

# Heat Stress Mitigation through Seed Priming Treatment in Wheat

RAVI BHUSHAN PRASAD, MONIKA A JOSHI\*, SUDIPTA BASU AND KIRAN B GAIKWAD<sup>1</sup>

Division of Seed Science and Technology, ICAR- IARI, New Delhi - 110012, India

<sup>1</sup>Division of Genetics, ICAR-IARI, New Delhi - 110012, India

\*monikakshat622@gmail.com

(Received : January 2018; Revised : April 2018; Accepted : May 2018)

**ABSTRACT:** Wheat is a major cereal crop of the world and one third of the world's population uses it as a staple food. Presently, heat stress is a major factor limiting wheat productivity which causes more than 30% yield loss and influences various processes including physiological, growth, developmental, yield and quality of wheat. The present study was conducted to evaluate the efficacy of various priming treatment for heat stress mitigation. The field experiment was conducted during rabi 2014-15 and 2015-16 in the field of the Division of Seed Science and Technology, ICAR - Indian Agricultural Research Institute (IARI), New Delhi, India. Eleven representative varieties from different zones were planted on three sowing dates viz.; normal sown (mid-November, S<sub>1</sub>), late sown (mid-December, S<sub>2</sub>) and extremely late sown (early January, S<sub>3</sub>) so as to study the comparative changes experienced in heat stress versus non-heat stress environment. Seed harvested from heat stressed environment (S<sub>3</sub>) was treated with different priming treatments and based on the speed of germination, best concentrations for the respective priming treatments were identified viz.; halo priming with KH<sub>2</sub>PO<sub>4</sub> (1%), osmopriming (PEG-6000 @ - 1Mpa and plant growth regulator- GA<sub>3</sub>@ 50 ppm. The study revealed significant effect of all the priming treatments in increasing the plant height and yield contributing traits. Seed quality parameters also increased significantly as a result of seed priming. Seed priming with GA<sub>3</sub> was found to be the best treatment as compared to others.

**Keywords:** Germination, Heat stress mitigation, Seed Priming, Seed quality, Vigour index

Wheat (*Triticum aestivum* L.) is a major cereal crop of the world and one third of the world's population uses it as a staple food. Wheat production in India during the crop year 2016-17 was 96.68mt (DoAC) with an acreage of 30.37mha. It is a thermo-sensitive long day crop and is excellent matched to temperate climates; but growing population pressure and increased demand for food has forced farmers to grow wheat in non-traditional, hotter environments where heat stress is major factor limiting wheat productivity. In changing climate scenario, abiotic stresses are serious threat in crop production [1].

In India, the whole wheat growing area falls under the tropical and subtropical environment. The optimum sowing time for wheat in the major wheat growing area in India (North-west and central India) is first three weeks of November. Wahid *et al.* [2] suggested that the best temperature for all physiochemical processes of wheat from vegetative to reproductive stage is 20°C or lower. Wardlaw *et al.* [3] reported that the ratio of different protein and carbohydrate is affected due to rise in temperature. Kaur and Behl [4] reported that a yield

reduction of 0.7% per day occurs when sowing is delayed since the reproductive and ripening phases of growth of late sown wheat crop are generally exposed to high temperature stress during the month of March and April, which in turn reduces the growth and yield. An increase in 1°C can decrease grain weight up-to 4mg [5]. Thus, heat stress at different stages of crop, may accelerate the vegetative growth, shorten the phenological events and ultimately reduce the yield. It also has a profound impact on seed quality and seed health status of cereals, mainly because of their impact on nutrient uptake, assimilates supply, partitioning, and remobilization of nutrients.

Pre-sowing seed treatments seem to be a promising technique to raise successful crop in arid and semi-arid tropics since they stimulate germination and subsequent seedling growth [6]. It has been reported that priming enhances days to emergence, anthesis and increases dry matter production. Wheat seed primed with 0.3% P<sub>2</sub>O<sub>5</sub> gave less time to anthesis and yield increased with each increment of priming [7]. Various morphological

traits in wheat viz.; tiller number, spike length, number of grains /spike, thousand grain weight and seed yield per plot increased as a result of seed priming [8]. In lieu of the above, the present study was carried out to evaluate the efficacy of various seed priming treatments for heat stress mitigation in wheat (*Triticum aestivum* L.).

## MATERIALS AND METHODS

The experiment was conducted during *rabi* 2014-15 and 2015-16 in the Division of Seed Science and Technology, ICAR - Indian Agricultural Research institute (IARI), New Delhi, India. Eleven representative varieties, from different zones of the country were used for the study (Table 1).

