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GERMINATION AND SEEDLING GROWTH IN PRIMED SORGHUM SEED WITH GIBBERELLIC AND SALICYLIC ACIDS

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Abstract

A laboratory experiment was conducted in the labs of Seeds Testing and Certification Department, Ministry of Agriculture in 2017 to improve germination and seedling growth in primed sorghum seeds by different concentrations and soaking durations of acids of gibberellic (GA3) (distilled water, 75, 150 and 300 mg l^{-1}), salicylic (SA) (distilled water, 40, 70 and 100 mg l^{-1}) and soaking duration (SD) (12 and 24 h). Factorial experiment in completely randomized design was applied with four r replications. The results showed the superiority of the two soaking treatments with GA3 (300 mg l^{-1}) and SA (70 mg l^{-1}) at germination ratio, radicle and plumule lengths, seedling dry weight and seedling vigour index (81.3%, 2.7 cm, 8.9 cm, 0.081 mg and 984) and (79.6%, 2.8 cm, 8.2 cm,8.2, 0.083 mg and 881.5), respectively. Soaking duration (12 h) surpassed at germination ratio and seedling vigour index (79.3% and 820.8), respectively. The combination 300×70×12 surpassed at germination ratio, radicle length and seedling vigour index (86.5%, 3.8 cm and 1308.6), respectively. A significant positive correlation relationship was showed between most traits. It can be concluded that using sorghum seed priming technology by using the combination 300×70×12 before planting, it has increased the seed vitality and vigour through improving germination ratio and seedling growth.

Key words: seed viability, seed vigour, seedling vigour, sorghum, growth regulators, soaking duration, seed priming

Introduction

The technology of seed priming through soaking in plant growth regulators before planting for certain duration is one of the most important way that used and which proved its activity and efficiency where the process of activating relates to the process of germination to improve emerging, uniform, seedling vigour and good field establishing in early time. The regulation of the process of seeds germination using this technology may result in previous responding adaptation when different stresses happen. Moreover, this technology is simple, cheap and without risk. Thus, the farmers used it to their different crops like rice, maize, wheat, mung bean, millet and any other legumes. The plants, resulted from the activated seeds, has discerned with a rate of high and rapid emergence and seedling vigour which bloom and grow up early, giving a high result in comparison to the plants resulted from inactivated seeds (Khan and Naqvi, 2011). Natural growth regulators which are widely made were used to increase the agricultural production. It is added to the plants directly, to the soil or to the seeds which soaked in its solutions to change the form of growth, the yield increase, quality improvement and facilitation of harvesting (Attiya and Jadoaa, 1999). It has been found that soaking the seeds in the solutions of the growth regulators can improve the performance of plants after its emergence (Wilkins, 1985). GA3 is considered one of the most important hormones to the plants. It plays a great role in the cell elongation and division (Wrigely and Lord, 1985), increase of the capability of plants to motivate producing some enzymes like a-amylase and decrease the falling of leaves and flowers (Hassanein *et al.,* 2005). The internal growth regulators (which exist naturally inside the seeds) like gibberellic (GA3) can decrease the inhibitory impact and the dormancy status imposed by abscisic acid (ABA) during the stages of seed development (Toyomasu *et al.,* 1994, and Bewley, 1997, Debeaujon and Koornneef, 2000, Savage and Leubner, 2006). Steinbach *et al.,* (1997) agreed with them that when they registered this note on the seeds of sorghum, seeds of maple (Nicholas *et al.,* 1994), seeds

