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Effects of Priming of Wheat (*Triticum aestivum*) Seeds on its Growth and Yield Attributes under Rainfed and Irrigated Condition

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ABSTRACT: An experiment was performed to study the effects of priming of wheat (*Triticum aestivum*) seeds on its growth and yield attributes under rainfed and irrigated condition, during *Rabi* 2019-20 season at Experimental Farm AICRP of Wheat, at Uttar Banga Krishi Viswavidyalya, Cooch Behar, to assess the response of wheat seeds to priming with the chemicals namely-Salicylic acid and PEG (polyethylene glycol).The trial was laid out by using cv. "UP 262 (V_1) and K0307 (V_2)" in Factorial Randomized Block Design with three replications and six treatments, each for both variety comprised of two concentrations of each chemicals -Salicylic acid (10 ppm and 20 ppm) as well as polyethylene glycol or PEG (10% and 20%) and two control treatment (with water and without water) along with the same replication each, one in stress condition (Rainfed) and other in normal condition (Irrigated). During Rabi season in West Bengal, shortage of rainfall occurred which induces stress on wheat growth and with application of chemicals (SA and PEG), reduces abiotic stress such as salinity, water deficient, high and low temperature. So with respect to the response of the wheat cultivars to the chemicals, the superior was observed. The results revealed that priming of Salicylic acid at 20 ppm and PEG at 20% gave better results in terms of plant height, shoot weight, root weight, number of tillers per plant, spikelet's weight, spikelet's length, number of spikelet & total plant weight at different growth stages and yield attributing parameters of both varieties. But the overall result was at par with the treatment (PEG @ 20%) on variety V_2 (K0307).

Keywords: Priming, Salicylic acid, polyethylene glycol, rainfed, irriagted.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second-largest cereal crop in the world following rice plus the major important staple food concerning more than thousands of million human beings in the world. Likewise in India, wheat is the secondary staple food crop. It provides more than 20% of calories consumed by the world's population and offers a comparable symmetry of protein requirements for nearly 2.5 billion people. Around 25% of farming areas are affected by environmental stress throughout the world. Thus, agricultural fecundity is subject to crop failure and overall yields lose more than 50% (Fathi and Tari, 2016). Drought stress is one of the most limiting factors especially in warm dry areas yielding crops. (Qadir, 2019). Yield potential of wheat can be monitored either by alternation and reconstitution of genetic make-up or by modification of the environment through improved cultural treatment. Seed priming is an accessible, economical, and efficient process for intensification of seed germination, advanced seedling growth, and yield under stressed and non-stressed conditions (Heydecker, 1975). Salicylic acid is a phenolic plant growth regulator that restores physiological processes in plants. Salicylic acid (SA), induces chilling tolerance in plants (Sayyari 2012) Salicylic acid (SA), is also included in the regulation of proline metabolism (Sakhabutdinova *et al.*, 2003). Numerous reports show the function of salicylic acid in seed germination and plant growth and yield (Hussein *et al.*, 2007). The exogenous application of salicylic acid prevents plant damage caused by various abiotic stresses (drought, high and low temperatures, salinity) and helps plants to build resistance to biotic stresses (Kinga *et al.*, 2020). Further, it exerts enhancement in rate and percentage of germination and seedling emergence which ensures proper crop stand under a wide range of environmental conditions (Yadav *et al*., 2018). Polyethylene glycol is a polyether compound and Polyethylene glycol (PEG) is generally used as a promising osmoticum as it provides enough moisture to penetrate the seed and improve the enzymatic activities also morphological alterations occurred in primed seed and a portion of endosperm is hydrolyzed during priming that allows faster embryo growth (Burgass and Powell, 1984). The benefit of utilizing PEG corresponded to additional osmotic solutions (easily perceived by the cell) is that it cannot penetrate the cell as the water passed through the cell without harming the cell structure (Ahmad *et al.*, 2017). It helped in lowering down the water potential of nutrient solution without passing or acting as a phytotoxic (Khakwani *et al.*, 2011; Qadir, 2019) and causing less or no significant damage to the physiological of the crop plants (Khakwani *et al.*, 2011; Hellal *et al.*, 2018). Numerous researchers have done an investigation involving PEG to examine the ability to endure the drought stress of several wheat genotypes (Ahmad *et al.*, 2017; Kacem *et al.*, 2017; Hellal *et al.*, 2018; Abro *et al.*, 2020) at various concentrations. The present investigation was carried out with the following objectives: To study the effect of priming with PEG and SA on wheat varieties on its morphological parameters at maturity. To study the priming effect on yield attributes of wheat grown under rainfed and irrigated conditions.

