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Impact of Heat Stress on Seed Quality and Storability in Wheat (*Triticum aestivum* L.)

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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 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 thus conducted to study the effect of heat stress on seed quality parameters and the seed storability behaviour of seeds harvested from both stressed and non-stressed environments. The field experiment was conducted during rabi2014-15 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_1), late sown (mid-December, S_2) and extremely late sown (early January, S_3) so as to study the comparative changes experienced in heat stress versus non-heat stress environment. The freshly harvested seed from all three sowings was evaluated for the effect on seed quality parameters. The study revealed that germination percentage reduced from 94.49% under S_1 to 93.42 % (S_2) and to 84.94% under S_3. Vigour Index I reduced from 2645.4 under $S_1$to 2510.7 under S_2 and to 1885.4 under S_3. Similar trend was observed for VG II also. This decline in seed vigour was reflected in reduced shoot and root dry weight, increased shoot/root ratio, reduced root length, low root number per seedling and high seed conductivity.Karnal bunt and spot blotch incidence were also adversely affected by heat stress.Seed harvested from heat stressed environment showed a significant decline in the seed quality parameters when stored at room temperature; however it was able to maintain the seed quality standards when stored under cold condition*

Keywords*: Germination, heat stress, seed quality, storability, vigour index.*

1. .INTRODUCTION

Wheat (*TriticumaestivumL.*) 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 2014-15 was 90.78mt (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 (IPCC, 2007). 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. The best temperature for all physiochemical processes of wheat from vegetative to reproductive stage is 20°C or lower. The ratio of different protein andcarbohydrate is affected due to rise in temperature (Wahid *et* al., 2007).A yield reduction of 0.7% per day occurs when sowing is delayed (Wardlaw *et al.*,1989). The reproductive (spike initiation to anthesis) and ripening (anthesis to maturity) 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 (Kaur and Behl, 2010). An increase in 1°C can decrease grain weight upto 4mg (Ishag and Mohamed, 1996). Therefore the present study on "Impact of heat stress on seed quality and storability in wheat (*Triticum aestivum L.*)" was conducted to study the effect of heat stress on seed quality parameters; and to study the seed storability in seeds harvested from both stressed and non-stressedenvironments.

2. .MATERIAL AND METHODS

The field experiment was conducted during rabi2014-15 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 used from different zones are listed in Table 1. To study the comparative changes experienced in heat stress versus non-heat stress environment, the genotypes were evaluated under contrasting environments. Hence planting was done on three different sowing dates for two consecutive years viz. normal sown (mid-November) termed as S_1; late sown (mid-December) termed as S_2; and extremely late sown (first week of January) termed as S_3.

Table 1: List of varieties used for the study

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	DBW-17	NWPZ , timely sown
8	DBW-550	NWPZ, timely sown
9	HD: 2733	NEPZ, timely sown
10	HD-3118	NEPZ, normal sown
11	HD-3090	Peninsular zone, late sown

Seed germination was determined as per ISTA (2015). Seedling vigour was calculated following formula suggested by Abul-Baki and Anderson (1973) as

Vigour Index I = Germination% X Seedling length (Root + Shoot) (cm)

Vigour Index II= Germination % X Seedling dry weight (g).

For Seed storability studies, seed harvested from all three sowings from *rabi*2014-15 i.e S_1, S_2 and S_3 was used. The seed from all three sowings was packaged in three replications in 700 guage polythene. Seed was stored under two conditions, viz. ambient (room temperature) and cold condition. After every three months, seed quality parameters were recorded for all eleven varieties under all three sowing conditions.

