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Effect of various exogenous salicylic acid concentration on wheat seed germination

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Abstract
The present investigation has been carried out to study the effect of various concentrations of salicylic acid (SA) on the germination performance of wheat (cv. C 306 and HI 1544) seeds, which are most prominently grown varieties in Vidisha district of Madhya Pradesh. The seeds of these varieties were exposed to different concentrations of salicylic acid (Control D/W, 5 ppm, 10 ppm, 25 ppm, and 50 ppm). Both wheat varieties C 306 and HI 1544 showed significant germination by the use of various concentrations of SA application over control. After 48 hrs to 96 hrs, significant germination was observed for both the varieties of wheat, and it became constant afterward for all the concentrations of SA along with control. All the imposed SA concentrations increased germination percentage, shoot length, root length, shoot fresh weight and vigor index over control (distill water, D/W) except 50 ppm SA after 48 hrs of germination experiment, which showed a decline in value for all the observed parameters. A similar trend was observed at 72 hrs, 96 hrs and 120 hrs. However, soaking of seeds with 25 ppm SA is best for seedling characteristics, hence beneficial for obtaining the higher yield. But 50 ppm SA treatment is not advisable for germination and other seedlings characteristics. Thus, it can be zeroed that benefits of SA treatment for germination parameters are doses dependent; and supra optimal concentration is harmful to plant growth.

Keywords: Germination, root length, salicyclic acid, shoot length, wheat

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important staple cereal crops of the world, ranks next to rice. It is eaten in various forms by more than one billion people in the world. It ranks second in the world among the cereals, both in respect of acreage (219 m ha) and production (772 m tons) FAOSTAT [5]. India is the second-largest producer of wheat in the world (99 m tons) on 31 m ha area [1]. Wheat is growing prominently in Vidisha district of Madhya Pradesh.

The role of SA in the regulation of diverse plant development processes has been reported by many researchers such as in flowering (Martinez *et al*. 2004) [12], photosynthesis (Khan *et al*., 2003; Singh *et al*. 2003 and Cag *et al*. 2009) [9, 18, 4], transpiration, stomatal regulation, nutrient uptake and transport (Gunes *et al*. 2005) [7], inhibition of fruit ripening (Srivastava and Dwivedi 2000) [20]. SA exerts its role in a variety of plant developmental processes through coordinate interactions with gibberellins (GAs), abscisic acid (ABA), jasmonic acid (JA), and ethylene (Yasuda *et al* 2008; Alonso-Ramirez *et al*. 2009 and Leon-Reyes *et al* 2009) [21, 1, 11]. Seed germination is an important developmental trait that affects plant growth and productivity profoundly. Seed imbibition with SA leads to an activation of germination and seedling growth (Shakirova *et al*. 2003; Singh *et al*. 2010; Jadhav and Bhamburdekar 2011) [17, 19, 11].

The role of various growth hormones such as GA, ABA, and ethylene (Ariizumi and Steber 2007; Robert *et al* 2008 and Seo *et al*. 2009) [3, 15, 16], have been extensively studied in seed germination. SA also plays a role in germination under stressful conditions, although its precise role and the underlying molecular mechanisms involved have not been fully elucidated (Alonso-Ramirez *et al* 2009 and Rajjou *et al* 2006) [3, 14]. But whether SA affects germination even under normal condition without stress and effect is doses dependent or not are still not confirmed. That's why an experiment was, conducted to study the impact of SA on germination of wheat (*Triticum aestivum* L.) seeds under normal with different concentrations of SA.