**Table 1.** List of wheat varieties

S. No.	Variety	Zone
1	HI-1563	Central zone, timely sown
2	HI-1544	Central zone, timely sown
3	HD-2932	Central zone, late sown
4	GW-322	Central zone, timely sown
5	HD-3059	NWPZ, late sown
6	HD-2967	NWPZ, timely sown
7	PBW-17	NWPZ, timely sown
8	PBW-550	NWPZ, timely sown
9	HD: 2733	NEPZ, timely sown
10	HD-3118	NEPZ, normal sown
11	HD-3090	Peninsular zone, late sown

All the above eleven wheat varieties were planted on three sowing dates during *rabi* season 2014-15 viz.: normal sown (mid-November,  $S_1$ ); late sown (mid-December,  $S_2$ ) and extremely late sown (early January,  $S_3$ ). Seed harvested from heat stressed environment ( $S_3$ ) was treated with different priming treatments (Table 2) for all the eleven varieties.

**Table 2.** Seed priming treatments

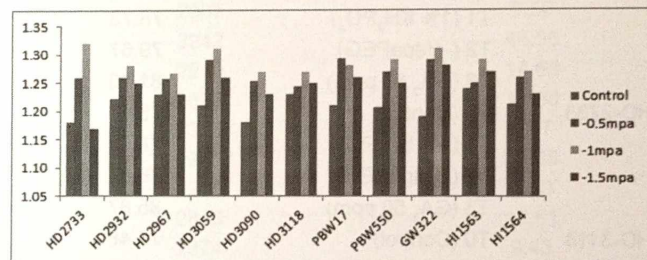
Treatment	Concentration	Duration	Temperature
Hydro priming (Water)	Distilled water	14 hour	20°C
Osmo priming (PEG- 6000)	-0.5, -1, -1.5 Mpa	14 hour	20°C
Plant growth regulator- $GA_3$	50ppm,100ppm	14 hour	20°C
Halo priming ( $KH_2PO_4$ )	0.5, 1, 2%	14 hour	20°C

For each priming treatment, an optimum dose was required to be worked out for the field evaluation. Hence, the speed of germination was worked out [9] for all the priming treatments. These selected best treatments were given to all the eleven varieties and sown in the experimental field along with control under normal sown

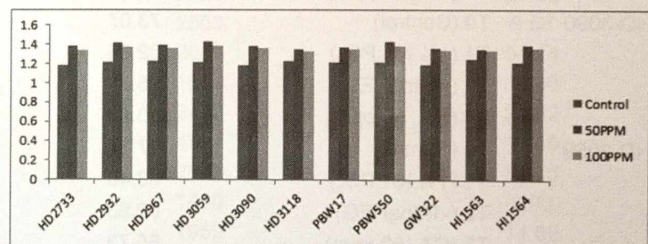
conditions during *rabi* season 2015-16. From the primed seed various morphological traits viz.; plant height, number of seeds per spike, thousand seed weight and seed yield per plot along with seed quality parameters (germination percentage and vigour indices) were recorded.

## RESULTS AND DISCUSSION

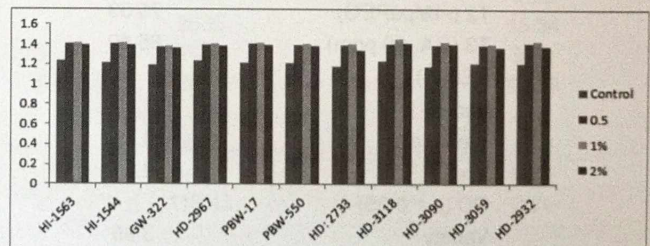
The speed of germination was worked out for all the priming treatments (Figures 1, 2, 3) so as to select the best concentration for the respective treatment. The study revealed that for Osmo priming (PEG- 6000), a concentration of -1Mpa was found to be the best (Figure 1). For Plant growth regulator  $GA_3$ , 50 ppm concentration was found to be the best (Figure 2). For halo priming with  $KH_2PO_4$  concentration of 1% was found to be the best (Figure 3); since all these respective concentrations for different priming treatments gave the maximum speed of germination. Thus, these three priming treatments (at their respective selected concentrations) were given to seed harvested from  $S_3$  environment for all the eleven



**Figure 1.** Selection of best priming concentration for Osmo priming (PEG 6000) on the basis of speed of germination



**Figure 2.** Selection of best priming concentration for  $GA_3$  on the basis of speed of germination



**Figure 3.** Selection of best priming concentration for Halo priming ( $KH_2PO_4$ ) on the basis of speed of germination

