planting period and 92% for the autumn planting period, while the control treatment recorded the lowest mean of 60.4 and 81.8% for both periods. Aminosalicylic acid is one of the newly discovered growth regulators. The amino salicylic role is effective in stimulating plants to withstand the biotic and abiotic stress, including drought stress (Hayat and Ahmed, 2007) as well as its positive effect in freeing the plant from reactive oxygen species (ROS), cleaning and disposing of them which, if kept in cells, lead to the destruction of nucleic acids and membranes and the destruction of proteins and fats and then the death of cells and plants. Salicylic acid is one of the most important non-enzymatic antioxidants, It has also found that acid increases the activity of superoxide dismutase (SOD) enzyme which is the first line of defence to transform (H_2O_2) by enzymatic (peroxidase and catalase) into water and to eliminate its harmful effect on the plant (Hayat *et al*., 2012) as well as its role in resisting the abiotic stress, which is exposed to the plant as it increases the tolerance of the plant to the conditions of water, salt and thermal stresses and heavy metals, as it speeds up the formation of chlorophyll and carotene dyes and accelerate the process of photosynthesis and growth rate (khan *et al*., 2003; Hayat and Ahmed, 2007). It has a role opposite to the effect of abscisic acid and prevents the internal oxidation of gibberellins, auxin and cytokinins and raises the proportion of nucleic and amino acids (Kumar *et al*., 2010; Abdi *et al*., 2011) and seed germination, osmotic regulation and increased production of sugars (Fahad and Bano, 2012), protection of plastids and mitochondria from drought stress damage (Rizhsky *et al*., 2003). Singh and Usha, (2003) stated that the growing wheat plant under the influence of drought when treated with salicylic acid, the addition led to increase the accumulation of dry matter and increase the activity of the enzyme (SOD) the addition also resulted in the preservation of the nitrate reeducates enzyme. The results of the study (Sheykhbaglou *et al*., 2014) pointed out that soak the sorghum seed with gibberellic and salicylic acid to different levels of water stress (-4, -8, -12 bar) by using polyethylene glycol (PEG-6000) has a positive effect on germination rate, dry seed weight, germination index and improved germination enzyme activity compared to the unprimed seed. Therefore, this study aimed to know the effect of interference between gibberellic and salicylic acids in the germination of sorghum seed under water stress and improving germination rate and seedling growth.

Material and Methods

A laboratory experiment was carried out in the laboratories of College of Agricultural Engineering Sciences, University of Baghdad in 2017. Three factors were studied; 1st factor was three sorghum cultivars (Inqath, Rabeh and Buhoth70); 2nd factor was unprimed and primed seed which were primed by soaking it in 300+70 mg*l^{-1} of gibberellic acid (GA3) and salicylic acid, respectively, for 12 hours; 3rd factor was osmotic potential (0, -5, -9, -13 bar) which were prepared by dissolving specific quantities of polyethylene glycol (PEG-6000) (202.1 and 279.3 and 340.5 gm), respectively, in one liter of distilled water at a temperature of 25°C (Michel and Kaufmann, 1973). The following tests were carried out.

Germination ratio (%)

200 pure seed were taken from the treated seed and planted, folded in blotting paper and placed in germinator at the temperature of 25°C±5). Normal seedlings calculated at the end of the 10th day of the standard germination test (ISTA, 2013).

The radicle and plumule lengths (cm) and dry seedling weight (mg)

Radicle length measured after being separated from its point of contact with the seed and plumule after separating it from its point of contact with the hypocotyl. A ruler was used to measure the length of 10 normal seedlings at the end of the 10th day of standard germination. Radicle and plumule were put in a perforated paper bag inside an electric oven for drying at 80°C for 24 hours (Hampton and Tekrony, 1995) to measure the seedling dry weight.