3. RESULTS AND DISCUSSION

Germination

The freshly harvested seed from all three sowings was evaluated for the effect of germination percentage. The study revealed that under S_1, the average germination recorded was about 94.49 % which reduced to 93.42% under S_2 and significant reduction under S_3 84.94% as depicted in Fig.1. The seed harvested from S_3 was visibly shrivelled in size; however, the germination was still maintained around the IMSCS. Crippled grain/seed filling due to high temperature leads to germination problems and less vigorous seedlings and ultimately reduced plant emergence and its establishment. Grass and Burris, 1995 also reported that long term effects of heat stress are reduced seed germination ability delayed or reduced emergence and loss of seedling vigour.Hasan*et al.*, 2013 also reported that high parent plant growth temperature during seed development and maturation resulted in poor seed quality. Similar results were also reported by other researchers (Wahid *et al*, 2007) and Dias *et a*l, 2008)

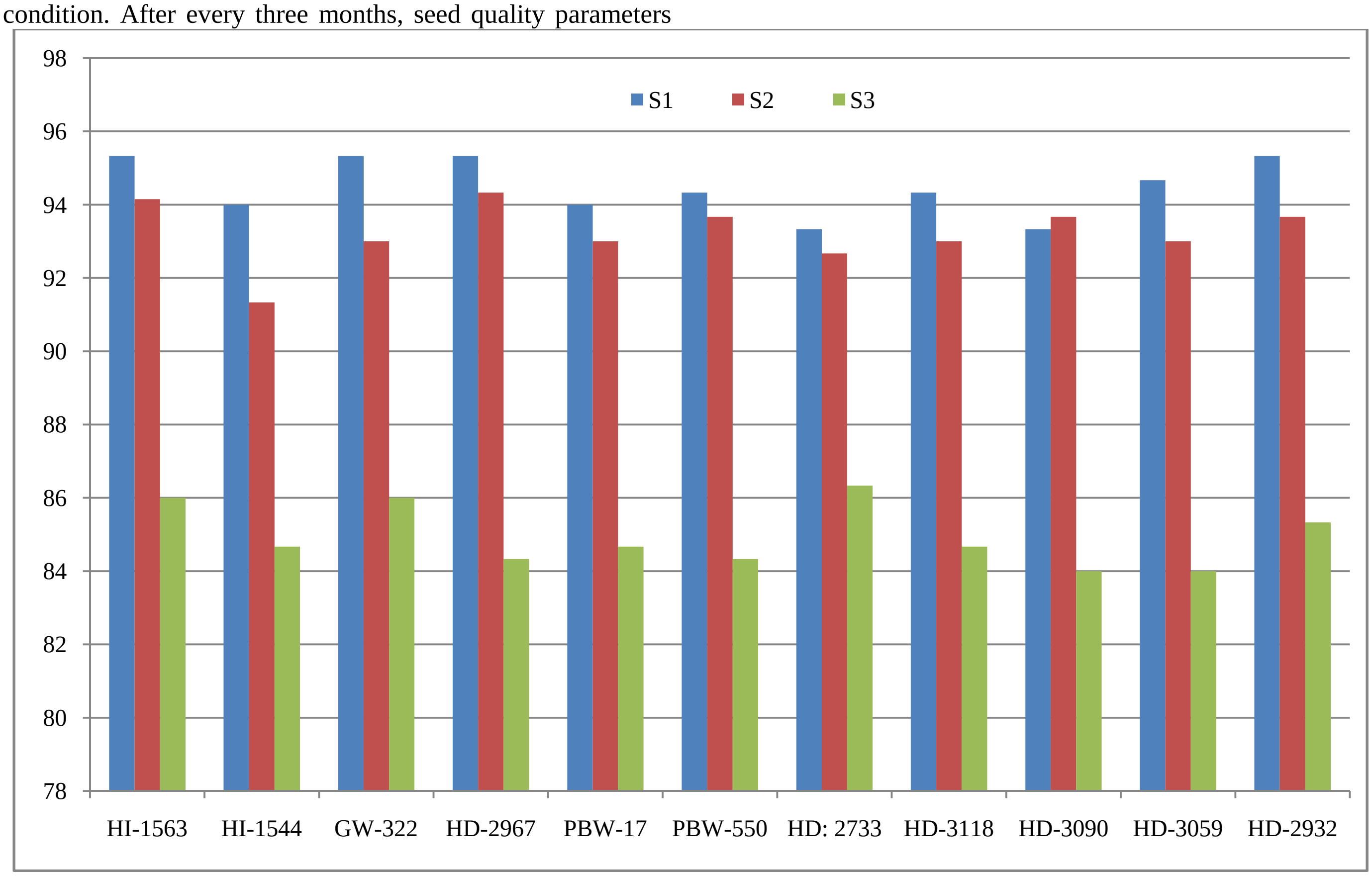

Fig. 1: Effect of sowing dates on germination percentage of wheat varieties

Seedling vigour

Vigour Index I

The VI 1 is a multiple of Germination% and the seedling length (Root + Shoot) (cm). The effect of heat stress on VG I is depicted in Fig.2. The study revealed that under S_1, the average VG I recorded was about 2645.4which reduced to 2510.7under S_2 and significant reduction under S_3 1885.4. Hence, it was observed that there was not much significant difference between S_1 and S_2. However, there was a prominent reduction under S_3 conditions.