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of maize (White *et al.*, 2000) and the seeds of lettuce (Toyomasu *et al.*, 1994). Cheyed (2008) found that the soaking of sorghum seeds in GA3 with concentration (300 mg l^{-1}) has increased its vitality and vigour to the fact that it succeeded in the first and final count test, the lengths of radicle and plumule, dry weight of seedling and cold test. Al-Selawy (2011) found that the treating of rice seeds with gibberellic under concentration 300 mg l^{-1} gave the highest rate of germination, the longest length to plumule and radicle, the highest dry weight of seedling and the highest vigour to seedling. Subedi and Ma (2005) pointed out that soaking the seeds in GA3 with concentration 20 mg l^{-1} for 30 minutes resulted in increasing the lengths of radicle and plumule of sorghum seedling. Vogt (1970), Krishnamurthy (1973), Chandra and Chauhan (1976) have found that GA3 is an essential requirement to the process of seeds germination. Steinbach *et al.*, (1997) referred that adding GA3 is necessary to get out of dormancy status of entire seeds. Some researches have found that GA3 takes control of germination through two processes; the first one is to decrease the mechanic resistance of tissues surrounded by the embryo (Groot and Karssen, 1987), and the second one is through motivating the potential capability of embryo to grow (Carpita *et al.*, 1979). Authors *et al.*, (2005) have noticed also that when the seeds of peanut are being soaked in GA3 under concentration (100, 125, 250, 300, 1000 mg l^{-1}) for (24 or 48 h), the seeds treated by concentration 125 mg l^{-1} for 48 h has showed higher rate of germination and the highest length to the plumule and radicle occurred to the treated seeds under concentration 100 mg l^{-1} for 48 h in comparison to other treatments. Ghobadi and Mohammmadi (2012) have found that when two species of wheat seeds are motivated in GA3 (0, 50, 100, 150 and 200 ppm) within time-duration (12, 18, 24 and 30 h), the concentration of 50 ppm within 24 h of soaking exceeded the rate and the rate of germination in comparison to other concentrations. Rawat and Childyal (2004) have pointed out that when they soaked three species of panacea in GA3 (100 mg l^{-1} for 24 h), it succeeded significantly to the rate of laboratory germination, field emergence and decrease the duration of germination as 10 days in comparison to the seeds which are not soaked. Yen and Carter (1972) have pointed out that soaking of sorghum seeds in GA3 (0, 10, 50, 100, 500, 1000 and 2000 mg l^{-1}) for 24 h before planting it resulted in rapid appearing of emergence in anvils and the field in all levels in comparison to the untreated seeds. Salicylic acid (SA) is one of plant hormones which play an important role in the growth of the plant and its development. It has physiological effects to the process of photo-synthesis, caring of organelles and processes of transpiration, taking ions and transferring it (Silverman *et al.*, 1995). It has also a mechanic and regulation role in the processes of the different metabolite of the plant (Popova and Uzunova, 1997). It can also change the physiology of the leaves and stem of the plant, and the structure of plastids (Rane, 1995). Azadi (2013) conducted a study using the accelerator of senescence to the seeds of sorghum. He soaked in the solutions of GA3 and SA, resulting in surpassing the treatment of pre-soaking of seeds in the rate of germination, germination index, normal seedling and the average time of germination, while the increase of senescence led to great decrease of germination characters. Hamid *et al.*, (2008) have found slight differences between the treatment of soaking of wheat seeds in SA (0 and 100 mg l^{-1}) in the germination rate and some characters of seedling. The soaked seeds under concentration 100 mg l^{-1} in SA appeared higher results to the characters of germination rate, radicle and plumule lengths, and dry weight of radicle and plumule in comparison to the control treatment which led to the least results of the mentioned characters. Due to the lack of researches of studying the effects of GA3 and SA and their interaction as well as the soaking duration, the study has aimed to shed light on the acidic impact of GA3 and SA and their interaction and the soaking duration in the seeds to improve the rate of germination and growth of sorghum seedling.

Materials and methods

A laboratory experiment was conducted in the labs of Seeds Testing and Certification Department, Ministry of Agriculture in 2017 upon the instructions of ISTA. Sorghum seeds were primed by different concentrations and soaking durations of acids of gibberellic (GA3) (distilled water, 75, 150 and 300 mg l^{-1}), salicylic (SA) (distilled water, 40, 70 and 100 mg l^{-1}) and soaking duration (SD) (12 and 24 h). Factorial experiment in completely randomized design was applied with four r replications. The seeds of "Inqath" cultivar were used. These seeds were produced in 2017 by the department of maze and sorghum researches, Agriculture Research Office, Ministry of Agriculture. The concentrations were prepared by solving one-gram gibberellic (GA3) acid which is commercially German origin put in one liter of distilled water to get a solution under concentration 1000 mg l^{-1}, and by solving one gram of SA in 30% of ethyl alcoholic where it is moved and heated (50°C) to reach to one liter in order to result in a solution under concentration 1000 mg l^{-1} as to get the required concentrations above. The prepared concentrations were put in a closed glass bottle

with black sacs to prevent its oxidation. The seeds were subject to the following tests:

1- Germination ratio (%): 200 pure seeds were taken from the treated seeds and implanted in four recurrences on blotting paper, using the way of wrapping. It was put in the germinator within 25°C ± 5. The normal seedlings were calculated in the 10th day from the duration of test the standard germination, and the results were transferred into percentage (ISTA, 2013).