Table 1: Squares mean (MS) according to variance analysis for effect of cultivars, priming and osmotic potential in the studied traits in sorghum

Source of variance	df	Germination ratio	Radicle length	Plumule length	Dry seedling weight	Seedling vigour index
C	2	345.5*	9.1867*	6.6103*	0.00144203*	312,663*
P	1	9,680.17*	2.8173*	13.1292*	0.00101016*	597,218*
OP	3	19,613.94*	676,541*	174.218*	0.02317268*	4,459,793*
C × P	2	45.17	0.1647	0.3759*	0.00009915*	1330*
C × OP	6	132.61*	1.6575*	8.0969*	0.00035806*	138,866*
P × OP	3	577.94*	0.5481*	8.2194*	0.0004563*	282,998*
C × P × OP	6	54.94*	0.1983	1.7582*	0.00017003*	21,948*
Error	72	15.28	0.114	0.1037	0.00002548	2,200
CV		7	9.72	8.26	9.71	8.64
SE		3.909	0.3377	0.322	0.005048	46.9

C = cultivars; P = priming; OP = osmotic potentials; CV = coefficient variance; SE = standard error; * = Significant at p<0.05.

Seedling vigour index (SIV)

It calculated by the equation of Abdul-Baki and Anderson, (1973).

SVI = germination ratio × (length of radicle + length of plumule).

Statistical analysis

Data were collected and analysed statistically by using the GenStat program V.12.1. Analysis of variance run according to the completely randomized design with four replications. The unbalanced design was used with most traits as some data were not balanced as seedlings of all cultivars which unprimed gave no data (germinated but died later) under the highest level of osmotic potential (-13 bar). Means compared by using the least significant difference at p<0.05 (LSD 5%). Simple correlation analysis was performed between the studied traits (Steel *et al*., 1997).

Results and Discussion

Effect of cultivars, priming and osmotic potentials in the studied traits in sorghum

The results of variance analysis (Table 1) showed that there were significant differences at the studied traits as affected by cultivars, priming and osmotic potentials and their combinations; except the effect of cultivars × priming on germination ratio and radicle length which was insignificant and the effect of cultivars × priming × osmotic potentials on radicle length which was insignificant too.

Germination ratio (%)

Buhoth70 cultivar showed superiority compared to others, while Inqath cultivar gave the lowest mean (Table 2). Cultivars may vary among them in the process of seed absorption of water, fill the tissues and restore the active growth that was resulting from the rupture of seed coat and emergence radicle and plumule. This result is consistent with Prathibha and Siddalingeshwara, (2013) about finding a significant difference between sorghum cultivars in germination ratio. The treatment of primed seed significantly exceeded the treatment of unprimed seed. Perhaps the reason for the effectiveness of seed activation is to accelerate the metabolic processes that begin with imbibition and end with the process of emergence radicle and plumule by increasing the vitality and vigour seed. This is consistent with Afzal *et al*., (2002); Siadat *et al*., (2011); Sudozai *et al*., (2013); Tian *et al*., (2014); Ali and Hamza, (2014) and Hamza and Ali, (2016, 2017). Germination ratio was decreased significantly as long as increasing levels of osmotic potentials as the control treatment gave the highest mean, while

Table 2: Germination ratio (%) by the effect of cultivars, priming and osmotic potential in sorghum.

Seed priming	Cultivars	Osmotic potential (bar)				Seed priming × Cultivars
		0	-5	-9	-13	
Primed seed	Buhoth70	94	77	69	35	68.8
	Inqath	90	76	51	38	63.8
	Rabeh	88	82	63	31	66
Unprimed seed	Buhoth70	78	73	53	0	51
	Inqath	75	62	38	0	43.8
	Rabeh	70	60	44	0	43.5
LSD 5%		5.5				NS
						Seed priming
Seed priming × Osmotic potential	Primed seed	90.7	78.3	61	34.7	66.2
	Unprimed seed	74.3	65	45	0	46.1
LSD 5%		3.2				1.6
						Cultivars
Cultivars × Osmotic potential	Buhoth70	86	75	61	17.5	59.9
	Inqath	82.5	69	44.5	19	53.8
	Rabeh	79	71	53.5	15.5	54.8
LSD 5%		3.9				2
Osmotic potential		82.5	71.7	53	17.3	
LSD 5%		2.2				

NS = Non-significant at p<0.05

Table 3: Radicle length (cm) by the effect of cultivars, priming and osmotic potential in sorghum.

