Journal of Agroecology and Natural Resource Management
p-ISSN: 2394-0786, e-ISSN: 2394-0794, Volume 3, Issue 3; July-September 2016 pp. 288-294

http://www.krishisanskriti.org/Publication.html

Study on Germination Related Seed Quality of Wheat Genotypes in Different Temperature Regimes

Pronay Bala[1] and Sripati Sikder[2]

[1]*Dept. of Agriculture Haji Lal mia City College, Gopalganj, Bangladesh*
[2]*Dept. of Crop Physiology and Ecology Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh*
E-mail: [1]kbdpronay@yahoo.com, [2]srisikder@gmail.com

Abstract–*The experiment was carried out at Crop Physiology and Ecology laboratory of HSTU, Dinajpur during the period of December, 2012. This experiment was carried out to evaluate germination characteristics, viz., rate of germination, co-efficient of germination and vigor indices of wheat genotypes under different temperature regimes and to determine seed metabolic efficiency of eight wheat genotypes under different temperature regimes. The experiment was carried out in two factors completely randomized design with three replications. The treatment factors three germination temperatures (low, moderate and stressful) of 18, 24 and 32°C and eight wheat genotypes of which three (BARI Gom-25, BARI Gom-26, BAW-1143) were heat tolerant (HT), four (Prodip, BAW-1146, BAW-1147and BAW-1148) were moderately heat sensitive (MHS) and one was heat sensitive (Pavon-76). Seeds of wheat genotypes were germinated to study seed metabolic efficiency and seed reserves mobilization at 18º, 24º and 32ºC temperature. Temperature had a tremendous effect on speed of germination and seed reserves mobilization. At moderate temperature (24º C), all the genotypes showed the highest seed metabolic efficiency (SME) than those of the lowest (18ºC) and highest (32ºC) temperatures. Heat tolerant (HT) genotypes attained higher SME than those of moderate heat tolerant (MHT) genotypes and heat sensitive genotype in all the temperature regimes.*

1. INTRODUCTION

Wheat is a C_3 plant that thrives well in cool environments. It is a widely grown crop from temperate, irrigated to dry and high rainfall areas and from warm, humid to dry cold environments [1]. However, the production of this important cereal is limited by a number of abiotic stress factors such as drought, heat and salinity. Heat stress is the most important stress factor that affects between 25 and 30 million hectares of wheat annually in the world and thereby causing significant grain yield reduction [2].

High temperature posed a severe threat to wheat production in many countries, particularly when it occurs during reproductive and grain filling phases. Unlike drought and salinity stresses, changes in ambient temperatures occur within hours. Therefore, plants need to suppress and respond to the adverse. For healthy wheat growth and a good yield, the range of the optimum temperatures was 18 to 24°C. Temperatures above 28 to 32°C for short periods (e.g., 5 to 6 days) found to cause about 20% or more wheat yield losses [3]. This is because heat stress causes an array of physiological, biochemical and morphological changes in wheat which reduce tillering capacity, shortens grain filling period and accelerates crop senescence [4].

High temperatures affect membrane integrity and subsequently impair germination and seedling vigor [5].Impair germination and decline in seed vigor in wheat reflected in reduced shoot and root dry weight and higher seed conductivity due to high temperature during seed development and maturation [6]. Germination and seed reserved mobilization may vary in different temperatures regimes [7]. Temperature is a modifying factor in germination since it can influence the rate of water and other substrates supply, necessary for plant growth and development [8]. The magnitude of variation in seed reserve mobilization also varies in different genotypes and higher seed metabolic efficiencies (SME) [9].Therefore, the study aimed was to determine the effects of temperature stress on seed germination, seedling growth and seed metabolic efficiencies at different temperatures were assessed to the laboratory for wheat.

2. MATERIALS AND METHOD

2.1. Location and duration

This experiment was carried out at Crop Physiology and Ecology Laboratory of HSTU, Dinajpur during the period of December, 2012.

2.2. Experimental design and treatments

The experiment was carried out in two factors completely randomized design with three replications. One factor was three germination temperatures (low, moderate and stressful) of 18, 24 and 32°C.And another factor was eight wheat genotypes of which three (BARI Gom-25, BARI Gom-26, BAW-1143) were heat tolerant (HT), four (Prodip, BAW-1146, BAW-1147and BAW-1148) were moderately heat sensitive (MHS) and one was heat sensitive (Pavon-76).