2- Lengths of radicle and plumule (cm) and seedling dry weight (mg): The length of radicle was measured after separating it from the point of connecting with the seed and the plumule after separating it from the point of connecting with hypocotyl (AOSA, 1988) through a ruler to ten natural seedlings after finishing the duration of test of standard germination. The radicle and plumule, then, are put in a punched paper sac inside an electric oven to dry it on 80°C for 24 h (Hampton and Tekrony, 1995) to measure the dry weight of seedling.

Seedling vigour index (SIV): It was calculated by the equation of Abdul-Baki and Anderson (1973); SVI = germination ratio × (length of radicle + length of plumule).

Results and Discussion

Effect of concentration and soaking duration in GA3 and SA in germination and growth of seedling

The results of analysis variance (Table 1) refer that there are significant differences in the studied characters due to the impact of concentration and soaking duration within GA3 and SA and the combinations except the effect of soaking duration in the lengths of radicle and plumule, dry weight of seedling and the effect of the two combinations between GA3 and SA × the soaking duration in germination ratio, dry weight of seedling and the three-interaction effect in the length of plumule, dry weight of seedling; it was not significant, knowing that the highest effect of the independent factors in most characters was because of the effect of concentration of GA3, the effect of salicylic concentration secondly and the effect of soaking duration thirdly.

Germination ratio

The 12 h of soaking duration gave 79.3% and surpassed significantly the 24 h which gave 75.1% (Table 2). The soaking duration affect directly and indirectly to the process of imbibition and absorbing of the seed to the water and filling its tissues. The increase of soaking duration may lead to increase infiltration of electrolytes, especially the weak seeds which have no vitality or enough vigour to arrange membrane to the fact that it prevents or decrease the infiltration of electrolytes, in addition to start seed coat tears, emergence of radicle or plumule or both when it regains its active growth. The concentration of GA3 300 mg l^{-1} gave 81.3% and surpassed significantly against the rest of the studied concentration. The lowest average of germination ratio which was 73.4% belonged to the control treatment (Table 2). The concentration of SA 70 mg l^{-1} gave 79.6% and surpassed significantly against the control treatment (74.1%) without differing significantly with the rest of the studies concentrations (Table 2). This may result from the efficiency of activating the seeds in accelerating the series of the metabolite processes which begin with imbibition and end with the process of radicle and plumule emergence through motivating the potential energy and improving the behavior of seeds and raising vitality and vigour. The combination of GA3 and SA (300 × 70) surpassed significantly against most of other combinations in this character and gave the highest average (85.3%) without differing significantly with some other combinations (75 × 40), (150 × 70), (300 × 40) and (300 × 100). The lowest average of the rate of germination was 70% which belongs to the treatment of 75×0 (Table 2). The combination of GA3, SA and SD (300 × 70 × 12) surpassed significantly against most other combinations. It gave the highest average which amounted 86.5% without differing significantly in some of other combinations, while the lowest average of the rate germination was (64%) which belongs to the combination (300 × 0 × 24) (Table 2).

Table 1: Mean of squares according to the analysis of variance to the effect of concentration and soaking duration in gibberellic and salicylic acids in the studies traits in sorghum.

Source of variance	df	Germinat-ion ratio	Radicle length	Plumule length	Seedling dry weight	Seedling vigour index
GA3	3	336.53*	2.3938*	77.359*	0.0016755*	901181*
SA	3	178.28*	1.1400*	8.284*	0.0011363*	148308*
SD	1	569.53*	0.3393	0.722	0.0003229	120062*
GA3×SA	9	123.11*	2.9303*	6.818*	0.0007437*	67260*
GA3×SD	3	60.03	3.5392*	10.957*	0.0003146	202929*
SA×SD	3	21.78	1.8610*	11.965*	0.0001596	170802*
GA3×SA×SD	9	124.95*	1.82077*	3.403	0.0001757	84499*
Error	96	51.51	0.2633	2.239	0.0001628	25290
CV		9.3	20.6	19.6	17.0	20.1
SE		7.177	0.5131	1.496	0.01276	159.0

GA3 gibberellic acid; SA salicylic acid; SD soaking duration; CV coefficient variance; SE standard error; * Significant at pd”0.05

Radicle Length (cm)