Seed priming	Cultivars	Osmotic potential (bar)				Seed priming × Cultivars
		0	-5	-9	-13	
Primed seed	Buhoth70	7.4	4.6	3.3	1.5	4.2
	Inqath	5.6	4.5	3.2	1.3	3.6
	Rabeh	5.6	3.4	2.8	0.7	3.1
Unprimed seed	Buhoth70	6.2	3	2.7	-	4
	Inqath	4.1	2.9	2.3	-	3.1
	Rabeh	4	2.5	1.8	-	2.7
LSD 5%		NS				NS
						Seed priming
Seed priming × Osmotic potential	Primed seed	6.2	4.1	3.1	1.1	3.6
	Unprimed seed	4.8	2.8	2.2	-	3.3
LSD 5%		0.3				0.1
						Cultivars
Cultivars × Osmotic potential	Buhoth70	6.8	3.8	3	1.5	3.8
	Inqath	4.8	3.7	2.7	1.3	3.1
	Rabeh	4.8	2.9	2.3	0.7	2.7
LSD 5%		0.3				0.2
Osmotic potential		5.5	3.5	2.7	1.1	
LSD 5%		0.2				

NS = Non-significant at p<0.05; - No data; seed were germinated but died later under the highest level of osmotic potential (-13 bar)

the lowest mean returns to the treatment of -13 bar. This may be due to the active water role because it is a solvent and a vector of necessary materials; therefore, any shortage in its availability to the critical extent will affect the vital processes that require water readiness to complete efficiently. The combinations between cultivars and osmotic potential showed that cultivars differ in their ability to tolerate the osmotic potential at the same level of stress, the combination (Buhoth70 × 0) was significantly superior compared to others in germination ratio without being significantly different with the combination (Rabeh × 0), while the lowest mean returned to the combinations (Rabeh × -13) (Table 2). The results of the combinations between priming and osmotic potential showed that priming had improved seed performance to tolerate osmotic potential compared to the unprimed at the same stress level (Table 2), the combinations (primed seed × 0) were superior compared to others, while the lowest mean returned to the combinations (unprimed seed × -13) (Table 2). The combination among cultivars, priming and osmotic potential (Buhoth70 × primed seed × 0) significantly exceeded compared to others, without significantly different with the combination (Inqath × primed seed × 0), while the lowest mean germination rate returned to the combinations (Rabeh or Inqath or Buhoth70 × unprimed seed × -13) (Table 2). This may be due to nature of genotype, which varies relatively from one cultivar to another, as well as the role of activation process in improving seed behaviour and raise its vitality and vigour by increasing the activity of metabolic processes.

Table 4: Simple correlation coefficient values among the studied traits in sorghum under the influence of cultivars, priming and osmotic potential in sorghum.

Studied traits	Germination ratio	Radicle length	Plumule length	Dry seedling weight
Radicle length	0.902**			
Plumule length	0.812**	0.921**		
Dry seedling weight	0.834**	0.948**	0.958**	
Seedling vigour index	0.815**	0.937**	0.985**	0.956**

** Significant at p<0.01

Radicle length (cm)

The cultivar of Buhoth70 significantly exceeded the others; while cultivar of Rabeh gave the lower mean (Table 3). This may be due to the difference in genetic structures among them in the nature and speed of cells growth and their division, resulting in radicle length variation. This is consistent with Achakzai, (2009) and Prathibha and Siddalingeshwara, (2013) about a significant difference between sorghum cultivars in the average radicle length. The treatment of primed seed was superior compared to the unprimed (Table 3). The increase in radicle length of the activated seed may be due to the role of growth regulators in the process of cell division and expansion, where the size of the meristem increases as well as the number of cells dividing (Attia and Jaddou, 1995). This result is in line with Chyad, (2008) in sorghum and Al-selawy, (2011) in rice about the significant effect of soaking seeds on radicle length. The length of the radicle significantly decreased with the increasing level of osmotic potential as the treatment of control gave the highest mean, while the lowest mean returned to the treatment of -13 bar (Table 3). This may be due to the lack of ready water at a critical stage, such as the stage of germination, which requires the availability of water for its active role in the beginning and continuation of all vital processes that lead to germination at the end, including growth and division of cells in areas of differentiation such as radicle. The combinations between cultivars and

Table 5: Plumule length (cm) by the effect of cultivars, priming and osmotic potential in sorghum.