2.3. Collection of seed

Eight wheat genotypes including four varieties and four advanced lines were collected from Wheat Research Centre (WRC) of BARI, Dinajpur were used for the present study.

2.4. Seed placement for germination

Before placement of seed for germination, the seeds of a genotype were thoroughly mixed and moisture percentage was determined gravimetrically using a portion of the seeds, the remaining seeds were used for the experiment. Individual weight of 30 seeds for each genotype was taken and was placed sequentially according to the marking on filter paper soaked with water in sterilized Petri dishes. Then the Petri dishes were kept in seed germinator (WTB-Binder, Germany) at 18, 24 and 32°C. For each temperature, three batches of Petri dishes each containing 30 seeds was used. Water was added to the petri dishes when necessary. Data were calculated by the following equations.

2.5. Rate of germination, co-efficient of germination and germination vigor

Germination was counted at 24-hour interval and continued up to the 5th day (120 h). A seed was considered germinated when plumule and radicle came out and was larger than 2 mm long. The rate of germination was calculated by following formula [10], as-

Rate of germination (%)

$$= \frac{\text{No. of seeds germinated at 48h}}{\text{No. of seeds germinated at 120h}} \times 100$$

Co-efficient of germination and vigor index were calculated using the following formulae (Copeland, 1976).

$$\textit{Co-efficient of germination} = \frac{100(A_1 + A_2 + \text{------} + A_n)}{A_1T_1 + A_2T_2 + \text{---} + A_nT_n}$$

$$\textbf{\textit{Vigor index}} = \frac{A_1}{T_1} + \frac{A_2}{T_2} + \text{--------} + \frac{A_n}{T_n}$$

Where,

A = Number of seeds germinated

T = Time (days) corresponding to A

n = No. of days to final count

2.6. Shoot and root length

At 5th day after placement for germination, five seedlings from each Petri dish were sampled, shoot and root length of the individual seedling was recorded manually with scale.

2.7. Dry matter partitioning

Shoot, root and remaining seeds were dried separately at 70ºC for 72h in electric oven (Model–E28 # 03-54639, Binder, Germany) and weights were recorded with an electric balance (Model-AND EK-300i). Dry weights were calculated for each treatment combination.

2.8. Seed metabolic efficiency (SME)

Seed metabolic efficiency in the present study is defined as the amount of shoot and root dry matter (g) produced from 1 unit (g) of dry seed weight that was respired. Thus higher the value of seed metabolic efficiency (SME), the higher is the efficiency of seed as more seed reserves would be used for producing roots and shoots.

Seed metabolic efficiency (SME) was calculated using the following formula [11].

$$SME = \frac{SHW + RTW}{SMR}$$

Where,

SDW=Seed dry weight before germination

SHW = Shoot dry weight

RTW = Root dry weight

RSW = Remaining seed dry weight

Amount of seed material respired (SMR) was calculated as -

SMR = SDW- (SHW +RTW +RSW)

2.9. Statistical analysis

The data were analyzed by partitioning the total variance with the help of computer using MSTAT program [12]. The treatment means were compared using Duncan's Multiple Range Test at P ≤ 0.05.

3. RESULT AND DISCUSSION

3.1. Germination characteristics

The rate of germination, co-efficient of germination and germination vigor indices of eight wheat genotypes are presented in Table 1. At 18ºC, all the genotypes showed the lowest rate of germination (27.36% to 43.25%). In this temperature (18ºC) genotype Pavon-76 showed the highest (43.25%) rate of germination. Whereas, genotype BAW-1146 had the lowest (27.36%) rate of germination. With increasing temperature, all the genotypes showed an increasing trend of rate of germination. Therefore, at 32ºC temperature all the genotypes reached their highest (82.33% to 98%) rate of germination. In this high temperature (32ºC), genotype BAW-1143 showed the highest rate of germination (98%) and genotype Pavon-76 and BAW-1148 attained the lowest rate of germination (82.33 and 83.33%). However, at 24ºC temperature, all the genotypes showed a moderate rate of germination (64.23% to 68.32%).

Co-efficient of germination which was the speed of germination varied markedly due to the interaction of wheat genotypes and temperature and increased with increasing temperature. The lowest co-efficient of germination (21.35% to 23.26%) was found at 18ºC. In this lowest temperature (18ºC), genotype BARI Gom-25 showed the lowest co-efficient of germination (21.35%), whereas, genotype BAW-1146 had the highest co-efficient of germination (27.12%). However, the overall highest co-efficient of germination (50%) was found in genotypes BAW-1143 and Prodip at 32ºC temperature.

