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A comparison between synthetic wheat derivatives and bread wheat (*Triticum aestivum*) at seedling stage under various levels of temperature and GA_3 priming

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ABSTRACT

In upcoming years, global warming could produce alarming situation for wheat. Yield and maturity of wheat are critically determined by seedling vigor, with temperature as modifying factor. For the same reason, it is required to determine the adaptation of bread wheat (B) and synthetic wheat derivative (SD) at seedling stage under the influence of temperature fluctuation. The study was conducted to compare synthetic wheat derivative (SD) with bread wheat (B) at low temperature (10°C), moderate temperature (22°C) and high temperature (35°C) with and without gibberellic acid (GA_3) priming at seedling stage. The plant material consisted of four wheat genotypes, two bread and two synthetic wheat derivatives. Following plant parameters were studied viz. germination percentage (G%), germination index (GI), root length (RL), coleoptile length (CL), shoot length (SL) and seed vigor index (SVI). Analysis of variance revealed significant effect of different levels of temperature on wheat genotypes. After making comparison between bread and synthetic wheat derivatives genotypes for all the parameters, results were significantly in favour of SD. Synthetic wheat derivatives obtained relatively higher values of G%, GI and CL at low temperature and G%, GI, SVI, CL, SL and RL at high temperature than bread wheat. High temperature combined with GA_3 priming showed zero results in all genotypes due to GA_3 inactivation at high temperature. These results indicate that synthetic wheat derivatives can perform better relatively than bread wheat at seedling stage, under the influence of temperature fluctuation.

Key Words: *Synthetic Wheat Derivative, Bread Wheat, Germination, Gibberellic Acid, Temperature and Genetic Diversity*

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I. Introduction

Bread or common wheat (*Triticum aestivum*L.) is a staple food of 4.5 billion people across the globe (Braun et al., 2010). It fulfills 20% of protein and 21% of calories requirement of the people (Braun et al., 2010). Besides having significant global consumption and all the diversity due to three diploid

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genomes (A, B and D), bread wheat genome is broad and narrow simultaneously. It is due to low frequency of hybridization between male *Aegilops tauschii* (DD) and female cultivated emmer *Triticum dicoccum* (AABB) naturally. This scenario created lack of genetic diversity of bread wheat due to less exploitation of diverse genome wheats and therefore, it is facing physiological, biochemical and morphological destabilization due to abiotic stresses, especially heat and cold stress with yield loss of 50 kg ha^{-1} because of increase in 1ºC and less germination due to low temperature (Khan, 2004). Keeping consequences in mind, efforts had been made in past decades to develop primary synthetic hexaploids by artificially crossing diploid (DD) and tetraploid (AABB). These primary synthetic hexaploids were utilized to incorporate absent useful genes in modern wheat breeding programs to increase genetic diversity of wheat (Mujeeb-Kazi et al., 1996). As a result, Synthetic wheat derivatives, derived from the primary synthetics and bread wheat crosses, having exceptional resistance to temperature fluctuation (Hughes, 2003).

Seed germination and seedling vigor are critical factors to determine yield and time of maturity, with temperature as modifying factor (Essemine et al., 2007). Due to same reason, good adaptation at seedling stage under the effect of temperature fluctuation could be beneficial for whole upcoming stages of crop. And, eventually it all depends on genetic diversity of genome. Temperature variations could disturb the plant at seedling stage. As, high temperature causes modification in chloroplast structure, organization in thylakoid and eventually photosynthesis (PS II) depletion, due to decrease in biochemical reactions and denaturation of enzymes (Nakamoto and Hiyama, 1999), and finally loss of grain yield (Gibson and Paulsen, 1999). And, low temperature can increase the viscosity of membrane, metabolism damage, and more time consumption in energy dissipation, oxidative stress and radical formation (Beck et al., 2007).

Application of Gibberellic acid (GA_3) on seed, not only at optimum temperature but also at high and low temperature, could unveil the adaptability of synthetic wheat derivatives and bread wheat. As, seed priming with gibberellic acid (GA_3) can cause significant improvement in germination and seedling growth (Ghobadi et al., 2012). As, GA_3 at imbibition stage, stimulate aleurone layer to produce specific RNA molecules encoding alpha-amylase (starch digesting enzyme) through complex interacting network of signaling pathways. It leads to promotion of cambial cell division, germination and hypocotyl growth in wheat (Pospíšilová, 2003).Temperature fluctuation due to global warming could produce alarming situation for wheat in upcoming years. So, the objective of this study is to check the intensity of adaptation of synthetic wheat derivatives and bread wheat by making comparison at different ranges of temperature, along with and without GA_3 priming.

