

The effect of seed priming with salicylic acid on the germination of two sorghum varieties

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Abstract

A laboratory experiment was conducted at the Center of Desert Studies- University of Anbar, to investigate the effect of seed priming with salicylic acid. Five levels (0, 45, 90, 180, 360 mg L⁻¹) of salicylic acid were applied to two plant varieties of sorghum (Tabat, Rabeh). The experiment was carried out according to the Complete Randomized Design (CRD) with four replications. The first factor represents the two sorghum varieties, while the second factor represents the seed activation treatments. The results varied: the Rabeh variety surpassed each of the germination percentages (53.55), root length (4.075 cm), shoot length (4.676 cm), seedling vigor (506.4), dry weight of the seedling (0.022 g), and seedling vigor index (1.250). As for the concentration of salicylic acid, the S2 concentration recorded the highest mean values for all germination parameters, root length, shoot length, dry weight of the seedling vigor, which reached 77.63%, 5.413 cm, 6.088 cm, 0.028 g, 913.9 and 2.187 respectively. It was noted that the high concentrations of salicylic acid showed a negative effect on the studied traits. As for the interaction between the factors, no significant effects appeared in most of the traits, indicating the independence of the effect of each factor individually. It can be concluded that the activation of seeds by salicylic acid can improve performance, but the appropriate concentration plays a decisive role in this process.

Keywords: Randomized Design, Desert Studies, salicylic acid, sorghum.

Introduction

Sorghum is considered one of the prominent and distinguished crops globally, as it is an effective solution to bridge the food shortage gap [20]. Sorghum plants suffer from low germination rates due to abiotic stresses (drought, high temperatures, poor nutrient soils), which negatively impact field establishment and overall productivity. Consequently, seed germination is used to improve seed priming technology, though to overcome the assumed challenges, [12] [15]. Seed priming is an innovative, low-cost, and ecologically friendly plan. Its goal is to develop seed germination, vigor, and the ability to survive biotic and abiotic stresses to enhance productivity. Soaking the seeds in a priming solution under specific environmental conditions for a limited period is called the seed priming process; then, drying them occurs, all the processes are completed before radicle appearance [6], either using plant hormones or adding some chemical compounds as oxidants to exceed the obstacles to biotic and abiotic stresses. Environmental circumstances affect seed germination by increasing their ability to bear biotic and abiotic stresses in field crops. There is proof that plant diseases may be affected by treating the seeds with some

catalyzers, which can show a visible increase in their defense reactions, so enduring biotic or abiotic stress [8]. stated that salicylic acid crucially helps the plant deal with environmental conditions to gain upgraded protection counter to different environmental stresses such as salinity, drought, and heat. Shihab and Hamza [19] mentioned that salicylic acid plays a vital role in all plant growth parameters, including Radicle and plumule lengths, the seedling vigor index, dry weight of seedlings. Furthermore, the plants that grow from the improved seeds show a quick and high rate of growth [9] [22].

Materials and Methods

The experiment was conducted at the Desert Studies Center laboratories at the University of Anbar in 2025, according to a completely randomized design (CRD) with four replicates and two factors. The first factor includes two varieties of sorghum cultivars, (Rabeh and Tabat) symbolized as V1 and V2 respectively. The seeds were taken from the University of Anbar/Desert Studies Center. The second factor (salicylic acid) has five concentrations: 0, 45, 90, 180, and 360 mg.L-1, symbolized as S0, S1, S2, S3, and S4 respectively.

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To determine the optimal concentration of salicylic acid and to select the variety that shows a noticeable response to stimulation treatments during the laboratory experiment. The seeds were sterilized using a 10% sodium hypochlorite solution for 10 minutes, then washed and soaked in distilled water three times to remove the effects of the sterilizing agent. The concentrations of salicylic acid were determined according to the previous treatments. The seeds were then soaked in distilled water for 24 hours at 20°C, and all the previous treatments were dried at room temperature (25°C) for 48 hours until reaching the original weight of the seeds. 200 seeds from each concentration of salicylic acid were taken and sown in four replicates, with 50 seeds per replicate, using plastic pots with a diameter of 9 cm. The cultivation was done at a temperature of (25±2)°C, and the number of germinated seeds was documented daily.

1. The percentage of germination (%): Two hundred pure seed samples were selected and tested. Healthy seedling growth was observed on the 10th day after the start of the germination test. The results were then converted to percentages according to ISTA 2008 standards [5].

2. The lengths of the root, stem, and leaf (cm): were measured during the standard plant examination. Ten randomly selected normal seedlings were collected after the test period (10 days), the roots were separated from the attached seeds, and the lengths of the roots, stems, and leaves were measured individually using an ISTA 2008 ruler [5].

3. The total weight of the seedlings (mg): was measured during the standard plant examination. A random sample of ten normal seedlings was taken after the test period (10 days), where the root, stem, and leaf of each were separated, placed in a perforated paper bag, and dried at 80°C for 24 hours. The dry seedling weight was calculated using a balance with four

decimal place accuracy by dividing the total dry weight of the seedlings by their number [5].