Seed priming	Cultivars	Osmotic potential (bar)				Seed priming × Cultivars
		0	-5	-9	-13	
Primed seed	Buhoth70	11.9	3.8	2.6	1.3	4.9
	Inqath	8	3.3	2.9	1.1	3.8
	Rabeh	7.3	4.8	3	0.9	4
Unprimed seed	Buhoth70	7.1	2.6	1.8	-	3.8
	Inqath	5.4	2.3	1.9	-	3.2
	Rabeh	5.1	3.6	1.2	-	3.3
LSD 5%		0.4				0.2
						Seed priming
Seed priming × Osmotic potential	Primed seed	9.1	4	2.8	1.1	4.2
	Unprimed seed	5.9	2.8	1.6	-	3.4
LSD 5%		0.3				0.1
						Cultivars
Cultivars × Osmotic potential	Buhoth70	9.5	3.2	2.2	1.3	4.1
	Inqath	6.7	2.8	2.4	1.1	3.3
	Rabeh	6.2	4.2	2.1	0.9	3.3
LSD 5%		0.3				0.2
Osmotic potential		7.5	3.4	2.2	1.1	
LSD 5%		0.2				

- No data; seed were germinated but died later under the highest level of osmotic potential (-13 bar)

osmotic potential showed that the cultivars differ in their ability to withstand the osmotic potential at the same level of stress (Table 3), the combination (Buhoth70 × 0) was significantly exceeded the others and gave the highest mean, while the lowest mean returned to the combination (Rabeh × -13) (Table 3). The combinations between priming and osmotic potential showed that primed seed had improved its performance to potential osmotic tolerance compared to the unprimed at the same level of stress (Table 3), the combination (primed seed × 0) showed superiority compared to others and gave the highest mean, while the lowest mean back to the combination (unprimed seed × -13) (Table 3). A highly significant positive correlation observed between traits of radicle length and germination ratio (Table 4).

Plumule length (cm)

The cultivar of Buhoth70 surpassed others; while Rabeh cultivar gave the lowest mean (Table 5). This result is consistent with Achakzai, (2009); Prathibha and Siddalingeshwara, (2013) about significant differences between the sorghum cultivars in plumule length. The treatment of primed seed was significantly superior compared to the unprimed (Table 5). This result is consistent with Chyad, (2008) in sorghum, Alselawy, (2011) in rice and Ali and Hamza, (2014) who found significant differences in the plumule length with the effect of seed soaking with gibberellic acid, perhaps for its active role in stimulating and regulating the biological processes that end in formation a seedling capable of relying on itself and performing photosynthesis. The length of the plumule decreased significantly with increasing levels of osmotic potential as the control treatment gave the highest mean, while the lowest mean returned to the treatment of -13 bar (Table 4). This may be due to the moisture lack, which leads to a decrease in the rate of photosynthesis and the rate of cell division and elongation. The combination of cultivars and priming showed that all cultivars had been improved their performance as a result of priming their seeds compared to the unprimed (Table 5), the combination (Buhoth70 × primed seed) was significantly higher than others and gave the highest mean, while the lowest mean backed to combination (Inqath × unprimed seed) (Table 5). The combination of cultivars and osmotic potential showed that the cultivars differ in their ability to withstand the osmotic potential at the same level of stress (Table 5), the combination (Buhoth70 × 0) was significantly exceeded the others and gave the highest mean, while the lowest mean returned to the combination (Rabeh × -13) (Table 5). The combination between priming and osmotic potential showed that priming seed has led to improved its performance to withstand osmotic stress compared to the unprimed at the same level of stress (Table 5), the combination (primed seed × 0) was significantly higher than other combinations and gave the highest mean, while the lowest mean backed to the combination (unprimed seed × -13) (Table 5). The combination between cultivars, priming and osmotic potential (Buhoth70 × primed seed × 0) was significantly superior compared to other combinations and gave the highest mean, while the lowest mean backed to the combination (Rabeh or Inqath or Buhoth70 × unprimed seed × -13) (Table 5). A highly significant positive correlation observed between the trait of plumule length and traits of germination ratio and radicle length (Table 4). This may indicate the extent of the strong relationship between radicle and plumule in providing one another with the available growth requirements to give a healthy seedling by the optimal expression of the potential energy of seed and reflect that in the growth nature and effectiveness. Hampton and Tekrony, (1995) indicated