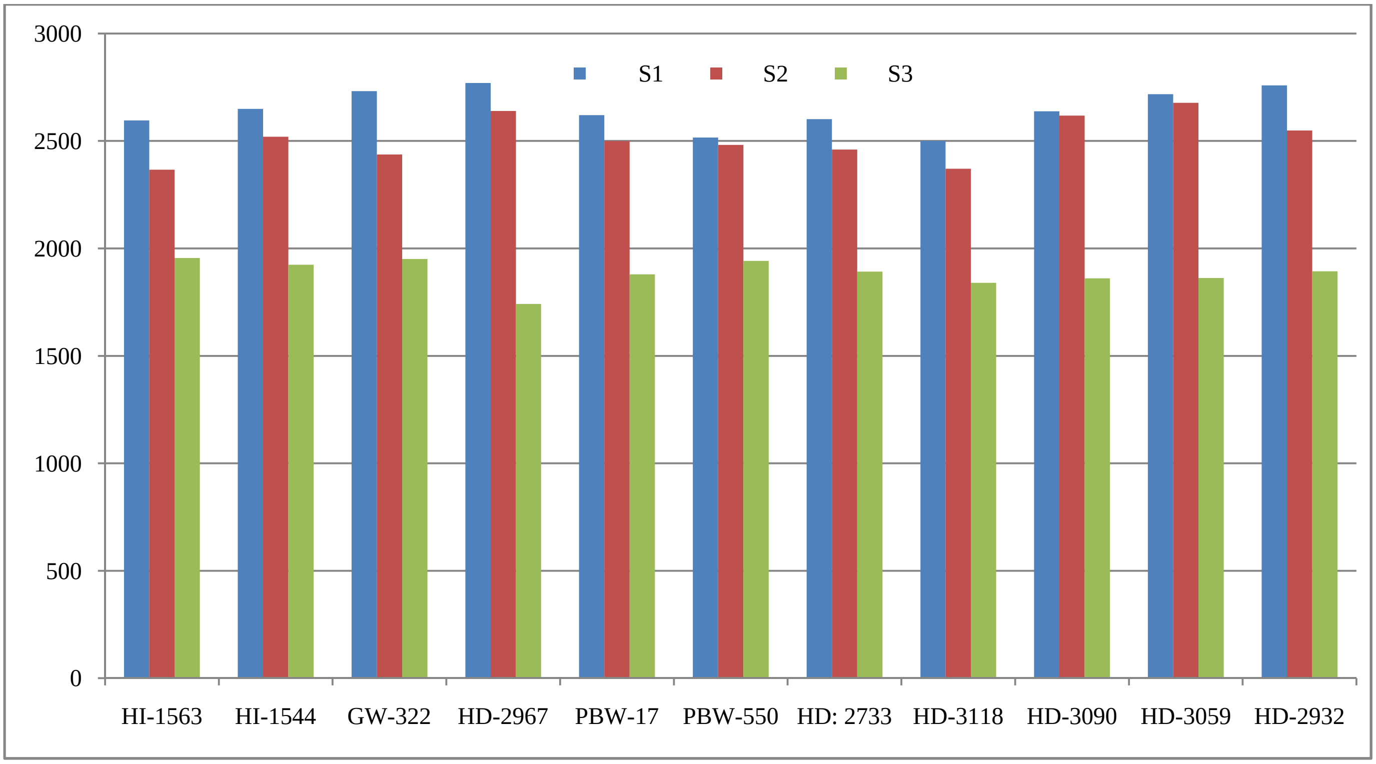

Fig. 2: Effect of sowing dates on Vigour index- I of wheat varieties

Vigour Index II

The VI II is a multiple of Germination% and the seedling dry weight (g). The study revealed that under S_1, the average VG II recorded was about 62.81 which reduced to 56.17under S_2 and significant reduction under S_3to44.99. There was a prominent reduction under S_3 conditions. Hence, seed vigour was adversely affected by heat stress. This decline in seed vigour was reflected in reduced root ratio, reduced root length, low root number per seedling.

Seed health studies

Seed health status was recorded as per Aujla*et al* 1989 for Karnal bunt and for spot blotch by Saari and Priscott 1975. The study revealed that under $S_{1,}$ Karnal bunt was 1-2%, under S_2 5-10% and under S_3 1-2% as depicted in Table 2. Spot blotch incidence was recorded as double digit score in all three sowings. Hence, both Karnal bunt and spot blotch incidence was adversely affected by heat stress.

Table 2: Effect of heat stress on disease incidence in wheat varieties

Timely sown	Genotypes	Disease Incidence(%)			Disease Severity (DD Score)		
		Karnal Bunt			Spot Blotch		
		First sowing	Second sowing	Third sowing	First sowing	Second sowing	Third sowing
	HI-1563	1-2%	5-10%	1-2%	23	34	46
	HI-1544	1-2%	5-10%	1-2%	12	24	34
	GW-322	1-2%	5-10%	1-2%	12	23	34
	HD-2967	Nil	2-5%	Nil	12	23	34
	PBW-17	1-2%	2-5%	Nil	12	23	34
	PBW-550	1-2%	2-5%	Nil	12	24	35
	HD: 2733	1-2%	5-10%	Nil	12	23	34