4. Seedling vigor: This feature was calculated using the following formula: Seedling vigor index = (Root length % + Shoot length %) [14].

5. Seedling vigor index: This feature was calculated using the following formula: Seedling vigor index = Seedling fresh weight x Germination percentage [3].

Percentage of seed germination

The results in Table (1) showed a significant difference between the cultivars in terms of salicylic acid concentration, while the interaction between the cultivars and the silicon concentrations did not show any significant differences in terms of germination percentage. The cultivar Rabeh was distinguished by the highest average, reaching 53.55%, which is significantly higher by 14.15% compared to the Tabat cultivar, in agreement with what was concluded by Ahmed et al. [1], Sari and Juniarti [16], who indicated the existence of significant differences between the cultivars in this characteristic. The soaking concentrations with salicylic acid showed significant differences for this trait, where soaking with salicylic acid had a positive effect with increasing concentration levels, as the concentrations S0 and S1 recorded averages of 40.00 and 42.63 respectively, which did not differ significantly from each other, and the superiority of low concentrations in the property of germination rate may be due to their role in increasing the growth of the radicle and plumule as a result of their role in increasing the transfer of nutrients from the endosperm to the sink, and this is consistent with what was reached by Shihab and Hamza [19] and Alzubaidi, Zwain [2], and Sheykhbaglou [18], who confirmed the positive effect of low concentrations of salicylic acid on the percentage of plants.

Table (1) Effect of soaking sorghum seeds in varying concentrations of salicylic acid on germination percentage

Varieties	Salicylic Acid					Varieties average
	S0 0	S1 45	S2 90	S3 180	S4 360	
V1 Rabeh	45.00	45.00	87.75	45.00	45.00	53.55
V2 Tabat	35.00	40.25	67.50	28.50	25.75	39.40
Treatments average	40.00	42.63	77.63	36.75	35.38	
LSD	S 9.4	VXS NS			V 5.94	

Radicle Length (cm)

The results in Table (2) indicate that the Rabeh variety had the highest average at 4.075 cm, with a significant difference of 0.900 cm compared to the Tabat variety. These results were consistent with what was reported by Sari and Juniarti et al. [16], Those who drew attention to the existence of statistically significant differences between the varieties with respect to this trait. There is a statistically significant difference between the treatments in terms of what is related to this characteristic, with the highest concentration of S2 on average, which relates to the effect of salicylic acid. The gap was 5.413 cm, with a significant difference of 1.988 and 1.288 cm for the S0 and S1 concentrations, respectively. No significant differences were observed for those with the lowest concentrations. A positive effect was observed, although there were no significant differences.

While increasing the concentration of salicylic acid up to S2 concentration, the high concentrations of salicylic acid showed a negative effect on this characteristic. As for the interactions between the concentrations of salicylic acid and the groups, no significant differences were observed, and the superiority of the low levels of salicylic acid may be due to its role in increasing the availability of ready-made materials in the radicle region, and these results were consistent with what Shihab and Hamza [19], Alzubaidi and Zwain [2] and Sheykhabaglou et al. [18] found regarding the varied effect of salicylic acid on radicle length.

Table (2) Effect of soaking sorghum seeds in varying concentrations of salicylic acid on radicle length (cm)

Varieties	Salicylic Acid					Varieties average
	S0 0	S1 45	S2 90	S3 180	S4 360	
V1 Rabeh	3.500	4.500	6.075	3.325	2.975	4.075
V2 Tabat	3.350	3.750	4.750	2.488	1.538	3.175
Treatments average	3.425	4.125	5.413	2.906	2.256	
LSD	S 0.954	VXS NS			V 0.604	

Plumule length (cm)

Based on the results extracted from Table (3), there is a significant difference between the varieties, where the Rabeh variety was characterized by the highest average of 4.676 cm, with a significant difference of 1.196 cm compared to the Tabat variety. This result is consistent with Sari and Juniarti [16], where they confirmed the existence of significant differences between the varieties for this trait. The effect of salicylic acid on the length of the plumule came in line with its effect on the germination rate and the length of the plumule, as the concentration S2 surpassed with the highest average of 6.088 cm, with a significant difference of 1.213 and 0.838 cm compared to the concentrations S0 and S1, respectively, which did not show a significant difference between them. As for the interactions between the varieties and the concentrations of salicylic acid, no significant differences were recorded. These results are consistent with what was reached by Kirit et al., [11], Shihab and Hamza [19], Alzubaidi and Zwain [2], and Shaykhabaglou et al. [18], who pointed to the effective role of salicylic acid in regulating and stimulating vital activities, which was positively reflected in increasing cell division and producing seedlings capable of self-reliance through the process of photosynthesis, in addition to the effective role of salicylic acid in enhancing tolerance to abiotic stress [21] and in regulating and stimulating metabolism, which was positively reflected in increasing cell division and thus increasing the length of the plumule [23] [7] [13] [17].