Material and Method

Healthy seeds of wheat cv C 306 and HI 1544, which are most prominently grown varieties in Vidisha district of Madhya Pradesh, were the first surface sterilized with 5% NaOCl (sodium hypochloride) for 5 min to avoid fungal invasion, and then washed with distilled water to remove toxic elements. The Petri plates were sterilized with hot air oven and lined with blotting filter paper at the bottom. The surface-sterilized twelve seeds were placed in each Petri plates. The desired treatments were given by adding 12 cm^3 of aqueous treatment solution of salicylic acid (Control-DW, 5 ppm, 10 ppm, 25 ppm, and 50 ppm), with three replicates each. The levels of SA used in the experiment were based on literature reports [18]. Germination experiment was conducted in seed germinator in dark at 25 ± 2^0C in 9 cm Petri dishes (20 in each) between the layers of moist filter paper, supplemented with Hoagland solution. Observations were recorded at different stages of germination from 24 to 120 hrs. Germination percentage was taken by counting the number of germinated seeds out of the total number of seeds and expressed in terms of percentage. The emergence of radical from seed coat was acknowledged as a criterion for germination. Germination parameters like shoot length and root length were taken at 15 days after soaking under laboratory conditions at the College of Agriculture, JNKVV, Ganj Basoda. Root and shoot length was measured with the help of a ruler scale. Shoot fresh weight was measured with the help of digital electronic balance. Vigor index was calculated based on shoot length as per Kumari *et al.* [19] (Vigor index = (shoot length X G %) /100).

The data obtained were subjected to analysis of variance by completely randomized design. F-test was carried out to test the significance of the treatment differences and the least significant differences (LSD) were computed to test the significance of different treatments at a 5% level of probability by the SPSS 10.0. In graphs, error bars are included in the bar diagram which is representative of std deviation among all the three replications.

Results

Germination Percentage

Effect of different concentration of Salicylic Acid at different times after starting of germination experiment (TAE) on germination percentage (%) in the seeds of two wheat varieties is shown in table I. At 24 hours after the start of germination experiment no significant germination was recorded. At 48 hrs, 42-45% germination was recorded in both the varieties with distilled water only (We took it as control). Germination percentage was increased 7-33% and 10-29% with the use of 5, 10 and 25 ppm of SA in C 306 and HI 1544 varieties respectively. For both, the genotypes germination percentage declined as compared to control with 50 ppm SA treatment during germination. Similar results were recorded at 72 hrs, 96 hrs and 120 hrs after the starting of the germination experiment. At every time of observation germination percentage increased for all concentrations of SA except 50 ppm, which produced a declining effect in germination percentage over control.

Table 1: Effect of different concentration of Salicylic Acid at different time after starting of germination experiment (TAE) on germination percentage (%) in the seeds of two wheat varieties

Varieties	The concentration of SA (in ppm)		Germination percentage (%)				
			Time after the experiment (TAE)				
			48 hrs		72 hrs	96 hrs	120 hrs
C 306	Control (D/W)		45		80	85	88
	5		48		85	90	91
	10		54		88	92	94
	25		60		90	94	95
	50		45		78	80	81
HI 1544	Control (D/W)		42		78	85	87
	5		46		82	89	91
	10		50		86	92	94
	25		54		87	95	96
	50		40		72	79	81
	Conc. Of SA (A)	Varieties (B)	A x B	Time after experiment (C)	A x C	B x C	A x B x C
S. Em	0.60	0.38	0.84	0.53	1.19	0.75	1.68
C.D. at 5%	1.68	1.06	2.37	1.50	3.35	2.12	4.74