The concentration of GA3 150 mg gave 2.8 cm and surpassed significantly against all the rest of concentrations without differing significantly with the concentration 300 mg l^{-1} which gave 2.7 cm and the lowest average of radicle length (2.2 cm) belonged to the control treatment (Table 3). The concentration of SA 70 mg l^{-1} gave 2.8 cm and surpassed significantly against all the studies concentrations, while the lowest average of radicle length belonged to the treatment of concentration 100 mg l^{-1} (2.4 cm) (table 3). The combination of GA3 and SA (150 × 100) surpassed significantly against the most of other combinations in the length of radicle. The highest average amounted 3.3 cm without differing significantly with some other combinations (300 × 70), (150 × 40) and (150 × 70), while the lowest average of radicle length (1.6 cm) belonged to the treatment 0 × 40 (Table 3). The activation of seeds in GA3 and SA may lead to the difference of growth speed to the cells and its fissions, resulting in disparity of the radicle length. The combination of GA3 and SD (150 × 24) surpassed significantly against the rest of combinations by giving the highest average of radicle length (3.2 cm) without differing significantly with the combination (300 × 12), while the lowest average of radicle length was (2.2 cm) which belonged to the treatment (0 × 24) (Table 3). The combination of SA and SD (70 × 12) surpassed significantly against the rest combinations by giving the highest average of radicle length (3cm) without differing significantly with the two combinations (100 × 12) and (40 × 24), while the lowest average of radicle length (2cm) belonged to the combination (100 × 24) (Table 3). The combination of GA3, SA and SD (300 × 70 × 12) surpassed significantly to the other combinations in the radicle length. The highest average is 3.8 cm without differing significantly with some other combinations, while the lowest average of radicle length is (0.8cm) which belonged to the combination (75×100×24) (Table 3). This active factor may affect motivating the metabolite processes and the processes of water dissolution which happens during germination as well as the soaking duration and its active impact on starting and continuing all vital processes which lead finally to germination like the processes of growth and dividing the cells in the distinguished areas like radicle. A significant positive high correlation relationship appeared between radicle length and germination ratio (0.255) (Table 4)

Table 2: Germination ratio (%) as affected by concentration (mg l^{-1}) and soaking duration (h) in gibberellic and salicylic acids in sorghum seed.

SD (h)	GA3 (mg l^{-1})	SA (mg l^{-1})				SD× GA3
		control	40	70	100	
12	Control	77.0	74.5	76.0	76.0	75.9
	75	66.0	83.5	84.0	81.0	78.6
	150	75.0	78.0	85.0	73.0	77.8
	300	86.0	83.5	86.5	84.5	85.1
24	Control	72.0	70.5	69.0	72.0	70.9
	75	74.0	83.5	71.0	74.0	75.6
	150	79.0	72.0	81.0	74.0	76.5
	300	64.0	82.0	84.0	80.0	77.5
LSD 5%			10.1			NS
						SD
SD×SA	12	76.0	79.9	82.9	78.6	79.3
	24	72.3	77.0	76.3	75.0	75.1
LSD 5%			NS			2.5
						GA3
GA3×SA	Control	74.5	72.5	72.5	74.0	73.4
	75	70.0	83.5	77.5	77.5	77.1
	150	77.0	75.0	83.0	73.5	77.1
	300	75.0	82.8	85.3	82.3	81.3
LSD 5%			7.1			3.6
SA		74.1	78.4	79.6	76.8	
LSD 5%			3.6			

GA3 gibberellic acid; SA salicylic acid; SD soaking duration; NS Non significant at p≤0.05.

Table 3: Radicle length (cm) as affected by concentration (mg l^{-1}) and soaking duration (h) in gibberellic and salicylic acids in sorghum seed.

SD (h)	GA3 (mg l^{-1})	SA (mg l^{-1})				SD× GA3
		control	40	70	100	
12	control	2.5	2.0	2.6	1.6	2.2
	75	2.5	2.4	2.9	2.9	2.7
	150	1.0	3.0	2.6	2.9	2.4
	300	3.3	1.5	3.8	3.2	2.9
24	control	2.7	1.3	2.7	2.0	2.2
	75	2.7	3.1	1.5	0.8	2.0
	150	2.4	3.3	3.4	3.6	3.2
	300	2.4	2.7	2.7	1.7	2.4
LSD 5%			0.7			0.4
						SD
SD×SA	12	2.3	2.2	3.0	2.7	2.5
	24	2.5	2.6	2.6	2.0	2.4
LSD 5%			0.4			NS
						GA3
GA3×SA	control	2.6	1.6	2.6	1.8	2.2
	75	2.6	2.8	2.2	1.9	2.4
	150	1.7	3.2	3.0	3.2	2.8
	300	2.9	2.1	3.2	2.5	2.7
LSD 5%			0.5			0.3
SA		2.4	2.4	2.8	2.3	
LSD 5%			0.3			

GA3 gibberellic acid; SA salicylic acid; SD soaking duration; NS Non significant at p≤0.05.

which is a low value due to dissimilarity of results between the two traits.