This could be predicted due to genetic potentiality of the wheat varieties to withstand the temperature fluctuation. The findings of this study are in agreement with the reports of Khodabandeh (2003) [13] who stated that best and most suitable temperature for wheat seed germination is 20 to 22ºC. No germination occurred at 5ºC [14].

For germination vigor indices, all the wheat genotypes showed an increasing trend with increasing temperature. At 18ºC, all the genotypes showed the lowest values of germination vigor index (14.24 to 17.21) which increased to moderate level (16.88 to 21.25) at 24ºC and then to the highest

3.2. Length of shoot and root of wheat seedlings

Effect of temperature on the length of shoot and root of wheat seedling is shown in Table 2. The shoot lengths increased with the increase of temperature in all the genotypes except BAW-1148 and Pavon-76. At 18ºC, all the genotypes showed their lowest shoot length (2.03 cm to 2.65 cm). In this lowest temperature (18ºC), the shoot lengths of all the genotypes were statistically similar. From 18º C to 24ºC, all the genotypes increased their shoot length and thereafter at 32ºC Prodip, BARI Gom-25, BARI Gom-26, BAW-1143, BAW-1146 and BAW-1147 continued their increasing trend in shoot length but the remaining two genotypes BAW-1148 and Pavon-76 decreased their shoot length. Therefore, genotypes BAW-1143 and BAW-1147 showed the highest shoot length (7.98 cm) and genotype BAW-1148 attained the lowest shoot length (5.24 cm) at the highest temperature (32ºC).

For root length, all the genotypes attained their lowest value (3.11 cm to 5.21 cm) at 18ºC and it was increased at moderate temperature 24ºC (8.01 cm to 10.90 cm) but thereafter, decreased at the highest temperature 32ºC (4.89 cm to 7.13 cm).However, at moderate temperature (24ºC) BARI Gom-25 attained the overall highest root length (10.90 cm), whereas BAW-1148 had the lowest (8.081 cm) root length.

The ratio of shoot to root length was increased with the increasing temperature in all the genotypes. These ratios were lowest at 18ºC (0.48 to 0.79), moderate at 24ºC (0.60 to 0.86) and highest at 32ºC (1.10 to 1.33). However, at 32º C BAW-1143 attained the highest shoot to root length ratio (1.33) and BARI Gom-25 and BARI Gom-26 had the lowest value (1.10).

From 18ºC to 24ºC temperatures all the genotypes increased their shoot length and thereafter at 32ºC, the heat tolerant genotypes Prodip, BARI Gom-25, BARI Gom-26, BAW-1143, and BAW-1146 and BAW-1147 continued their increasing trend but the two heat sensitive genotypes BAW-1148 and Pavon-76 decreased shoot length (Table 2). The root length was increased with increasing temperature up to 24ºC but thereafter decreased at 32ºC in all the genotypes. One HT genotype BAW-1143 had the highest and HS genotype Pavon-76 showed the lowest performance in shoot lengths. Another HT genotype BARI Gom-25 had the highest and HS genotype BAW-1148 showed the lowest performance in root lengths. The increasing ratio of shoot to root length with increasing temperature indicated that root was more affected than the shoot at high temperature.

3.3 .Dry weight of shoot and root of wheat seedlings

The dry weight of shoot and root of eight wheat genotype seedlings at different temperature regimes is presented in Table 3. Results showed that shoot dry weight was increased with increase of temperature in all the genotypes. There were significant variations among the genotypes in shoot dry weight at different temperature regimes. At 18º C, the shoot dry weights were lowest (0.71 mg to 1.15 mg) than those at 24ºC (4.62 mg to 6.41 mg) and 32ºC (5.12 mg to 7.62 mg). Therefore, at 18, 24 and 32ºC, BAW-1146 attained the highest shoot dry weight (1.15, 6.41 and 7.62 mg, respectively) and Pavon-76 had the lowest (0.71, 4.62 and 5.12 mg, respectively) shoot dry weight.