Table 6: Dry seedling weight (mg) by the effect of cultivars, priming and osmotic potential in sorghum.

Seed priming	Cultivars	Osmotic potential (bar)				Seed priming × Cultivars
		0	-5	-9	-13	
Primed seed	Buhoth70	0.125	0.055	0.041	0.025	0.062
	Inqath	0.109	0.054	0.039	0.018	0.055
	Rabeh	0.091	0.043	0.038	0.021	0.048
Unprimed seed	Buhoth70	0.1	0.042	0.03	-	0.057
	Inqath	0.065	0.036	0.03	-	0.044
	Rabeh	0.075	0.032	0.021	-	0.043
LSD 5%		0.007				NS
						Seed priming
Seed priming × Osmotic potential	Primed seed	0.108	0.051	0.039	0.021	0.055
	Unprimed seed	0.08	0.037	0.027	-	0.048
LSD 5%		0.004				0.002
						Cultivars
Cultivars × Osmotic potential	Buhoth70	0.113	0.049	0.036	0.025	0.055
	Inqath	0.087	0.45	0.034	0.018	0.046
	Rabeh	0.083	0.037	0.029	0.021	0.043
LSD 5%		0.005				0.002
Osmotic potential		0.094	0.044	0.033	0.021	
LSD 5%		0.003				

NS = Non-significant at p<0.05; - No data; seed were germinated but died later under the highest level of osmotic potential (-13 bar)

that the seedling vigour was associated with plumule length.

Seedling dry weight (mg)

Table 7: Seedling vigour index by the effect of cultivars, priming and osmotic potential in sorghum.

Seed priming	Cultivars	Osmotic potential (bar)				Seed priming × Cultivars
		0	-5	-9	-13	
Primed seed	Buhoth70	1,818	647	407	96	742
	Inqath	1,222	590	311	86	552
	Rabeh	1,137	671	361	48	554
Unprimed seed	Buhoth70	1,041	410	237	-	562
	Inqath	713	323	158	-	398
	Rabeh	635	364	131	-	377
LSD 5%		62				31
						Seed priming
Seed priming × Osmotic potential	Primed seed	1.392	636	360	77	616
	Unprimed seed	796	366	175	-	446
LSD 5%		36				18
						Cultivars
Cultivars × Osmotic potential	Buhoth70	1,429	528	322	96	594
	Inqath	967	456	235	86	436
	Rabeh	886	517	246	48	424
LSD 5%		44				22
Osmotic potential		7.5	3.4	2.2	1.1	
LSD 5%		25				

- No data; seed were germinated but died later under the highest level of osmotic potential (-13 bar)