Plumule length (cm)

The concentration of GA3 300 mg l^{-1} gave (8.9 cm) and surpassed significantly against the rest of concentrations without differing significantly with the concentration 150 mg l^{-1} (8.8 cm). and the lowest average of plumule length was (5.6 cm) which belonged to the control treatment (table 5). The concentration of SA 70 mg l^{-1} gave (8.2 cm) and surpassed significantly against the concentration 100 mg l^{-1} (6.9 cm) in the length of plumule without differing significantly with the treatments of control and concentration 40 mg l^{-1} (table 5). The combination of GA3 and SA (300×70) surpassed significantly against some other combinations in the length of plumule. It showed the highest average which amounted 9.6 cm without differing significantly with some other combinations which are: (300×100), (150×70), (150×100) and others, while the lowest average of plumule length was (4.7 cm) which belonged to (75×100) (Table 5). The significant differences in the length of plumule under the impact of seeds soaking in salicylic and GA3 and SA may result from its efficient role to motivate and regulate the vital processes and generate a seedling which is able to invest the available requirements of growth, reaching to depend on itself to do photo-synthesis. The combination of concentration of GA3 and SD (150×24) surpassed significantly against the rest of combinations by showing the highest average of plumule length (9.6 cm) without differing significantly with the combination (300×12), while the lowest average of plumule length was (5.3 cm) which belonged to the treatment (0×24) (table 5). The combination of concentration of SA and SD (70×12) surpassed significantly against the rest of

Table 4: Simple correlation values between traits studied in sorghum as affected by concentration and soaking duration in gibberellic and salicylic acids.

Studied traits	Germin-ation ratio	Radicle length	Plumule length	Seedling dry weight
Radicle length	0.255**			
Plumule length	0.324**	0.415**		
Seedling dry weight	0.080	0.433**	0.616**	
Seedling vigour index	0.629**	0.636**	0.899**	0.571**

*Significant at p≤0.05 **Significant at p≤0.01

Table 5: Plumule length (cm) as affected by concentration (mg l^{-1}) and soaking duration (h) in gibberellic and salicylic acids in sorghum seed.

SD (h)	GA3 (mg l^{-1})	SA (mg l^{-1})				SD× GA3
		control	40	70	100	
12	control	5.2	6.2	6.5	5.8	5.9
	75	7.8	7.2	8.9	6.0	7.5
	150	8.3	7.0	9.2	7.5	8.0
	300	9.2	7.8	11.4	9.2	9.4
24	control	5.4	5.7	5.6	4.4	5.3
	75	8.6	8.4	7.6	3.4	7.0
	150	10.1	10.1	8.3	9.9	9.6
	300	7.4	9.1	7.9	9.2	8.4
LSD 5%			NS			1.1
						SD
SD×SA	12	7.6	7.1	9.0	7.2	7.7
	24	7.9	8.3	7.3	6.7	7.6
ÃLSD 5%			1.1			NS
						GA3
GA3×SA	control	5.3	6.0	6.0	5.1	5.6
	75	8.2	7.8	8.2	4.7	7.2
	150	9.2	8.5	8.7	8.7	8.8
	300	8.3	8.5	9.6	9.2	8.9
LSD 5%			1.5			0.7
SA		7.8	7.7	8.2	6.9	
LSD 5%			0.7			

GA3 gibberellic acid; SA salicylic acid; SD soaking duration; NS Non significant at p≤0.05

Table 6: Plumule length (cm) as affected by concentration (mg l^{-1}) and soaking duration (h) in gibberellic and salicylic acids in sorghum seed.

SD (h)	GA3 (mg l^{-1})	SA (mg l^{-1})				SD× GA3
		control	40	70	100	
12	control	0.063	0.061	0.073	0.079	0.069
	75	0.085	0.072	0.088	0.056	0.075
	150	0.074	0.085	0.078	0.078	0.079
	300	0.078	0.078	0.105	0.072	0.083
24	control	0.072	0.058	0.075	0.060	0.066
	75	0.070	0.078	0.068	0.041	0.064
	150	0.077	0.090	0.080	0.086	0.083
	300	0.069	0.081	0.094	0.073	0.079
LSD 5%			NS			NS
						SD
SD×SA	12	0.075	0.074	0.086	0.071	0.077
	24	0.072	0.077	0.079	0.065	0.073
LSD 5%			NS			NS
						GA3
GA3×SA	control	0.067	0.059	0.074	0.070	0.068
	75	0.078	0.075	0.078	0.049	0.070
	150	0.076	0.087	0.079	0.082	0.081
	300	0.073	0.080	0.099	0.073	0.081
LSD 5%			0.013			0.006
SA		0.074	0.075	0.083	0.068	
LSD 5%			0.006			