Root length and shoot length

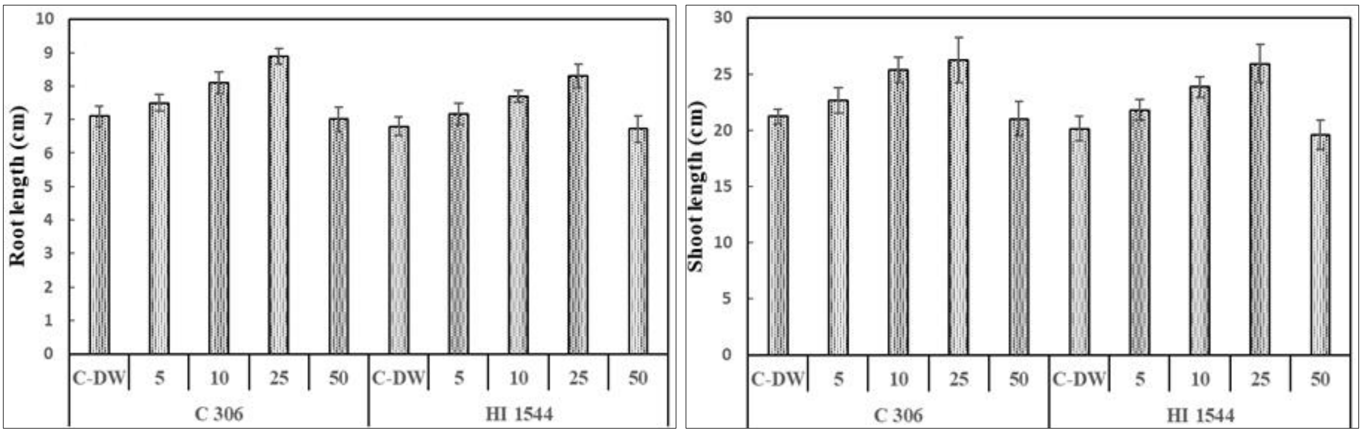
Effect of different concentration of Salicylic Acid at 15 days after starting of germination experiment on Root length, and Shoot length of two wheat varieties have been presented in fig. IA and IB. Root length was 7.1 and 6.8 cm in control seedlings of C 306 and HI 1544 wheat varieties respectively. Increase of 6-25 % and 5-22 % in root length of wheat varieties of C 306 and HI 1544 was measured with 5, 10 and 25 ppm SA treatment as compared to control, while 50 ppm SA showed about 1.2 % decline in root length for both the varieties of wheat seedling at termination of experiment, i.e., 15 days after starting of germination experiment.

Shoot length was 21.2 and 20.1 cm in control seedlings of C 306 and HI 1544 wheat varieties respectively. Increase of 7-24 % and 8-29 % in root length of wheat varieties of C 306 and HI 1544 was measured with 5, 10 and 25 ppm SA treatment as compared to control, while 50 ppm SA showed about 1 and 2.6 % decline in root length for C 306 and HI 1544 wheat varieties respectively at termination of experiment, i.e., 15 days after starting of germination experiment.

Shoot fresh weight and vigor index

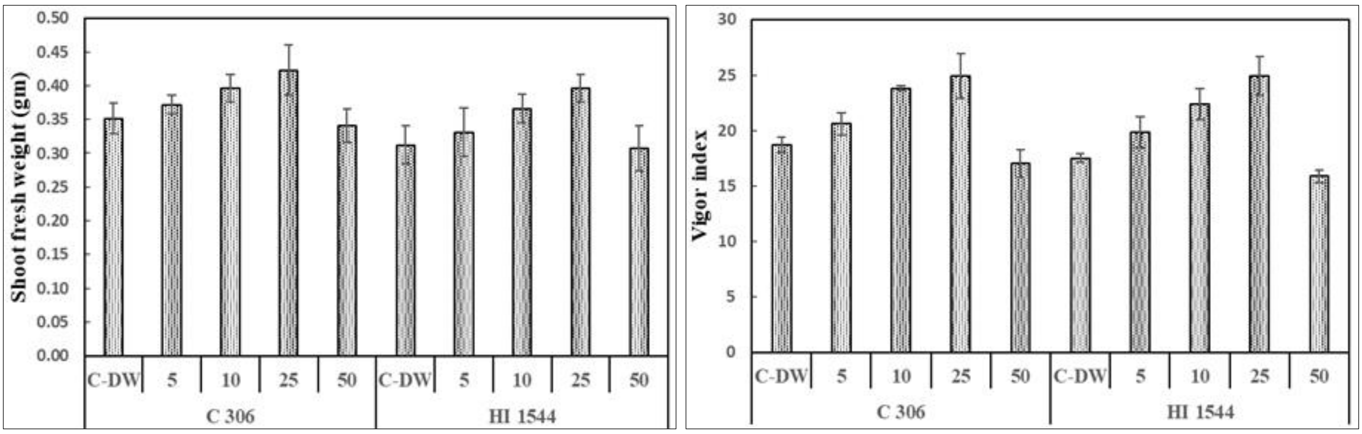
The effect of different concentrations of Salicylic Acid at 15 days after the starting of the germination experiment on Shoot fresh weight (gm), and Vigor index, of two wheat varieties, has presented in Fig. IIA and II B respectively. Average shoot fresh weight was 0.35 and 0.31 gm of control seedling of C 306 and HI 1544 wheat varieties respectively. Increase of 6-20 % and 6-27 % in shoot fresh weight of wheat varieties of C 306 and HI 1544 was measured with 5, 10 and 25 ppm SA treatment as compared to control, while 50 ppm SA showed about 3 and 1.6 % decline in shoot fresh weight for C 306 and HI 1544 wheat varieties respectively at termination of experiment, i.e., 15 days after starting of germination experiment.