MATERIAL AND METHODS

Present investigation was conducted at University Research Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar during *Rabi* season of 2018-19. The experiment was laid out in factorial RBD of Plot size - 1500 cm × 200 cm, with 3 replication consisting of two varieties UP262 and K0307 under rainfed and irrigated, where irrigated with 15 days of interval after sowing (critical stage-CRI stage) for Irrigated field only. The seed was shown on 7th November 2018 and the harvesting was done on 10th April 2019. Treatment consist of T1 = Salicylic acid (10 ppm), T2 = Salicylic acid (20 ppm), T3 = PEG (10%), T4 = PEG (20%), T5 = control with water treatment (Hydro priming) and T6 = control without water treatment. The experimental data were statistically analyzed following the methods described by Panse and Sukhatme (1989). Morphological, biological and yield attributing parameters were taken for the estimation of growth and yield attributes which includes the following:

A. Effective number of tillers (per plant)

Productive tillers were considered those tillers which produced ears filled with grains out of total tillers recorded within a running meter row length. The effective number of tillers was counted by selecting at least 5-7 plants from each plot and were recorded according to their tillering.

B. Spikelet length (cm)

Five representative spikes were taken from each plot. The spike length (cm) was measured from the base of the peduncle (lower spikelet) to the tip of the top spikelet.

C. Spikelet weight (g)

From each plot, five plants were selected, weigh their spikelet, and took the average weight of the spikelet.

D. Number of spikelet (per head)

From the spikes that was selected for measuring spike length, the grains were separated from the spikelet and the number of grains was counted and the grains per spike were worked out.

E. Shoot weight (g)

Five representative plants from each plot were taken and weigh only their shoot and took the average of the weight.

F. Plant height (cm)

Plant height was recorded at maturity. For each plot height of 10 plants were measure and their average has been presented as cm per plant.

G. Root weight (g)

Five representative plants from each plot were taken and weigh only their root and took the average of the weight.

H. Total plant weight (g)

Five representative plants from each plot were taken and weigh both the shoot and root and took the average of the weight.

I. Harvest index (%)

The harvest index was calculated as the ratio of grain yield to total above-ground biomass. It was computed by dividing the seed yield of a plant by the biological yield of the plant and expressed as the ratio of seed yield to biological yield.

J. Biological yield (g/plant)

Pre-selected five plants were weighed individually after air-drying including shoot, dried leaves, and a spike which was expressed as gram per plant.

K. Seed yield per plant (g/plant)

The above-selected plants per replication were threshed manually after air drying. The seed yield of each plant was recorded separately and the mean was expressed in grams.

L. Number of filled and unfilled seed (per ear)

The number of grain filled and unfilled grain were counted from five different plant's ears collected from a single plot and took the average of the five ears.

M. Total grain yield (kg/plot)

After threshing with the help of a mini-plot thresher, the grain yield was measured for each net plot area. Then it was converted into kg/plot.

N. 1000-grain weight (g)

For estimating the test weight 1000-grains were counted and weighed in gram with the help of electronic balance. The test weight was expressed in gram per 1000 grain.

RESULT AND DISCUSSION

A. Effect of priming on morphological parameters

In Table 1. All treatment was seen significant for spikelet's length under rainfed and irrigated condition, the highest treatment was observed in T2 (@ 20 ppm SA), 11.66 cm and T3 (@10% PEG), 11.92 cm respectively at pre harvesting stages. Spikelet's weight was shown significant in all treatments under rainfed and irrigated condition and the highest treatment were observed in T1 (@10 ppm), 156.60 g, and T2 (@ 20 ppm SA), 186.17 g respectively at pre harvesting stages. All treatments were shown significant for the number of spikelets under both rainfed and irrigated conditions and the highest treatment was observed in T4 (@ 20% PEG), 69.62, and T4 (@ 20% PEG), 75.34 respectively at pre harvesting stages. Similarly, all treatments were seen significant for shoot weight under both rainfed and irrigated conditions, and the highest treatment was observed in T2 (@ 20 ppm SA), 145.45 g, and 136.17 g respectively at pre harvesting stages. For variety and treatment interaction under rainfed and irrigated, spikelet length and shoot weight were significant respectively, however, the number of spikelet and spikelet weight was found insignificant. Similar findings were observed by Sharma *et al.*, (2012) as priming gave the best result in a change in growth parameter through the accumulation of more nutrients than the unprimed seed resulting in early maturation giving a higher yield.