GA3 gibberellic acid; SA salicylic acid; SD soaking duration; NS Non significant at p≤0.05

combinations by showing the highest average of plumule length (9 cm) without differing significantly with the combination (40×24), while the lowest average of plumule length was (6.7 cm) which belonged to the treatment (100×24) (Table 5). A high positive significant correlation relationship appeared between the plumule length and both of germination ratio and radicle length (0.324 and 0.415), respectively, (Table 4). This may refer to the nature of the relationship between the rate of germination and radicle and plumule length which depends on the status of balance in investing the available requirements of growth to produce a normal seedling reflects the potential energy in the seed itself.

Seedling dry weight (mg)

The concentration of GA3 300 mg l^{-1} gave (0.081 mg) and surpassed significantly against the concentration 75 mg l^{-1} and the control treatment without differing significantly with the concentration 150 mg l^{-1} of the seedling dry weight. The lowest average was (0.066 mg) which belonged to the control treatment (table 6). The concentration of SA 70 mg l^{-1} gave (0.083 mg) and surpassed significantly against the rest of concentrations in the dry weight of seedling, while the lowest average was (0.068 mg) which belonged to the treatment of concentration 100 mg l^{-1} (Table 6). The combination of GA3 and SA (300×70) surpassed significantly against all the rest of combinations except the combination (150×40) which showed the highest average of the dry weight of seedling (0.099 mg), while the lowest average of dry weight of seedling was (0,049 mg) which belonged to the combination (75×100) (table 6). A high positive correlation relationship between the character of seedling dry weight and each character of plumule and radicle lengths (0.433 and 0.616), respectively, (Table 4). This character is seen that it is affected by the length of plumule which is higher than its effect of the radicle length. That value consolidates the higher relationship between it and the length of plumule in comparison to the value of relationship between it and the length of radicle.

Table 7: Seedling vigour index affected by concentration (mg l^{-1}) and soaking duration (h) in gibberellic and salicylic acids in sorghum seed.

SD (h)	GA3 (mg l^{-1})	SA (mg l^{-1})				SD× GA3
		control	40	70	100	
12	control	598.3	608.7	686.3	563.4	614.2
	75	689.7	803.4	996.4	727.6	804.3
	150	692.7	774.8	1001.2	774.5	810.8
	300	1079.3	780.3	1308.6	1047.7	1054.0
24	control	594.8	491.2	570.2	467.8	531.0
	75	839.2	961.7	656.1	308.5	691.4
	150	991.7	962.7	944.2	996.4	973.7
	300	626.3	975.7	888.9	877.6	842.1
LSD 5%			223.2			111.6
						SD
SD×SA	12	765.0	741.8	998.1	778.3	820.8
	24	763.0	847.8	764.8	662.6	759.5
LSD 5%			111.6			55.8
						GA3
GA3×SA	control	596.6	549.9	628.2	515.6	572.6
	75	764.4	882.6	826.3	518.0	747.8
	150	842.2	868.7	972.7	885.4	892.3
	300	852.8	878.0	1098.7	962.7	948.0
LSD 5%			157.8			78.9
SA		764.0	794.8	881.5	720.4	
LSD 5%			78.9			

GA3 gibberellic acid; SA salicylic acid; SD soaking duration

Seedling vigour index

The SD (12 h) gave (820.8) and surpassed significantly against the SD (24 h) which gave (759.5) in the seedling vigour index (Table 7). The concentration of GA3 300 mg l^{-1} gave (948) and surpassed significantly against the rest of concentrations without differing significantly with the concentration 150 mg l^{-1} (892.3) and the lowest average of the seedling vigour index was (572.6) which belonged to the control treatment (Table 7). The concentration of SA 70 mg l^{-1} gave (881.5) and surpassed significantly against all the studied concentrations, while the lowest average of seedling vigour index belongs to the treatment of concentration 100 mg l^{-1} (720) (Table 7). The combination of GA3 and SA (300×70) gave (1098.7) and surpassed significantly against the whole combinations except two combinations (150×70) and (300×100) in the seedling vigour index, while the lowest average was (515.6) which belonged to the treatment (0×100) (table 7). The combination between the concentration of GA3 and SD (300×12) surpassed significantly to all other combinations by giving it the highest average of the seedling vigour index (1054) without differing significantly with the treatment (150×24), while the lowest average (531) belonged to the combination (0×24) (table 7). The combination between the concentration of SA and SD (700×12) surpassed significantly to all other combinations by giving the highest average of the seedling vigour index (998.1), while the lowest average which is (662.6) belongs to the combination (100×24) (table 7). The combination between the concentration of GA3, SA and SD (300×70×12) surpassed significantly to all other combinations by giving the highest average of the seedling vigour index (1308.6), while the lowest average (308.5) belonged to the combination (75×100×24) (Table 7). The surpassing of