The cultivar of Buhoth70 significantly exceeded others; while Rabeh cultivar gave the lower mean (Table 6). The reason behind the superiority of Buhoth70 cultivar seedling by giving the highest average of dry weight belongs to its superiority in the lengths of radicle and plumule (Tables 3 and 5). The treatment of primed seeds significantly exceeded the treatment of unprimed seeds (Table 6). The reason for the dry weight increase of the growing seedling from primed seed is due to the physiological effects of increased division, elongation, cell growth, a positive reflection on radicle and plumule lengths (Tables 3 and 5), which means increased growth and improved seedling dry weight. Chyad, (2008) found a significant effect on the sorghum seed soaking on the seedling dry weight. Seedling dry weight decreased significantly with the increasing level of osmotic potential as the control treatment gave the highest mean, while the lowest mean returned to the treatment -13 bar (Table 6). This is because water stress slows or stops the growth and cellular expansion due to a change in the balance of metabolic materials, resulting in a slowdown in the construction of structural units such as protein, carbohydrates and nucleic acids (Beltrano, 2008). The combination between cultivars and osmotic potential showed that cultivars differ in their ability to withstand the osmotic potential at the same level of stress (Table 6). The combination (Buhoth70 × 0) significantly exceeded all other combinations and gave the highest mean, while the lowest mean returned to the combination (Inqath × -13) (Table 6). The combinations between priming and osmotic potential showed that priming had improved seed performance to tolerate osmotic potential compared to the unprimed at the same stress level (Table 6), the combination (primed seed × 0) was significantly higher than the rest of the other combinations and gave the highest mean, while the lowest mean backed to the combination (unprimed seed × -13) (Table 6). The combination among cultivars, priming and osmotic potential (Buhoth70 × primed seed × 0) was significantly higher than other combinations and gave the highest mean, while the lowest mean backed to the combination (Rabeh or Inqath or Buhoth70 × unprimed seed × -13) (Table 6). A highly significant positive correlation observed between the trait of dry seedling weight and all traits of germination ratio and radicle and plumule lengths (Table 4).

Seedling vigour index

Buhoth70 cultivar significantly exceeded others; while Rabeh cultivar gave the lowest mean (Table 7). The treatment of primed seeds significantly exceeded the treatment of unprimed seed (Table 7). Seedling vigour index decreased significantly with the increased level of osmotic potential as the control treatment gave the highest mean, while the lowest mean returned to the treatment -13 bar (Table 7). The combination of cultivars and priming showed that all cultivars had been improved their performance as a result of priming their seeds in comparison with unprimed (Table 7), the combination (Buhoth70 × primed seed) exceeded other combinations and gave the highest mean, while the lowest mean returned to the combination (Rabeh × unprimed seed) (Table 6). The combination between cultivars and osmotic potential showed that the cultivars differ in their ability to tolerate the osmotic potential at the same level of stress (Table 7), the combination (Buhoth70 × 0) significantly exceeded other combinations and gave the higher mean, while the lowest mean returned to the combination (Rabeh × -13) (Table 7). The combination between priming and osmotic potential showed that primed seed has improved its performance to withstand the osmotic stress compared to the unprimed at the same level of stress (Table 7), the combination (primed seed × 0) significantly exceeded other combinations and gave the higher mean, while the lowest mean returned to the combination (unprimed seed × -13) (Table 7). The combination among cultivars, priming and osmotic potential (Buhoth70 × primed seed × 0) significantly exceeded other combinations and gave the highest mean, while the lowest mean returned to the combinations (Rabeh or Inqath or Buhoth70 × unprimed seed × -13) (Table 7). The superiority of the treatments above was the result of their superiority in the traits of germination ratio and lengths of radicle and plumule (Tables 2, 3 and 5). A highly significant positive correlation observed between the trait of seedling dry weight and traits of germination ratio, radicle and plumule lengths and seedling dry weight (0.815 and 0.937 and 0.985 and 0.956), respectively, (Table 4). It seems that plumule length has the highest influence in the seedling vigour index as evidenced by the highest correlation value between them compared to other correlation values above and this may indicate the possibility of considering the length of plumule as one of the essential criteria that reflects seedling vigour, activity of division, growth and elongation.

Conclusions

It can conclude that the difference between the cultivars in tolerating drought stress was due to their potential. The increase of osmotic potential at germination stage led to decrease germination rate, which may be inhibited entirely at osmotic potential -13 bar. The technology of seed priming could be a useful technique in dry and semi-dry areas and led to improving seed performance under drought stress conditions as well as it is easy to implement and low-cost. Therefore, it can recommend priming seed of Buhoth70 cultivar before planting under conditions of drought stress or not.

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