Table 1: Effect of priming of wheat seeds on morphological parameter under rainfed and irrigated condition.

Treatment	Rainfed				Irrigated			
	No. of Spikelet (per ear)	Spikelet length (cm)	Spikelet's wt. (g.)	Shoot weight (g.)	No. of Spikelet (per ear)	Spikelet length (cm)	Spikelet's wt. (g.)	Shoot weight (g.)
A. Variety								
V1	67.59	10.83	131.50	111.41	68.91	10.95	147.17	10.86
V2	67.36	10.80	126.17	106.92	66.05	11.03	146.72	11.85
SEm±	1.16	0.28	14.40	4.09	2.78	0.38	19.94	7.96
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B. Salicylic								
acid, PEG								
and control								
T1	67.83	10.85	156.60	130.64	68.09	10.86	125.00	124.31
T2	68.39	11.66	155.67	145.45	69.53	11.57	186.17	136.17
T3	69.33	11.25	138.00	107.34	72.92	11.92	174.67	99.26
T4	69.62	10.88	129.17	102.72	75.34	11.61	177.00	120.83
T5	64.56	9.77	97.67	78.65	60.29	9.59	109.50	84.42
T6	64.36	10.49	96.00	90.10	58.05	10.40	109.33	100.14
SEm±	0.67	0.16	8.31	2.36	1.61	0.22	11.51	4.59
CD at 5%	1.96	0.48	24.38	6.93	4.71	0.64	33.76	13.47
C.								
Interaction:								
V × T								
V1 × T1	66.33	11.13	155.33	125.08	67.98	11.05	126.67	120.33
V1 × T2	71.40	12.03	169.67	142.50	69.42	11.73	181.67	122.33
V1 × T3	71.40	10.32	159.00	116.90	77.00	10.43	162.00	111.33
V1 × T4	67.71	10.69	115.33	112.88	80.13	11.52	175.33	122.39
V1 × T5	64.62	10.22	100.67	76.59	59.55	10.15	119.00	90.47
V1 × T6	64.07	10.57	89.00	94.49	59.39	10.83	118.33	92.37
V2 × T1	67.83	10.56	157.67	136.20	68.20	10.66	123.33	128.29
V2 × T2	68.39	11.28	141.67	148.40	69.63	11.40	190.67	150.00
V2 T3	67.26	12.19	117.00	97.78	68.84	13.40	187.33	106.16
V2 × T4	71.54	11.07	143.00	92.70	70.54	11.70	178.67	130.33
V2 × T5	64.50	9.32	94.67	80.72	61.04	9.03	100.00	78.37
V2 × T6	64.55	1040	103.00	85.70	58.05	9.97	100.33	77.95
SEm±	1.64	0.40	20.36	5.76	3.94	0.53	28.20	11.25
CD at 5%	NS	1.20	NS	17.55	NS	1.62	NS	34.12

Significant differences *($P \leq 0.05$)* between varieties as well as between treatments are indicated by different letters according to two way Anova test; NS- Non significant

As data presented in Table 2, the number of tillers per plant was seen significant for both rainfed and irrigated conditions, and the highest treatment was observed in T2 (@ 20 ppm SA), 10.54 (tiller/plant), and T3 (@10% PEG), 11.11 (tiller/plant) respectively at pre harvesting stages. Plant height was seen significant in all treatment significant for both rainfed and irrigated conditions and the highest treatments were observed in T2 (@ 20 ppm SA), 90.09 cm, and 93.14 cm respectively at pre-harvesting stages. Root weight was seen significant in all treatment under rainfed and irrigated conditions and the highest treatment was observed in T2 (@ 20 ppm SA), 5.77 g, and 6.53 g respectively at pre-harvesting stages. However, the only number of tillers per plant was significant for variety and treatment interaction whereas in the case of plant height and root weight were insignificant. Several studies have suggested that seed priming increases yield potential by stimulating the metabolism during its maturation, hence increasing leaf length, number of tillers, plant height, and biochemical change (Kalpana *et al*., 2015; Sreenivasasareddy and Chaurasia 2021).