II. Materials and Methods

Experimental Material: The present study was conducted during Aug-Nov, 2019 at plant breeding and genetics laboratory, Faculty of Crops and Food sciences, PMAS- Arid Agriculture University, Rawalpindi. Experimental material consisted of 4 genotypes (2 Bread wheat B1, B2 and 2 Synthetic derivatives SD1, SD2) (Table 01) Synthetic wheat derivatives were obtained by crossing already available synthetic derivatives with respective bread wheat, making common parentage between B1 & SD1 and B2 & SD2. Ten healthy seeds of each genotype were sterilized with sodium hypochlorite to get contamination free seeds, followed by 3 times washing with distilled water. Then seeds were placed in 90-mm-diameter petri dishes on Whatman No.2 filter paper moistened with 10 ml of water (Toklu et al., 2015).Required moisture level (10ml) was maintained by adding the distilled water as and when needed.

Table 01. Pedigree of Bread and Synthetic derivative genotypes

Name	Pedigree
B1	PBW-343
SD1	PBW-343//DOY1/AE.SQUARROSA(188)
B2	INQALAB 91
SD2	INQALAB 91/TSAPKI//SCA/AE.SQUARROSA(518)

B1, bread wheat 1; B2, bread wheat 2; SD1, synthetic derivative 1; SD2, synthetic derivative 2.

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Treatments: Comparison of B and SD genotypes for germination percentage were made through six experiments conducted in the incubator (SANYO, MIR-153) available in lab. In first three experiments, petri dishes were placed in incubator at three different temperatures i.e. low temperature (LT=10°C), moderate temperature (MD=22°C) and high temperature (HT=35°C). Next three experiments were done by soaking the sterilized seeds in priming media of GA_3 (500ppm) for 20 hours, then washed thricewith distilled water and driedat room temperature by ventilation to obtain the previous moisture level of seed (Giri and Schillinger, 2003).After drying, petri dishes were placed in the incubatoragain at three different temperatures (LT, MT and HT).

Estimation of Seedling Parameters:
Seed vigor traits
Germination percentage (G%): Germination count was recorded on daily basis for 5days after sowing in petri dish. Germination percentage (G%) was calculated by adopting following formula (Ashraf and Abu-Shakra, 1978):

$$G\% = \frac{total\ germinated\ seeds}{total\ number\ of\ seeds} \times 100$$

Germination Index (GI): Germination index (GI) was calculated by following formula(Association of Official Seed Analysts, 1984):

$$GI\ (germination\ index) = \frac{number\ of\ germinated\ seeds}{days\ of\ first\ count} + \frac{number\ of\ germinated\ seeds}{days\ of\ final\ count}$$

Seedling Vigor Index (SVI): Seedling length and germination percentage helped to calculate the seedling vigor index by using the following formula (Kharb et al., 1994):

$$Seedling\ Vigor\ Index\ (SVI) = \frac{seedling\ length \times germination\ percentage}{100}$$

Seedling traits
Root length (RL), shoot length (SL) and coleoptile length (CL) were measured with measuring tape and averaged data was obtained by randomly selecting five seedlings of each genotype.

Statistical analysis: Complete Randomized Design (CRD) was used for experiments with three replications. The data for all three replications were averaged to make comparative response of each bread and synthetic wheat derivative genotypes in terms of response to different temperature levels with and without GA_3 priming at seedling stage. Analysis of variance (ANOVA) was done by using Statistix 8.1 computer software.

III. Results and Discussion

Analysis of variance (ANOVA) showed significant effect of different levels of temperature and its combinations with GA_3 priming on all studied parameters viz. G%, GI, SVI, CL, SL and RLin all breadand synthetic wheat derivatives genotypes (Table 02, Table 03).

Comparison of means of bread and synthetic wheat derivatives: Comparison between bread and synthetic wheat derivative showed that SD2 gained highest GI (with GA_3 priming) and SVI (without and with GA_3 primingat moderate temperature. Similarly, highest G% was obtained at moderate temperature by both SD2 and SD1 with and without GA_3 priming, respectively (Table 02). Both types of wheat (bread and synthetic wheat derivative) showed no germination at high temperature combined with GA_3 priming. At low temperature combined with GA_3 priming, both B1 and B2 showed minimum values of G%, GI and SVI (Table 02). SD1 gained longest SL at high temperature (with and without GA_3 priming) and moderate temperature (with GA_3 priming). SD2 obtained longest RL at moderate temperature (without GA_3 priming). And, longest CL was obtained in SD1 and SD2 at moderate temperature with and without GA_3 priming, respectively (Table 03). Bread wheat genotypes showed shortest CL, SL and RL at low temperature with GA_3 priming (Table 03). However, it was observed that synthetic wheat derivative genotypes performed better than bread wheat genotypes under different conditions (Table 02, Table 03).