the studies factors in this trait may belong to its surpassing in the two traits of germination ratio and plumule length, and similarity of the results of these traits is rather an evidence (Tables 2 and 5). A high significant positive correlation relationship appeared between the seedling vigour index and each traits of germination ratio, the lengths of radicle and plumule and dry weight of seedling (0.629, 0.636, 0.899 and 0.571), respectively, (Table 4). The length of plumule seems to be the highest effective to the seedling vigour index to the fact that the value is the highest in comparison to the rest of the other connection values mentioned-above. This may refer to the possibility of enumerating the length of plumule as one of the main important criteria which reflect the vigour of seedling. Thus, this interprets that the rising of germination rate does not necessarily reflect the vigour of seedling like plumule due to activating the process of fission, growth and prolonging.

Conclusions

It can be concluded that there is an important role played by GA3 and SA and the soaking duration in the seeds of sorghum before planting it which leads to improvise the germination of seeds and growth of seedlings. The technology of seed priming is one of the effective technologies to improve the vitality and vigour of seeds as well as it is easy to be implemented and low cost.

References

Abdul-Baki, A.A. and J.D. Anderson (1973). Vigor determination in soybean seed by multiple criteria. *Crop Sci.,* **13:** 630-633.

Al-Selawy, R.L.A. (2011). Response of growth and yield of some rice cultivars to the seed enhancement (Doctoral dissertation, Ph. D. Thesis. University of Baghdad, College of Agriculture, Department of Field Crops).

Association of Official Seed Analysts (AOSA) (1988). Rules for Testing Seeds. *J. Seed Tech.,* **12(3):** 109.

Attiya, H.J. and K.A. Jadoaa (1999). Plant Growth Regulator Theory and Application. Book House Publish, Baghdad. P .327.

Azadi, M.S., E. Younesi and S.A. Tabatabaei (2013b). Seed germination, seedling growth and enzyme activity of wheat seed primed under drought and different temperature conditions. *Journal of Stress Physiology & Biochemistry,* **9(4):** 2013, pp. 310-318 ISSN 1997-0838.

Authors, B.E., A.I. Ozguven and Y. Nikaeyma (2005). The effect of GA3 applications on pistachio nut seed germination and seedling growth. http://www.actahort.org.

Bewley, J.D. (1997). Seed germination and dormancy. *The Plant Cell,* **9:** 1005 - 1066.

Carpita, N.C., C.W. Ross and M.W. Nabors (1979). The influence of plant growth regulators on the growth of the embryonic axes of red, and far- red treated lettuce seeds. *Plant,* **145:** 516 - 522.

Chandra, J.P. and P.S. Chauhan (1976). Note on germination of spruce seeds with gibberellic acid. *Indian Forester,* **102(10):** 721 - 725.

Cheyed, S.H. (2008). Effect of gibberellic acid on viability and seed vigor of sorghum (*Sorghum bicolor* L. Moench) resulted from different plant population. M. Ph (Doctoral dissertation, Thesis. University of Baghdad, College of Agriculture, Department of Field Crops).

Debeaujon, I. and M. Koornneef (2000). Gibberellin requirement for Arabidopsis seed germination is determined both by test a characteristic and embryonic abscisic acid. *Plant Physiology,* **122:** 415 - 424.

Ghobadi, M., M.S. Abnavi, S.J. Honarmandi, M.E. Ghobadi and G.R. Mohammadi (2012). Effect of hormonal priming (GA3) and osmopriming on behavior of seed germination in wheat (*Triticum aestivum* L.). *Journal of Agricultural Science,* **4(9):** 244-250.

Groot S.P.C. and C.M. Karssen (1987). Gibberellins regulate seed germination in tomato by endosperm weakening: a study with gibberellins - deficient mutants. *Plant,* **171:** 525 - 531.

Hamid, M., M.Y. Ashraf, K.U. Rehman and M. Arashad (2008). Influence of salicylic acid seed priming on growth and some biochemical attributes in wheat grown under saline conditions. *Pak. J. Bot.,* **40(1):** 361-367.