**Table 3.** Effect of various seed priming treatments on morphological characters in Wheat

Variety	Treatment	Plant height (cm)	No. of seeds per spike	1000 seeds wt (g)	Seed yield per plot
		75.87	37.67	33.02	1.10
HI-1563	T0 (Control)	81.53	42.00	35.11	1.27
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	82.33	44.67	33.84	1.00
	T2 (-1MpaPEG)	86.47	54.33	38.94	1.47
	T3 (GA <sub>3</sub> 50 ppm)	79.27	34.67	31.97	0.80
HI-1544	T0 (Control)	85.93	43.67	34.52	0.93
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	85.33	44.33	32.95	1.17
	T2 (-1MpaPEG)	87.23	53.33	35.98	1.30
	T3 (GA <sub>3</sub> 50 ppm)	74.67	35.33	31.18	1.13
GW-322	T0 (Control)	80.40	43.67	33.87	1.23
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	79.13	43.67	32.24	1.00
	T2 (-1MpaPEG)	83.47	53.00	37.27	1.47
	T3 (GA <sub>3</sub> 50 ppm)	71.93	34.67	30.12	0.97
HD-2967	T0 (Control)	79.07	43.33	32.59	1.27
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	73.53	38.67	30.94	1.23
	T2 (-1MpaPEG)	81.20	52.00	35.97	1.50
	T3 (GA <sub>3</sub> 50 ppm)	76.73	37.33	32.11	1.10
PBW-17	T0 (Control)	84.13	45.33	35.11	1.20
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	82.13	38.67	33.72	0.83
	T2 (-1MpaPEG)	82.73	53.33	37.81	1.40
	T3 (GA <sub>3</sub> 50 ppm)	75.13	33.33	31.99	0.87
PBW-550	T0 (Control)	78.73	42.67	34.87	1.17
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	79.67	42.00	35.42	0.97
	T2 (-1MpaPEG)	81.80	51.00	37.91	1.37
	T3 (GA <sub>3</sub> 50 ppm)	75.47	32.33	30.87	0.97
HD-2733	T0 (Control)	78.53	44.33	33.02	0.93
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	76.67	40.67	35.09	0.90
	T2 (-1MpaPEG)	85.87	53.67	37.32	1.43
	T3 (GA <sub>3</sub> 50 ppm)	75.48	37.33	30.85	1.20
HD-3118	T0 (Control)	88.20	43.67	33.83	1.43
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	85.67	43.33	35.09	1.00
	T2 (-1MpaPEG)	91.67	55.00	37.87	1.30
	T3 (GA <sub>3</sub> 50 ppm)	73.07	36.00	30.85	0.90
HD-3090	T0 (Control)	82.86	43.70	33.83	1.23
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	85.73	34.00	35.09	1.00
	T2 (-1MpaPEG)	90.67	51.70	37.87	1.33
	T3 (GA <sub>3</sub> 50 ppm)	77.27	33.00	31.92	1.37
HD-3059	T0 (Control)	83.40	43.00	34.92	1.20
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	82.53	43.30	32.95	1.40
	T2 (-1MpaPEG)	85.73	51.00	37.07	1.40
	T3 (GA <sub>3</sub> 50 ppm)	69.67	33.70	32.04	0.87
HD-2932	T0 (Control)	79.03	45.70	33.59	1.37
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	75.33	37.30	34.79	1.33
	T2 (-1MpaPEG)	85.60	53.00	37.76	1.47
	T3 (GA <sub>3</sub> 50 ppm)				
	SEm(±)				
	Variety	1.40	0.74	0.22	0.08
	Treatment	0.85	0.45	0.13	0.05
	V x T	2.81	1.48	0.44	0.15
	CD (p = 0.05)				
	Variety	3.95	2.08	0.63	N/A
	Treatment	2.38	1.25	0.38	0.13
	V x T	N/A	4.16	1.26	N/A

varieties and sown in the experimental field along with control under normal sown conditions during *rabi* season 2015-16. Field evaluation was done to study the effect

of these priming treatments on morphological and yield parameters (Table 3) and seed quality parameters (Table 4).