Comparison between B1 & SD1 and B2 & SD2: B1 & SD1 and B2 & SD2 share the parentage as mentioned in Table 01. Due to this reason, similarity in trend of increasing and decreasing of all parameters was observed. Therefore, comparison between B1 &SD1 and B2 & SD2 at different conditions is more reasonable. SD1 showed significant highest G% and GI at low temperature with GA_3 priming than corresponding B1 (Figure 01 and Figure 02). SD2 showed significant highest G% and SVI at high temperature (without GA_3 priming) and moderate temperature (with GA3 priming) and highest GI at moderate temperature (with GA_3 priming), then corresponding B2 (Figure 01, Figure 02 and Figure 06). SD1 gained noteworthy CL at low temperature (without GA_3 priming), SL and RL at high temperature (without GA_3 priming) than corresponding B1 (Figure 03, Figure 04 and Figure 05). SD2 obtained substantial RL at high temperature (without GA_3 priming) and moderate temperature (with GA_3 priming), then corresponding B2 (Figure 05). However, it was observed that difference of efficiency between bread and synthetic wheat derivative genotypes at low temperature (with and without GA_3 priming) was not as significant as compared to other conditions (Figure 01-06).

Table 02. ANOVA showng mean square values of Bread and synthetic derivate cultivars for Germination index and Germination Percentage

SOV	Df	GI %				G %			
		B1	SD1	B2	SD2	B1	SD1	B2	SD2
Temp	2	7400**	6650**	3150**	4838.8**	60.3**	36.5**	5.7**	70**
PGR	1	5000**	2450**	6050**	5688.8**	44.6**	23.2**	123**	17**
Temp X PGR	2	1400**	950**	50**	2038.8**	83.5**	111.1**	32**	116**
Error	10	56.67	70	16.67	32.22	0.07	0.09	0.02	0.02
CV		6.6	7.9	9.3	8.6	5.2	7.4	6.1	5.5

** and * denoted significance at the 0.01 and 0.05 probability level, respectively. CV, coefficient of variation; PGR, Plant growth regulator (GA_3, 500ppm); Temp, temperature; B, bread wheat; SD, synthetic derivative; G%, germination percentage; GI, germination index.

Table 03. ANOVA showing mean square values of Bread and synthetic derivate cultivars for shoot length and coleoptile length

SOV	Df	SL				CL			
		B1	SD1	B2	SD2	B1	SD1	B2	SD2
Temp	2	59.7**	52.3**	48.7**	83.5**	10.5**	10.9**	8.2**	18**
PGR	1	38.7**	51**	79.3**	58.3**	10.1**	5.7**	5.4**	5.7**
Temp X PGR	2	56.4**	132.1**	42.9**	47.5**	3.3**	5.5**	2.2**	2.7**
Error	10	0.09	0.08	0.06	0.07	0.07	0.07	0.07	0.07
CV		6.6	7.9	9.3	8.6	5.2	7.4	6.1	5.5

** and * denoted significance at the 0.01 and 0.05 probability level, respectively. CV, coefficient of variation; PGR, Plant growth regulator (GA_3, 500ppm); Temp, temperature; B, bread wheat; SD, synthetic derivative; SL, shoot length; CL, coleoptile length.

Table 04. ANOVA showing mean square values of Bread and synthetic derivate cultivars for Root Length and Seed vigour Index

SOV	Df	RL				SVI			
		B1	SD1	B2	SD2	B1	SD1	B2	SD2
Temp	2	7.8**	8.8**	20.8**	22.4**	137.6**	148.9**	93.8**	227**
PGR	1	41.4**	69.6**	29.6**	59.4**	49.3**	82.3**	124**	159**
Temp X PGR	2	2.01**	4.08**	8.01**	8.06**	15.9**	40**	28**	34**
Error	10	0.1	0.01	0.02	0.08	0.4	1.01	0.4	0.8
CV		6.6	7.9	9.3	8.6	5.2	7.4	6.1	5.5

** and * denoted significance at the 0.01 and 0.05 probability level, respectively. CV, coefficient of variation; PGR, Plant growth regulator (GA_3, 500ppm); Temp, temperature; B, bread wheat; SD, synthetic derivative; RL, root length; SVI, seed vigor index.