Hampton, J.H. and D.M. Tekrony (1995). Handbook of Vigor Test Methods. 3rd Edn. International Seed Testing Association. (ISTA). Zurich. pp. 102.

Hassanien, R.A., H.K. Khattab, H.M. EL- Bassiouny and M.S. Sadak (2005). Increasing the active constituents of sepals of *Zea mays* L. plant by applying Gibberellic acid and benzyladenine. *J. appl Sci. Res.,* **1(2):** 137- 146.

International Seed Testing Association (ISTA) (2013). International Rules for Seed Testing. Adopted at the ordinary meeting 2012, Venlo, the Netherlands to become effective on 1st January 2013, Chapter 5.

Karssen, C.M., S. Zagorsk, J. Kepcznsli and S.P.C. Groot (1989). Key role for endogenous gibberellins in the control of seed germination. *Annals of Botany,* **63:** 71-80.

Khan, N. and F. Naqvi (2011). Effect of water stress on bread wheat hexaploids. *Current Res. J. of Boil. Sci.,* **3(5):** 487-498.

Krishnamurthy, H.N. (1973). Gibberellins and plant growth. *Wiley Eastern Limited, New Delhi,* **356:** 19 - 114.

Nicolas, C., D. Poulsen, F. Eriksen and E.N. Nicolas (1997). The expression of absisic acid responsive glycine - rich protein coincides with the level of seed dormancy in *Fagus sylvatica . Plant and Cell Physiology,* **(38):** 1303 - 1310.

Popova, L., T. Pancheva and A. Uzunova (1997). Salicylic acid:

properties, biosynthesis and physiological role. *Bulg. J. Plant Physiol.*, **23(1-2):** pp.85-93.

Rane, J., K.C. Lakkineni, P.A. Kumar and Y.P. Abrol (1995). Salicylic acid protects nitrate reductase activity of corn leaves. *Plant physiol. Biochem.*, **22:** 119 - 121.

Rawat, B.S., C.M. Sharma and S.K. Childyal (2004). Improvement of seed germination in three important conifer species by gibberellic acid (GA3). *J. of Ecology and Application*, pp. **8:** http://www.viewArticlephp.htm.

Savage, F. and M. Leubner (2006). Seed dormancy and the control of germination. *New Phytologist*, **171:** in press. Blockwell Science. http://www.new phytologist.org.

Silverman, P., M. Seskar, D. Kanter, P. Schweizer, J.P. Metraux and I. Raskin (1995). Salicylic acid in *Zea mays* L., biosynthesis, conjugation and possible role. *Plantphysio*, **108:** 633 -639.

Stefanov, B.J., L.K. Lliev and N.I. Popova (1998). Influence of GA3 and 4-PU-30 on leaf protein composition, photosynthetic activity and growth of maize seedlings. Biol. *Plant*, **41(1):** 57.

Steinbach, H.S., R.L. Benech-Arnold and R.A. Sanchez (1997). Hormonal regulation of dormancy in developing sorghum seeds. *Plant Physiology*, **113:** 149 - 154.

Subedi, K.D. and B.L. Ma (2005). Seed priming does not improve corn yield in a humid temperate environment. *Agron. J.*, **97:** 211-218.

Toyomasu, T., H. yamanc, N. Murofushi and Y. Inow (1994). Effects of exogenously applied gibberellins and red light on the endogenous levels of abscise acid in photoblastic lettuce seeds. *Plant and Cell Physiology*, **35:** 127-129.

Vogt, A.R. (1970). Effect of gibberellic acid on germination and initial seeding growth of northern oak. *Forest Sciences*, **16(4):** 453 - 459.

White, C.N., W.M. Hedden and P. Rivin (2000). Gibberellins and seed development maize .1. Evidence that gibberellins abscisic acid gaverns germination versus maturation path ways. *Plant Physiology*, **122:** 1081-1088.

Wilkins, M.B. (1985). Advanced Plant Physiology. (part 2). The Pitman Press, Bath, Great Britain.

Wrigely, A. and J.M. Lord (2014). The effect of gibberellic acid on organelle biogenesis in the indosperm of germination corn seeds. *J. Exp. Botany*, **28(2):** 345-353.

Yen, S.T. and O.G. Carter (1972). The effect of seed pretreatment with gibberellic acid on germination and early establishment of grain Sorghum. *Australian J. of Experimental Agriculture*. http://www.publish.csiro. aulnid/72/paper/EA 9720653.htm.