**Table 4.** The effect of various priming treatments on seed quality parameters in wheat

Variety	Treatment	Germination %	Seed Vigour Index I	Seed Vigour Index II
HI-1563	T0 (Control)	73.5	2163	10.27
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	89.5	2704	17.93
	T2 (-1MpaPEG)	84.5	2540	11.41
	T3 (GA <sub>3</sub> 50 ppm)	90.5	2987	42.56
HI-1544	T0 (Control)	71.5	1656	5.37
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	86.0	2676	18.90
	T2 (-1MpaPEG)	84.0	2121	11.36
	T3 (GA <sub>3</sub> 50 ppm)	91.0	3027	40.19
GW-322	T0 (Control)	79.0	2367	11.45
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	84.5	2502	19.85
	T2 (-1MpaPEG)	85.0	2501	9.76
	T3 (GA <sub>3</sub> 50 ppm)	92.5	2938	41.10
HD-2967	T0 (Control)	79.0	2249	12.24
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	86.0	2728	17.19
	T2 (-1MpaPEG)	85.5	2449	11.54
	T3 (GA <sub>3</sub> 50 ppm)	88.5	2778	46.49
PBW-17	T0 (Control)	79.0	1830	8.75
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	89.0	2580	24.57
	T2 (-1MpaPEG)	82.5	2087	9.50
	T3 (GA <sub>3</sub> 50 ppm)	93.0	3242	46.56
PBW-550	T0 (Control)	82.5	2219	14.03
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	87.5	2633	15.80
	T2 (-1MpaPEG)	80.5	2326	9.67
	T3 (GA <sub>3</sub> 50 ppm)	92.5	2968	38.38
HD-2733	T0 (Control)	80.0	2265	8.80
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	85.5	2815	17.51
	T2 (-1MpaPEG)	82.0	2374	9.43
	T3 (GA <sub>3</sub> 50 ppm)	89.5	2826	48.38
HD-3118	T0 (Control)	75.5	2256	11.35
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	89.0	2721	23.18
	T2 (-1MpaPEG)	88.0	2553	9.68
	T3 (GA <sub>3</sub> 50 ppm)	94.0	2956	54.14
HD-3090	T0 (Control)	81.5	1834	10.60
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	86.5	2472	21.22
	T2 (-1MpaPEG)	85.0	1911	11.45
	T3 (GA <sub>3</sub> 50 ppm)	92.5	2831	52.75
HD-3059	T0 (Control)	77.5	1410	8.90
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	86.0	1959	14.59
	T2 (-1MpaPEG)	82.0	2148	10.25
	T3 (GA <sub>3</sub> 50 ppm)	88.5	2412	48.88
HD-2932	T0 (Control)	76.5	2295	6.89
	T1 (1% KH <sub>2</sub> PO <sub>4</sub> )	87.5	2635	15.34
	T2 (-1MpaPEG)	83.5	2436	9.60
	T3 (GA <sub>3</sub> 50 ppm)	92.0	2835	48.29
SEm(±)				
Variety		1.08	56.72	1.10
Treatment		0.65	34.20	0.67
V x T		2.17	113.43	2.21
CD (p = 0.05)				
Variety		N/A	162.31	3.16
Treatment		1.87	97.88	1.90
V x T		N/A	324.63	6.31

The study revealed that there was a significant effect of all the priming treatments in increasing the plant height as compared to the control (Table 3). For the control, an average of 74.96 cm plant height was recorded which increased to 81.98 cm for T<sub>1</sub>; 80.73 cm for T<sub>2</sub> and 85.68 cm for T<sub>3</sub>. Various other morphological parameters such as number of seeds per spike, thousand grain weight and seed yield per plot was also higher in primed seed as compared to control. Seed priming with GA<sub>3</sub> was found to be the best treatment as compared to others. GA<sub>3</sub> priming-induced increase in grain yield is attributed to the GA<sub>3</sub> priming-induced modulation of ions uptake, partitioning, and hormone homeostasis under abiotic stress conditions [10]. Toklu *et al.* [11] also observed the positive effect of priming treatments on grain yield, and several characteristics of bread wheat. Hussain *et al.* [12] also found that seed priming resulted in more number of productive tillers per unit area, spike length, number of grains per spike, thousand grain weight and also improved the grain yield. This can be attributed to the fact that seed priming significantly decreases time to start emergence, time to 50% emergence, mean emergence time and improves energy of emergence in seeds harvested from all previous sowing dates. Bolek *et al.* [13] also reported that seed priming treatment gave better field emergence in plant.

The freshly harvested seed from all priming treatment was evaluated for the effect on seed quality parameters (Table 4). The study revealed that there was a significant effect of all the priming treatments in increasing the germination percentage as compared to the control. For the control, an average of 77.77% germination was recorded which increased to 87.00% for T<sub>1</sub>; 83.86% for T<sub>2</sub> and 91.32% for T<sub>3</sub>. Hence, priming treatments significantly increased germination percentage as compared to control and highest germination percentage was observed in T<sub>3</sub> as compared to other priming treatment.