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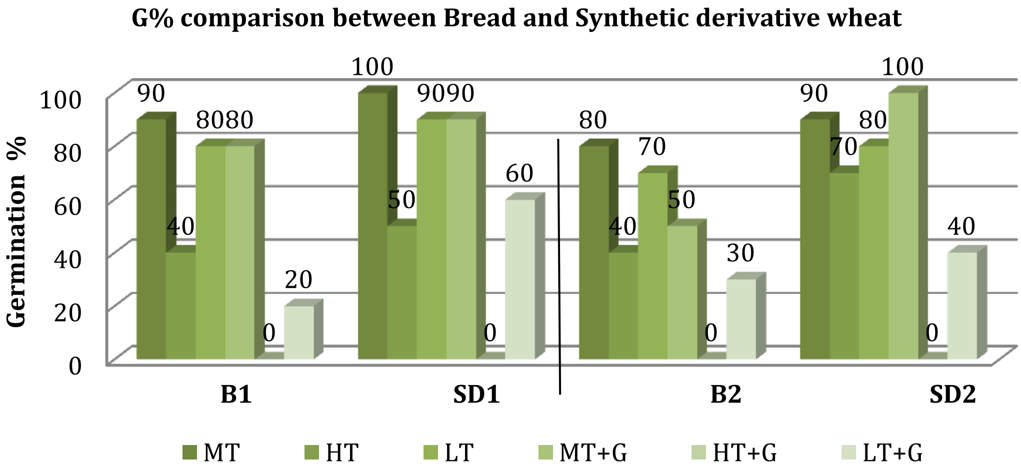
Spring wheat is grown in wide range of environments, exposing to range of temperature fluctuations such as February second half (25/10°C), March (30/15°C) and April (40/25°C). These conditions affect wheat yield negatively at different temperature and result in huge yield losses. Such losses can be compensated by exploiting novel genetic resources. Synthetic wheat derivatives appeared as barrier against temperature fluctuations, due to presence of useful abiotic stress resistant genes (Hughes, 2003).Therefore, critical comparison between bread and synthetic wheat derivative genotypes at seedling stage is a nice strategy to explore genetic resources harboring tolerance to abiotic stresses in wheat (Toklu et al., 2015).

It was observed that without GA_3 priming, G% decreased under both low temperature and high temperature. But the decrease was more under high temperature than low temperature (Figure 01) (Toklu et al., 2015). Without GA_3 priming, high temperature caused increase in GI than moderate and low temperature (Figure 02). It is because; high temperature causes increase in activity of alpha amylase which increases mobilization of seed reserves (Hasan et al., 2004; Sultana et al., 2015).A variable trend of G% was observed with GA_3 priming, for both bread and synthetic wheat derivatives (Figure 01) (Yari et al., 2010). GI after GA_3 priming increases at moderate temperature in both types of wheat (Figure 02). GA_3 priming increases the metabolic activity in seeds which cause enhance in germination speed and synchronization (Sikder and Paul, 2010). However, zero or low efficiency of all parameters (G%, GI, SVI, CL, SL and RL) at high and low temperature with GA_3 priming (Figure 01-06), is due to rapid decrease of incorporation of amino acid (^{14}C-amino-acid) by GA_3 above 25°C and below 10-15°C, and due to increase in inhibitors at high temperature which effect plant growth (Stoddart et al., 1978; Gonai et al., 2004). RL decreased significantly at moderate temperature with GA_3 priming (Figure 05) (Ghobadi et al., 2012). RL without GA_3 priming, showed efficient increase from low temperature to moderate temperature and decreased at high temperature (Figure 05). It is due to increase in dry matter of root from low to moderate temperature and decrease above moderate temperature (Hasan et al., 2004; Sikder and Paul, 2010). However, large root system plays vital role in valuable traits such as deep-water capture and increase in absorption efficiency (Reynolds et al., 2006).



G%, germination percentage; MT, moderate temperature (22°C); HT, high temperature (35°C); LT, low temperature (10°C); MT+G, moderate temperature with GA_3 priming; HT+G, high temperature with GA_3 priming; LT+G, low temperature with GA_3 priming; B, bread wheat; SD, synthetic derivative.

Figure 01. Comparison between G% mean values of two bread and two synthetic derivatives wheat at different temperatures and GA3 priming.

It was observed that first pair of genotypes (B1 and SD1) followed different trend as compared to second pair (B2 and SD2) for all parameters. First pair (B1 and SD1) without GA_3 priming showed more decrease in CL at high temperature than low temperature and long SL at high temperature than moderate temperature and low temperature. Similarly, first pair with GA_3 priming showed long CL and SL at moderate temperature. This trend of first pair (B1 and SD1) is opposite to second pair (B2 and SD2) (Figure 03 and Figure 04). Overall, it was observed that synthetic wheat derivative genotypes originated from same parents of bread wheat genotypes, appeared to be more efficient and consistent at different environmental conditions. However, difference in trend of CL and SL among both types of wheat may be due to the presence or absence of height reducing genes (*Rht1* and *Rht2*). These genes