Vigor index was 19 and 18 of the control seedling of C 306 and HI 1544 wheat varieties, respectively. Increase of 10-33 % and 13-42 % in vigor index of wheat varieties of C 306 and HI 1544 was measured with 5, 10 and 25 ppm SA treatment as compared to control, while 50 ppm SA showed about 9 % decline in vigor index for both wheat varieties at the termination of the experiment.



(A) (B)

Fig 1: Effect of different concentration of Salicylic Acid at 15 days after starting of germination experiment on A.) Root length, and B.) Shoot length, of two wheat varieties



(A) (B)

Fig 2: Effect of different concentration of Salicylic Acid at 15 days after starting of germination experiment on A.) Shoot fresh weight (gm), and B.) Vigor index, of two wheat varieties

Discussion

The results inferred that at the 24 hrs incubation, no significant germination was recorded in all treatments. But, successive induction of germination was observed from 48 to 120 hrs. The 5, 10, and 25 ppm of salicylic acid significantly increases germination percentage in both cultivars over the control. Similar results were obtained by Jadhav and Bhamburdekar (2011) [13] and Patil *et al*. (2015) [18] in the case of groundnut and pigeon pea crops respectively. These scientists are reported that seed germination performance in groundnut and pigeon pea increases with the application of salicylic acid. In the case of *Vicia faba* Anaya *et al*. reported that low concentrations of SA have more positive effects on *V. faba* germination than high concentrations (Anaya *et al* 2015) [20]. They showed that 0.25 mM SA concentration significantly improved the germination percentage and germination.

Root and shoot length of wheat seedlings in both varieties increased in response to incubation with 5, 10, and 25 ppm SA over control, i.e., soaking only with distilled water. A similar result is reported by Jadhav and Bhamburdekar (2011) [13] in the case of groundnut. But 50 ppm SA treatment observed declining trend in root and shoot length of wheat seedlings for both the varieties. It may be due to the supra optimal inhibitory effect of growth hormone. Fariduddin *et al*. 2003 [21] also observed the same that initial rise in the endogenous level of salicylic acid supported the idea of upregulating (overexpression and activation) the antioxidative defense system to alter the activity of transcription factors and cellular signaling (Fariduddin *et al*. 2003) [21]. However, the supra-optimal level is reported to harm the plant metabolism Fariduddin *et al*. 2003) [21]. Zhang *et al*. (2016) [22] also reported that supra-optimal levels of SA negatively influence growth.

We can speculate that seed priming of wheat with a low concentration of SA will speed up the germination process and enhance the establishment of seedlings. Better germination and seedling establishment (measured in terms of root and shoot length) lead to better shoot fresh weight and seedling vigor in the experiment. Therefore, the planted seeds will be less susceptible to soil-borne pests and diseases and produce more biomass and photosynthetic capacity, especially at the planting stage. In this way, we can get a robust plant stands. This has positive consequences on the management of this crop at the planting and germination stage.

From the present experiment, we can conclude that seed treatment with salicylic acid influences seeds' germination performance in wheat varieties. 5 to 25 ppm SA treatment is better for wheat seed germination and seedling emergence. However, soaking of seeds with 25 ppm SA is best for seedling characteristics. Hence, the application of 25 ppm salicylic acid can be beneficial for obtaining a higher yield. But 50 ppm SA treatment is not advisable for germination and other seedlings characteristics. Hence, it can be zeroed that benefits of SA treatment for germination parameters are doses dependent; and supra optimal concentration is harmful to plant growth.

Conclusion

Our observations indicate that SA has a positive response in wheat seed germination under normal growth conditions. Based on the results of this study, seed priming of wheat seeds with low concentrations of SA (25 ppm) is recommended for better germination and seedling characteristics, which will ultimately turn into high productivity of the wheat crop.

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