Table 2: Effect of priming of wheat seeds on morphological parameter under rainfed and irrigated condition.

Treatment	Rainfed			Irrigated		
	No. of tillers/plant	Plant height(cm)	Root weight (g.)	No. of tillers/plant	Plant height(cm)	Root weight (g.)
A. Variety						
V1	8.92	106.97	4.68	8.86	110.08	5.49
V2	8.96	100.62	5.37	7.65	106.92	5.68
SEm ±	0.32	13.12	0.38	0.55	3.97	0.33
CD at 5%	NS	NS	1.10	NS	NS	NS
B. Salicylic acid,						
PEG and control						
T1	9.63	126.67	5.55	9.11	130.64	6.28
T2	10.54	136.48	5.77	10.76	145.45	6.53
T3	8.50	104.08	5.28	11.11	107.34	6.00
T4	9.12	90.67	5.63	8.58	98.80	5.57
T5	7.56	84.08	3.73	7.49	78.65	4.48
T6	8.29	80.79	4.18	7.28	90.10	4.66
SEm±	0.19	7.57	0.22	0.32	2.29	0.19
CD at 5%	0.56	22.31	0.64	0.93	6.79	0.55
C. Interaction:						
V × T						
V1 × T1	9.64	126.67	5.10	8.65	125.08	6.44
V1 × T2	9.71	151.33	5.23	9.03	142.50	6.49
V1 × T3	8.38	102.00	5.13	11.42	116.90	6.29
V1 × T4	8.77	91.53	4.61	8.67	104.90	5.72
V1 × T5	8.28	86.67	3.52	8.49	76.59	4.47
V1 × T6	8.75	83.63	4.47	6.91	94.49	4.64
V2 × T1	9.62	126.67	6.01	9.57	136.20	6.11
V2 × T2	11.38	121.62	6.31	12.49	148.40	6.56
V2 × T3	8.62	106.16	5.42	10.80	97.78	5.71
V2 × T4	9.47	89.81	6.65	8.48	92.70	5.42
V2 × T5	6.84	81.50	3.95	6.48	80.52	4.50
V2 × T6	7.82	77.95	3.89	7.65	85.70	4.67
SEm±	0.46	18.55	0.53	0.78	5.61	0.46
CD at 5%	1.41	NS	NS	2.36	NS	NS

Significant differences *($P \leq 0.05$)* between varieties as well as between treatments are indicated by different letters according to two way Anova test; NS- Non significant

B. Effect of priming on Biological parameters

From Table 3 all treatments of total plant weight were shown significant for both rainfed and irrigated conditions and the highest treatment were observed in T2 (@ 20 ppm SA), 296 g, and 572.67 g respectively at post-harvesting stages. Total grain weight was seen significant in all treatments under rainfed and irrigated condition and the highest treatment were observed in T4 (@ 20% PEG), 556.67 g and T2 (@ 20 ppm SA), 572.67 g respectively at the post-harvest stage. The number of filled and unfilled seed (per ear) were seen significant in all treatments under rainfed and irrigated condition and the highest treatment were observed in T4 (@ 20% PEG), 62.00 (filled seed/ear), and 65.00 (filled seed/ear) respectively, however for unfilled it was recorded highest at T2 (@ 20 ppm SA), 7.50 (unfilled seed/ear) and 5.83 (unfilled seed/ear) at the post-harvest stage. Whereas for varieties and treatments interaction number of unfilled grains and total plant weight was only insignificant however filled grain and total grain weight were seen significant under rainfed and irrigated conditions. A similar finding was observed by Farooq *et al*. (2008) that seed priming has the potential to develop seeds size, viability, and vigor of seeds over control. Seed size plays an important part in germination and the establishment of vigorous seedlings that is crucial in achieving high yield and early maturation. However, Sreenivasasareddy and Chaurasia (2021) in mustard observed that with the application of different priming (PEG especially) the height of the plant, flowering to fruiting, yield of the mustard was better than control.

Table 3: Effect of priming of wheat seeds on biological parameter under rainfed and irrigated condition.