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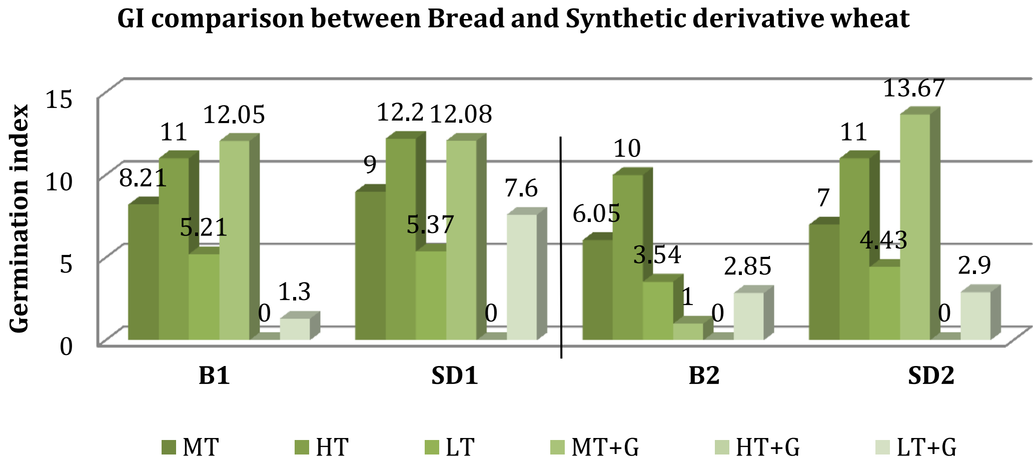
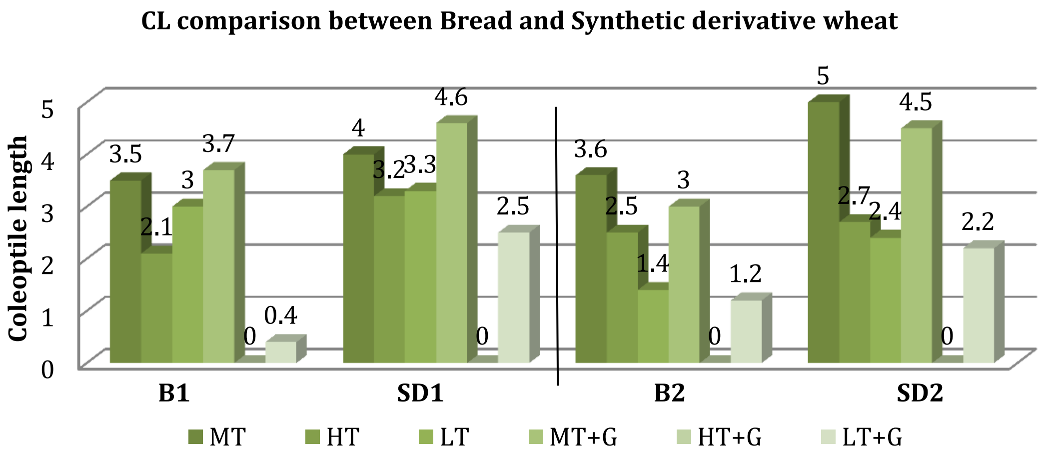
reduced length CL and SL before GA_3 priming due to insensitivity of endogenous gibberellin and after GA_3 priming due to insensitivity of exogenous gibberellin. So, eventually CL and SL depend on genotype (Rebetzke et al., 1999). However, high CL plays key role in seedling emergence from deeper soils in wheat (Matsui et al., 2002). Highest SVI was obtained at optimum temperature. However, for all environmental conditions variable trends were obtained for SVI (Figure 06). The reason may be that SVI is a product of variable values of seedling (CL, SL and RL) and germination (G% and GI) parameters (ISTA, 2014) and solely depends on these parameters at different conditions.



GI, germination index; MT, moderate temperature (22°C); HT, high temperature (35°C); LT, low temperature (10°C); MT+G, moderate temperature with GA_3 priming; HT+G, high temperature with GA_3 priming; LT+G, low temperature with GA_3 priming; B, bread wheat; SD, synthetic derivative.

Figure 02. Comparisons between GI mean values of two bread and two synthetic derivatives wheat at different temperatures and GA_3 priming.

Plants respond to harsh conditions by making changes in their architecture, cell enlargement or due to activation of cold acclimation or thermo-tolerance genes (Halliday and Whitelam, 2003; Penfield, 2008). And, these indicate plasticity in plant's adaptation to severe conditions (Casal et al., 2004). In our case synthetic wheat derivative genotypes appeared to be more adoptable than bread wheat adjustments genotypes in all optimum and stress conditions. However, absence of significant difference at low temperature between bread and synthetic derivatives for almost all parameters (G%, GI, SVI, CL, SL and RL) was observed, as these limitations were also found for specific environments (Zaharieva et al., 2001).



CL, coleoptile length; MT, moderate temperature (22°C); HT, high temperature (35°C); LT, low temperature (10°C); MT+G, moderate temperature with GA_3 priming; HT+G, high temperature with GA_3 priming; LT+G, low temperature with GA_3 priming; B, bread wheat; SD, synthetic derivative.

Figure 03. Comparison between CL mean values of two bread and two synthetic derivatives wheat at different temperatures and GA_3 priming.