	HD-3118	Nil	1-2%	Nil	12	23	34
Late sown	HD-3090	2-5%	15-25%	5-10%	23	34	46
	HD-3059	2-4%	10-15%	3-5%	12	24	35
	HD-2932	1-2%	3-5%	Nil	12	23	34

Seed storability studies

The effect of heat stress on stored seed was recorded after six months and twelve months of storage under ambient conditions (room temperature) and under cold conditions. The results revealed that under ***ambient conditions***, the germination percentage for all three sowings was almost maintained after six months of storage. However, after a year of storage the germination percentage reduced from 94 to 92 under S_1; reduced from 93 to 89 under S_2; and reduced from 84 to 82 under S_3 conditions.

Whereas when the seed is stored under ***cold conditions***, there is significantly lower reduction in the loss of percent germination even after one year of storage. The germination percentage reduced from 94 to 93 under S_1; reduced from 93 to 91 under S_2; and reduced from 84 to 82 under S_3 conditions. Similar trend was recorded for vigour index I and vigour index II, which revealed that under ambient conditions, there was a significant decline after twelve months of storage as compared to storage under cold conditions.

Hence, seed harvested from heat stressed environment shows a significant decline in the seed quality parameters when stored at room temperature; however it is able to almost maintain the standards when stored under cold conditions.

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