Treatment	Irrigated				Rainfed			
	FG (per ear)	UFG (per ear)	Total grain wt. (g.)	Total plant weight (g.)	FG (per ear)	UFG (per ear)	Total grain wt. (g.)	Total plant weight (g.)
A. Variety								
V1	57.06	8.44	464	248.33	61.61	8.89	490.94	272.00
V2	58.33	9.89	490	250.00	58.61	7.89	511.72	286.94
SEm±	1.50	0.89	40.47	19.55	2.09	0.56	35.07	28.70
CD at 5%	NS	2.62	NS	NS	NS	1.65	NS	NS
B. Salicylic								
acid, PEG								
and control								
T1	57.83	7.83	526.83	266.17	61.83	7.50	565.83	311.33
T2	58.17	7.50	556.67	296.00	64.17	5.83	572.67	363.33
T3	60.67	7.67	505.50	284.67	61.50	8.50	566.00	297.33
T4	62.00	9.00	572.50	263.00	65.00	7.83	540.83	268.67
T5	51.67	10.33	379.17	193.33	51.83	10.00	396.17	215.67
T6	55.83	12.67	323.50	205.17	56.33	10.67	366.50	220.50
SEm±	0.86	0.52	23.37	11.13	1.20	0.32	20.25	16.57
CD at 5%	2.53	1.51	68.53	32.65	3.53	0.95	59.39	48.60
C. Interaction:								
V × T								
V1 × T1	58.67	6.63	491.67	269.67	64.00	8.00	560.00	299.00
V1 × T2	57.00	8.00	565.00	275.33	62.33	6.00	600.67	311.67
V1 × T3	61.67	7.00	516.67	296.00	62.00	9.33	550.00	300.33
V1 × T4	58.33	8.67	560.00	270.00	66.67	8.33	491.67	308.00
V1 × T5	48.33	10.00	386.67	193.33	53.67	10.00	386.67	206.00
V1 × T6	58.33	10.67	265.33	212.33	61.00	11.67	356.37	207.00
V2 × T1	57.00	9.33	562.00	262.67	62.67	7.00	571.67	323.67
V2 × T2	59.33	7.00	548.33	316.67	66.00	5.67	544.67	415.00
V2 × T3	59.67	8.33	494.33	273.33	61.00	7.67	582.44	294.33
V2 × T4	65.67	9.33	585.00	256.00	63.33	7.33	590.00	229.33
V2 × T5	55.00	10.67	371.67	193.33	50.00	10.00	405.67	225.33
V2 × T6	53.33	14.67	381.67	198.00	48.67	9.67	376.33	234.00
SEm±	2.12	1.26	57.23	27.27	2.95	0.79	49.60	40.59
CD at 5%	6.42	NS	173.60	NS	8.95	NS	150.46	NS

Significant differences ($P \leq 0.05$) between varieties as well as between treatments are indicated by different letters according to two way Anova test, NS- Non significant

C. Effect of priming on yield attributes

From Table 4, the harvest index in all treatments was seen as significant for both rainfed and irrigated conditions, and the highest treatment was observed in T3 (@10% PEG), 93.02 %, and T4 (@ 20% PEG), 102.34 % respectively at the post-harvest stage. The biological yield was seen significant for both rainfed and irrigated conditions in all treatments and the highest treatment was observed in T1 (@10 ppm) 53.58 g and T4 (@ 20% PEG), 57.50 g respectively at the post-harvest stage. Similarly, seed yield per plant was significant in all treatments under rainfed and irrigated condition and the highest treatment were observed in T4 (@ 20% PEG), 93.02 g and T4 (@ 20% PEG), 102.34 g respectively at the post-harvest stage, whereas in case of test weight the treatment were all seen significant in both rainfed and irrigated and the data recorded highest in T4 (@ 20% PEG) for both with 37.03 g and 37.06 g respectively for rainfed and irrigated. Among the interaction, harvest index, biological yield, grain yield per plant, and test weight were all significant. Furthermore, Harris *et al*., (2001) noted that the priming of wheat seeds increased 5- 36% higher yield as contrasted to non-primed seeds, and seed priming enhanced crop stand establishment and growth. Rehman *et al.*, (2014) also noticed that seed priming of linseed reduced crop branches and flowering and maturation period and received maximum plant height, number of branches, tillers, pods, and seeds per pod.