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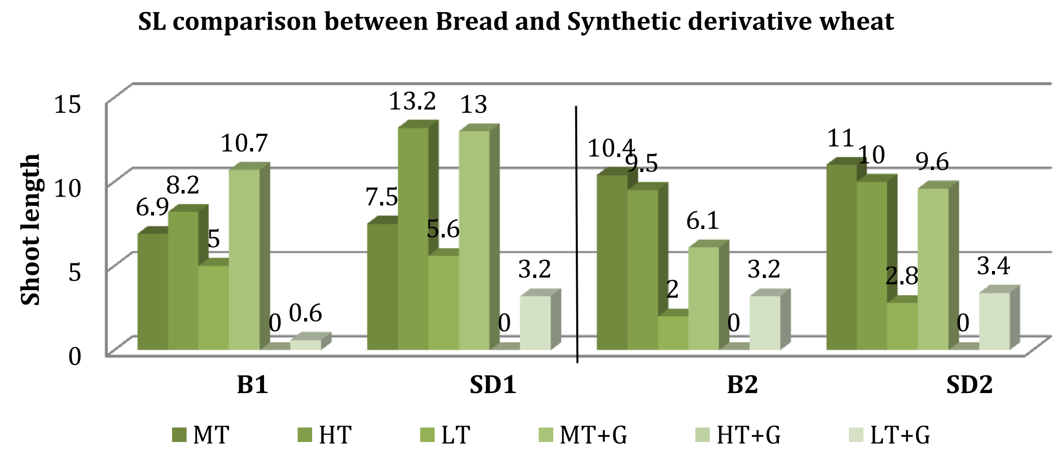
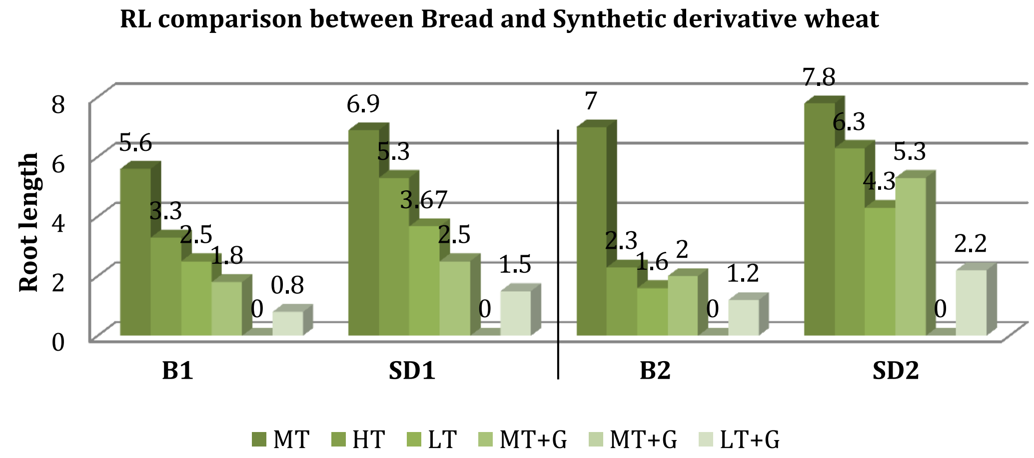


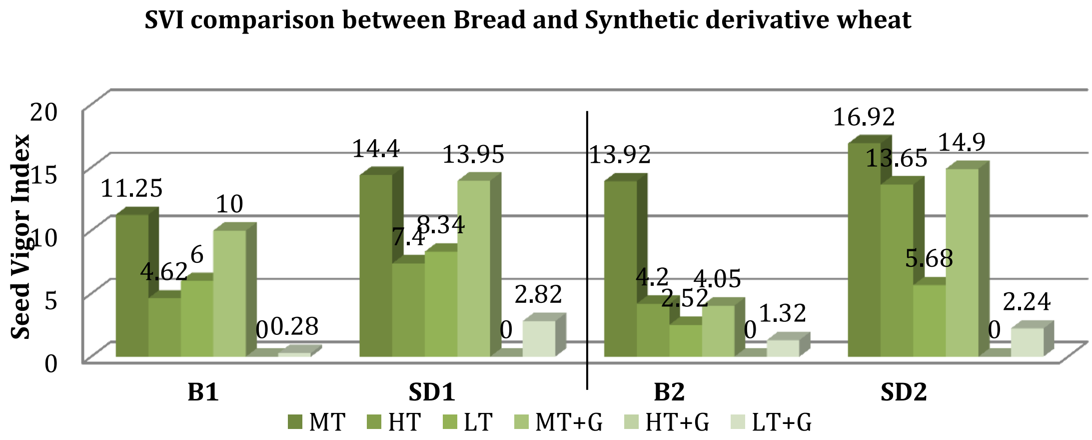
SL, shoot length; MT, moderate temperature (22°C); HT, high temperature (35°C); LT, low temperature (10°C); MT+G, moderate temperature with GA_3 priming; HT+G, high temperature with GA_3 priming; LT+G, low temperature with GA_3 priming; B, bread wheat; SD, synthetic derivative.

Figure 04. Comparison between SL mean values of two bread and two synthetic derivatives wheat at different temperatures and GA_3 priming.