Vigour index I is a multiple of germination percentage and the seedling length (Root + Shoot) (cm). The effect of heat stress on VI-I is depicted in Table 4. The study revealed that there was a significant effect of all the priming treatments in increasing the Vigour index I as compared to the control. For the control, an average of 2049.47 was recorded which increased to 2584.11 for T<sub>1</sub>; 2313.15 for T<sub>2</sub> and 2890.88 for T<sub>3</sub>. The VI-II is a multiple of germination percentage and the seedling dry weight (g). The study revealed that there was a significant effect

of all the priming treatments in increasing Vigour index II as compared to the control. For the control, an average of 9.88 was recorded which increased to 18.73 for T<sub>1</sub>; 10.33 for T<sub>2</sub> and 46.16 for T<sub>3</sub>. Hence, priming treatments also significantly increased VI-II as compared to control.

The improvement in seed quality parameters occurs since priming induces several biochemical changes in the seed that are required to start the germination process such as breaking of dormancy, hydrolysis or mobilization of inhibitors, imbibitions and enzyme activation. All of these processes that precede the germination are triggered by priming and persist following the re-desiccation of the seeds. Several workers [10 and 13] also reported improvement in seed quality parameters a result of seed priming in various crops.

## CONCLUSION

The study revealed that plant height, yield contributing traits and seed quality parameters increased as a result of seed priming. Seed priming with GA<sub>3</sub> was found to be the best treatment as compared to others.

## REFERENCES

1. IPCC (2007). Intergovernmental Panel on Climate Change, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, UK: 2007.
2. WAHIDA, S GELANI, M ASHRAF AND MR FOOLAD (2007). Heat tolerance in plants: an overview. *Environmental and Experimental Botany*, **61**(3): 199-223.
3. WARDLAW IF, IA DAWSON AND P MUNIBI (1989). The tolerance of wheat to high temperatures during reproductive growth. *Crop and Pasture Science*, **40**(1): 15-24.
4. KAUR V AND R BEHL (2010). Grain yield in wheat as affected by short periods of high temperature, drought and their interaction during pre- and post-anthesis stages. *Cereal Research Communications*, **38**(4): 514-520.
5. ISHAG HM AND BA MOHAMED (1996). Phasic development of spring wheat and stability of yield and its components in hot environments. *Field Crops Research*, **46**(1): 169-176.
6. IDRIS M AND M ASLAM (1975). The effect of soaking and drying seeds before planting on the germination and growth of *Triticum vulgare* under normal and saline conditions. *Canadian Journal of Botany*, **53**(13): 1328-1332.
7. KHALIL SK, S KHAN, A RAHMAN, AZ KHAN, IH KHALIL, SW AMANULLAH AND A KHAN (2010). Seed priming and phosphorus application enhance phenology and dry matter production of wheat. *Pakistan Journal of Botany*, **42**(3): 1849-1856.
8. IQBAL M, M ASHRAF, A JAMIL AND S URREHMAN (2006). Does seed priming induce changes in the levels of some endogenous plant hormones in hexaploid wheat plants under salt stress? *Journal of Integrative Plant Biology*, **48**(2): 181-189.

9. MAGUIRE JD (1962). Speed of Germination—Aid in selection and evaluation for seedling emergence and vigour. *Crop Science*, **2**(2): 176-177.
10. IQBAL M, MASHRAF, A JAMIL AND S UR-REHMAN (2006). Does seed priming induce changes in the levels of some endogenous plant hormones in the hexaploid wheat plants under salt stress? *Journal of Integrative Plant Biology*, **48**(2): 181-189
11. TOKLU F, FS BALOCH, T KARAKOY AND H OZKON (2015). Effects of different priming applications on seed germination and some agro morphological characteristics of bread wheat (*Triticum aestivum* L.) *Turkish Journal of Agriculture and Forestry*, **39**(6):1005-1013.
12. HUSSAIN I, R AHMAD, M FAROOQ AND A WAHID (2013). Seed Priming improves the performance of poor quality wheat seed. *International Journal of Agriculture and Biology*, **15**: 1343-1348.
13. BOLEK Y, MN NAS AND H COKKIZGIN (2013). Hydropriming and hot water-induced heat shock increase cotton seed germination and seedling emergence at low temperature. *Turkish Journal of Agriculture and Forestry*, **37**(3): 300-306.