Table 4: Effect of priming of wheat seeds on yield or biological parameter under rainfed and irrigated condition.

Treatment	Rainfed				Irrigated			
	Harvest Index (%)	Biological yield (g.)	Gain yield per plant (g)	Testwt. (g.)	Harvest Index (%)	Biological yield (g.)	Gain yield per plant (g)	Test wt. (g.)
A. Variety								
V1	91.12	62.11	56.48	35.94	85.54	55.50	47.36	35.94
V2	80.27	47.44	39.51	34.45	76.86	42.06	39.78	34.45
SEm±	4.24	1.99	2.53	0.70	4.42	2.44	2.39	0.70
CD at 5%	12.45	5.84	7.41	2.05	12.96	7.15	NS	2.05
B. Salicylic acid, PEG and control								
T1	82.07	65.33	53.58	36.11	97.75	56.17	54.58	36.11
T2	91.02	63.67	57.42	36.26	99.33	54.17	53.49	36.26
T3	93.02	53.17	58.58	36.49	97.96	57.50	55.32	36.49
T4	92.94	64.50	59.83	37.03	102.34	57.50	58.87	37.06
T5	78.54	51.83	41.90	33.35	63.29	43.67	27.65	33.35
T6	76.59	54.00	41.72	31.93	76.75	51.00	38.78	31.93
SEm±	2.45	1.15	1.46	0.40	2.55	1.41	1.38	0.40
CD at 5%	7.19	3.37	4.28	1.18	7.48	4.13	4.04	1.18
C. Interaction: V × T								
V1 × T1	90.04	63.06	57.00	37.89	95.05	57.67	54.67	37.89
V1 × T2	93.56	63.00	58.83	37.45	93.75	54.33	51.00	37.45
V1 × T3	86.72	64.00	55.50	36.79	80.49	62.00	50.00	36.79
V1 × T4	88.37	66.67	59.00	37.33	92.53	58.00	53.33	37.33
V1 × T5	96.65	59.33	57.00	34.07	67.13	52.67	34.67	34.07
V1 × T6	91.41	56.67	51.52	32.08	84.27	48.33	40.50	32.08
V2 × T1	74.10	67.67	50.17	34.32	100.45	54.67	54.50	34.32
V2 × T2	88.48	64.33	56.00	35.06	104.91	54.00	55.97	35.06
V2 × T3	99.32	62.33	61.67	36.19	115.44	53.00	60.63	36.19
V2 × T4	97.51	62.33	60.67	36.72	112.15	57.00	64.41	36.72
V2 × T5	60.43	44.33	26.80	32.63	54.45	34.67	20.62	32.63
V2 × T6	61.77	51.33	31.92	31.77	69.22	53.67	37.06	31.77
SEm±	6.00	2.81	3.57	0.99	6.25	3.45	3.38	0.99
CD at 5%	18.20	8.54	10.84	NS	18.96	10.46	10.24	NS

Significant differences ($P \leq 0.05$) between varieties as well as between treatments are indicated by different letters according to two way Anova test; NS- Non significant

CONCLUSION

This research provided us an opportunity to gain practical knowledge about the production technology of wheat and about the effect of priming on growth and yield attributes. Based on the observed data, we can recommend that priming of seed before sowing improves the establishment of crop, early maturation, uniformity in growth, yield, and also stress-tolerant. The result suggests that the treating of Salicylic acid with 20 ppm and PEG with 20 % proved to be efficient towards improving growth, morphology & yield attributing characters. However, overall 20 % of PEG treatment is more suitable for both rainfed i.e. non-irrigated, and irrigated conditions. And also from the result, we can conclude that both chemicals also relieve the crop from stress conditioned where Salicylic acid enhances more stress tolerance than the PEG.

FUTURE SCOPE/CONFLICT OF INTEREST

The author wants to conclude that seed priming and enhancements have a wide range of commercial applications from improved crop stands through better germination rates and seedling vigor effective in crop stress management, and improved crop yields together with efficient use of resources such as fertilizers, water, and seeds. Sustainable crop production requires the adoption of low-cost and environmentally friendly seed enhancement techniques. Chemical seed enhancement with PEG and SA is one of the most appropriate techniques in increasing germination and vigor which can be exploited by the seed industry.

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