RL, root length; MT, moderate temperature (22°C); HT, high temperature (35°C); LT, low temperature (10°C); MT+G, moderate temperature with GA_3 priming; HT+G, high temperature with GA_3 priming; LT+G, low temperature with GA_3 priming; B, bread wheat; SD, synthetic derivative.

Figure 05. Comparison between RL mean values of two bread and two synthetic derivatives wheat at different temperatures and GA_3 priming.



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SVI, seed vigor index; MT, moderate temperature (22°C); HT, high temperature (35°C); LT, low temperature (10°C); MT+G, moderate temperature with GA_3 priming; HT+G, high temperature with GA_3 priming; LT+G, low temperature with GA_3 priming; B, bread wheat; SD, synthetic derivative.

Figure 06. Comparison between SVI mean values of two bread and two synthetic derivatives wheat at different temperatures and GA_3 priming.

IV. Conclusion

In conclusion, synthetic wheat derivative genotypes can be effectively substitute bread wheat genotypes against temperature stresses and certain limitations at low temperature can be overcome by exploiting cold resistant genes from diploid and tetraploid wheat.

V. References

[1]. Ashraf, C. M. and Abu-Shakra, S. (1978). Wheat seed germination under low temperature and moisture stress. Agronomy Journal, 70, 135-139. https://doi.org/10.2134/agronj1978.00021962007000010032x
[2]. Association of Official Seed Analyst. (1984). Rules for testing seeds. Journal of Seed Technology, 12(3), 1-109.
[3]. Beck, E. H., Fettig, S., Knake, C., Hartig, K. and Bhattarai, T. (2007). Specific and unspecific responses of plants to cold and drought stress. Journal of Biological Science, 32(3), 501-510. https://doi.org/10.1007/s12038-007-0049-5
[4]. Braun, H. J. Atlin, G. and Payne, T. (2010). Multi-location testing as a tool to identify plant response to global climate change. p. 115-138. In: Climate change and crop production, CABI, Wallingford, UK. https://doi.org/10.1079/9781845936334.0115
[5]. Casal, J. J., Fankauser, C., Coupland, G. and Blázquez, M. A. (2004). Signalling for developmental plasticity. Trends in Plant Sciences, 9(6), 309-314. https://doi.org/10.1016/j.tplants.2004.04.007
[6]. Essemine, J., Ammar, S., Jbir, N. and Bouzind, S. (2007). Sensitivity of two wheat species's seeds (*Triticum durum*, variety Karim and *Triticum aestivum*, variety Salambô) to heat constraint during germination. Pakistan Journal of Biological Sciences, 10(21), 3762-3768. https://doi.org/10.3923/pjbs.2007.3762.3768
[7]. Ghobadi, M., Abnavi, M. S., Honarmand, S. J., Ghoadi, M. E. and Mohammadi, G. R. (2012). Effect of hormonal priming (GA_3) and osmopriming on behavior of seed germination in wheat (*Triticum aestivum* L.). Journal of Agricultural Sciences, 4(9), 244-250. https://doi.org/10.5539/jas.v4n9p244
[8]. Gibson, L. R. and Paulsen, G. M. (1999). Yield components of wheat grown under high temperature stress during reproductive growth. Crop Sciences, 39(6), 1841-1846. https://doi.org/10.2135/cropsci1999.3961841x
[9]. Giri, G. S. and Schillinger, W. F. (2003). Seed priming winter wheat for germination, emergence and yield. Crop Sciences, 43(6), 2135-2141. https://doi.org/10.2135/cropsci2003.2135
[10]. Gonai, T., Kawahara, S., Tougou, M., Satoh, S., Hashiba, T., Hirai, N., Kawaide, H., Kamiya, Y. and Yoshioka, T. (2004). Abscisic acid in the thermoinhibition of lettuce seed germination and enhancement of its catabolism by gibberellin. Journal of Experimental Botany, 55(394), 111-118. https://doi.org/10.1093/jxb/erh023
[11]. Halliday, K. J. and Whitelam, G. C. (2003). Changes in photoperiod or temperature alter the functional relationships between phytochromes and reveal roles for phyD and phyE. Plant Physiological, 131(4), 1913–1920. https://doi.org/10.1104/pp.102.018135
[12]. Hasan, M. A., Ahmed, J. U., Hossain, T., Hossain, M. M. and Ullah, M. A. (2004). Germination characters and seed reserve mobilization during germination of different wheat genotypes under variable temperature regimes. Journal of National Science. Foundation of Sri Lanka, 32(3-4), 97–107. https://doi.org/10.4038/jnsfsr.v32i3-4.2429
[13]. Hughes, L. (2003). Climate change and Australia: Trends, projections and impacts. Aus. Ecol. 28, 423–43. https://doi.org/10.1046/j.1442-9993.2003.01300.x