Table (3) Effect of soaking sorghum seeds in Varying Concentrations of salicylic acid on plumule length (cm)

Varieties	Salicylic Acid					Varieties average
	S0 0	S1 45	S2 90	S3 180	S4 360	
V1 Rabeh	5.375	5.625	7.050	2.688	2.643	4.676
V2 Tabat	4.375	4.875	5.125	1.538	1.488	3.480
Treatments average	4.875	5.250	6.088	2.113	2.065	
LSD	S 0.513	VXS NS			V 0.325	

The dry weight of the seedling (mg)

The results of Table (4) indicate the presence of a significant difference between the salicylic acid treatments, while there was no significant effect among the study factors. However, the concentrations of salicylic acid have increased. The dry weight of the seedling with the S2 treatment achieved the highest average of 0.028 mg, which differed significantly from the treatments S0 and S1 by 0.009 and 0.008 mg, respectively, and the two did not differ from each other. On the other hand, the high concentrations in this S4 gave the lowest average of 0.013 mg, which differed significantly by 0.015 mg from the S2 treatment. The interactions between the study factors did not show any significant effect on this, and the superiority of the S2 treatment in the characteristic of dry weight is due to its distinction in both. The length of the radicle and the length of the plumule are positively affected by the silicic acid, which in turn reflects on the increase in the dry weight of the seedling, according to [19] [18].

Table (4) Effect of soaking sorghum seeds in Varying Concentrations of salicylic acid on the dry weight of the seedling (mg)

Varieties	Salicylic Acid					Varieties average
	S0 0	S1 45	S2 90	S3 180	S4 360	
V1 Rabeh	0.020	0.021	0.030	0.025	0.015	0.022
V2 Tabat	0.018	0.020	0.026	0.015	0.011	0.018
Treatments average	0.019	0.020	0.028	0.020	0.013	
LSD	S 0.005	VXS NS			V NS	

Vigor Seedling

The results of Table (5) showed a statistically significant difference between the cultivars and the concentration of salicylic acid, as well as the interaction between them. The Rabeh cultivar had the highest average of 506.4, which differed significantly from the Tabat cultivar by 207.9. Regarding the effect of salicylic acid, it was observed that seedling vigor increased with the increase in the concentration of salicylic acid, reaching the highest average of 913.9 for the S2 concentration, which was statistically significant. However, the averages for the characteristics of S3 and S4 concentrations, which were 722.4 and 746.9 respectively, did not differ significantly. The treatment showed clear differences between the two treatments, on average, amounting to 1149.5. The treatment S4 V2 achieved a lower average for this trait. The low concentration of salicylic acid is the reason for the superiority of the S2 treatment in root length and shoot length, as shown in Tables 2 and 3, in addition to its variation in plant ratios, as shown in Table 1. The reason for the decrease in this trait is the decrease in concentration, which led to the deterioration of the previous traits that we depend on in calculating (seedling length and the percentage of seed germination) according to [18] [19] on seedling vigor.

Table (5) Effect of soaking sorghum seeds in varying concentrations of salicylic acid on seedling vigor

Varieties	Salicylic Acid					Varieties average
	S0 0	S1 45	S2 90	S3 180	S4 360	
V1 Rabeh	400.8	460.8	1149.5	266.8	254.1	506.4
V2 Tabat	274.3	344.0	678.4	116.1	79.9	298.5
Treatments average	337.5	402.4	913.9	191.5	167.0	
LSD	S 46.9	VXS 66.3			V 29.6	

Index Vigor Seedling

Table (6) showed that there are statistically significant differences between the cultivars in the concentration of salicylic acid, while the interactions between the two factors did not show any significant differences. The cultivar Rabeh was distinguished by the highest average of 1.250, which is significantly higher than the cultivar Tabat by 0.466. As for the concentration of salicylic acid, the S2 concentration was the highest. The average difference between the concentrations S0 and S1 was 2.187, while the significant difference between the concentrations S2 and the sequences S3 and S4 was 1.738. This feature was observed to outperform each percentage of seed germination and the dry weight of the seedling. This was achieved by stimulating the release of hormones such as cytokinins, which subsequently facilitated the enhancement of metabolic products, thereby positively influencing the growth and dry weight of the seedlings [10] [18] [19].

Table (6) Effect of soaking sorghum seeds in Varying Concentrations of Salicylic Acid on Seedling Vigor Index

Varieties	Salicylic Acid					Varieties average
	S0 0	S1 45	S2 90	S3 180	S4 360	
V1 Rabeh	0.912	0.915	2.602	1.209	0.615	1.250
V2 Tabat	0.626	0.784	1.772	0.452	0.284	0.784
Treatments average	0.769	0.849	2.187	0.831	0.449	
LSD	S 0.386	VXS NS			V 0.244	

Conclusions

The study indicates that the Rabeh variety excelled by achieving the highest average for all the studied traits. As for the effect resulting from the priming of salicylic acid, the S2 treatment stood out in all the studied traits, while the high concentrations had a negative effect on those traits. Moreover, the interactions did not have any significant effect on the majority of the studied traits. Based on this, we recommend using concentrations of 90 mg L⁻¹ of salicylic acid, while stressing the need to conduct further studies on a diverse group of genetic structures.

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