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[14]. International Rules for Seed Testing – ISTA (2014). Seed Vigor Testing organization in Zurich, Switzerland. Available at: https://www.seedtest.org/en/international-rules-_content---1--1083.html. (Accessed: 19 April 2017)

[15]. Khan (2004). Wheat crop management for yield maximization. Annual Research Program, Arid Zone Research Institute, Bhakkar, Pak. Available at: http://www.aari.punjab.gov.pk/institutes-sections/arid-zone-research-institute/415-research-projects/1196-arid-zone-research-institute-bhakkar. (Accessed: 19 April 2017)

[16]. Kharb, R. P. S., Lather, B. P. S. and Deswal, D. P. (1994). Prediction of field emergence through heritability and genetic advance of vigour parameters. Seed Science Technology, 22(3), 461–466.

[17]. Matsui, T., Inanaga, S., Shimotashior, T., An, P. and Sugimoto, Y. (2002). Morphological characters related to varietal differences in tolerance to deep sowing in wheat. Plant Production Sciences. 5(2), 169-174. https://doi.org/10.1626/pps.5.169

[18]. Mujeeb-Kazi, Rosas, A. and Roldan, V. (1996). Conservation of the genetic variation of *Triticum tauschii* (Coss.) Schmalh. (Aegilops squarrosa auct. non-L.) in synthetic hexaploid wheat's (*T. turgidum* L. s.lat. x *T. tauschii*; 2n=6x=42, AABBDD) and its potential utilization for wheat improvement. Plant Breeding, 115, 407–409. https://doi.org/10.1007/BF00126756

[19]. Nakamoto, H. and Hiyama, T. (1999). Heat-Shock Proteins and Temperature Stress. p. 209-221. In: Handbook of Plant and Crop Stress, Marcel Dekker, Inc., Publishers, New York, USA.

[20]. Penfield, S. (2008). Temperature perception and signal transduction in plants. New Phytological, 179(3), 615-628. https://doi.org/10.1111/j.1469-8137.2008.02478.x

[21]. Pinthus, M. J. and Abraham, M. (1996). Effects of light, temperature, gibberellin (GA_3) and their interaction on coleoptile and leaf elongation of tall, semi-dwarf and dwarf wheat. Plant Growth Regulators, 18(3), 239–247. https://doi.org/10.1007/BF00024388

[22]. Pospíšilová, J. (2003). Participation of phytohormones in the stomatal regulation of gas exchange during water stress. Biology of Plant, 46(4), 491–506. https://doi.org/10.1023/A:1024894923865

[23]. Rebetzke, G. J., Richards, R. A., Fischer, V. M. and Mickelson, B. J. (1999). Breeding long coleoptile, reduced height wheats. Euphytica, 106(2), 159–168. https://doi.org/10.1023/A:1003518920119

[24]. Reynolds, M., Dreccer, F. and Trethowan, R. (2006). Drought-adaptive traits derived from wheat wild relatives and landraces. Journal of Experimental Botany, 58(2), 177–86. https://doi.org/10.1093/jxb/erl250

[25]. Sikder, S., and Paul, N. K. (2010). Study of influence of temperature regimes on germination characteristics and seed reserves mobilization in wheat. African Journal of Plant Sciences, 4(10), 401-408.

[26]. Society of Commercial Seed Technologists (SCST) (1984). Association of official seed analysts' officers and committees for 1983-1984. Journal of Seed Technology, 9, 162-164.

[27]. Stoddart, J. L., Tapster, S. M. and Jones, T. W. A. (1978). Temperature dependence of the gibberellin response in lettuce hypocotyls. Planta, 141(3), 283–88. https://doi.org/10.1007/BF00388345

[28]. Sultana, N., Ikeda, T. and Mitsui, T. (2015). GA_3 and proline promote germination of wheat seeds by stimulating α-amylase at unfavorable temperatures. Plant Production Science, 3(3), 232–37. https://doi.org/10.1626/pps.3.232

[29]. Toklu, F., Baloch, F. S., Karakoy, T. and Ozkan, H. (2015). Effects of different priming applications on seed germination and some agromorphological characteristics of bread wheat (*Triticum aestivum* L.). Turkish Journal of Agriculture and Foresty, 39(6), 1005–1013. https://doi.org/10.3906/tar-1404-41

[30]. Yari, L., Majid, A. and Fardin, K. (2010). Effect of seed priming duration and temperature on seed germination behavior of bread wheat (*Triticum aestivum* L.). Journal of Agriculture and Biological Sciences, 5(1), 1–6.

[31]. Zaharieva, M., Gaulin, E., Havaux, M., Acevedo, E. and Monneveux, P. (2001). Drought and heat responses in the wild wheat relative Aegilops geniculata roth: Potential interest for wheat improvement. Crop Sciences, 41(4), 1321–1329. https://doi.org/10.2135/cropsci2001.4141321x

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Chicago

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Harvard

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Vancouver

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