Table 1: Rate of germination, co-efficient of germination and germination vigor index in different wheat genotypes as influenced by different temperature regimes

Genotypes	Temperature (ºC)	Rate of germination (%)	Co-efficient of germination (%)	Germination vigor index
Prodip	18	28. 27k	25.46fg	14.24g
	24	66.56ef	46.81b	20.75bc
	32	89.33c	50.00a	21.85ab
BARI Gom-25	18	41.57i	21.35h	15.34fg
	24	64.23f	34.55e	16.88dg
	32	93.74b	39.58d	19.88cd
BARI Gom-26	18	27.68k	23.12gh	15.36fg
	24	65.08ef	41.67cd	21.25ac
	32	94.33b	42.50cd	23.40ab
BAW-1143	18	29.21k	26.32f	15.16f
	24	68.32e	34.55e	18.63ce
	32	98.00a	50.00a	25.67ab

BAW-1146	18	27. 36k	27.12f	16.22eg
	24	59.65h	40.00d	19.22bd
	32	87.45c	41.67cd	21.83ac
BAW-1147	18	33.47j	23.14gh	14.73fg
	24	63.58fg	42.51cd	21.17ac
	32	83.33c	46.15b	24.60ab
BAW-1148	18	41.56i	22.45gh	14.23g
	24	63.25gh	34.55e	16.38eg
	32	83.33c	46.15b	21.6ac
Pavon-76	18	43.25i	23.26gh	17.21df
	24	60.25gh	44.44bc	20.33bc
	32	82.33d	47.50ab	23.55ab
C V (%)		3.44	4.67	7.63

In a column, mean followed by the same letter(s) did not differ significantly at 5 % level by DMRT

Table 2. Length of shoot and root of wheat seedlings as influenced by temperature regimes in eight wheat genotypes

Genotypes	Temperature (ºC)	Length (cm)		
		Shoot	Root	Shoot: Root
Prodip	18	2.03h	4.25hi	0.48f
	24	6.15f	10.12ab	0.61f
	32	6.95ce	6.23eh	1.12ae
BARI Gom-25	18	2.65h	5.21fi	0.51f
	24	6.56ef	10.90a	0.60f
	32	7.86ab	7.13cf	1.10ae
BARI Gom-26	18	2.37h	4.52gi	0.52f
	24	7.14be	10.31ab	0.69df
	32	7.56ac	6.89dg	1.10ae
BAW-1143	18	2.16h	4.11hi	0.53f
	24	7.68ac	8.96ad	0.86bf
	32	7.98a	5.98eh	1.33a
BAW-1146	18	2.13h	4.01hi	0.53f
	24	7.49ad	8.94ad	0.84bef
	32	7.61ac	5.98eh	1.27a
BAW-1147	18	2.69h	5.20fi	0.52f
	24	6.83df	10.37ab	0.66ef
	32	7.98a	6.89dg	1.16ac
BAW-1148	18	2.45h	3.11i	0.79cf
	24	6.64ef	8.01be	0.83bf
	32	5.24g	4.89fi	1.07ae
Pavon-76	18	2.43h	4.10hi	0.59f
	24	7.11be	9.25ac	0.77cf
	32	6.45ef	5.65eh	1.14ad
C V (%)		7.36	9.86	8.24

In a column, mean followed by the same letter(s) did not differ significantly at 5 % level by DMRT

Shoot dry weight and ratio of shoot to root dry weight were increased with increasing temperature from 18 to 32ºC in all the genotypes but in root dry weight, the highest values were at the moderate temperature (24ºC) and it was decreased both at 18ºC and 32ºC in all the genotypes .

In case of root dry weight, the highest values were found at moderate temperature 24ºC and it was reduced significantly both at 18ºC and 32ºC in all the genotypes. The lowest root dry weight (1.88 mg) was found in Pavon-76 at 18ºC and the highest root dry weight was found in BAW-1143 at 24ºC. The shoot to root dry weight ratios were increased with increasing temperature in all the genotypes. However, at 32ºC, BAW-1146 showed the highest (1.56) shoot to root dry weight ratio, whereas, Pavon-76 had the lowest (1.19) shoot to root dry weight ratio.

The increasing shoot to root dry weight ratios with increasing temperature indicated that root dry weights were reduced but shoot dry weights were increased at high temperature. The increase in temperature (10-30ºC) significantly enhanced germination and related traits [16].

3.5 .Seed dry matter distribution

Seed dry matter distribution (%) at five days after placement for germination of eight wheat genotypes as influenced by temperature regimes is presented in Table 4. The amount of seed reserves respired was increased (6.50% to 30.13%) with the increasing temperature (18 to 32ºC) in all the genotypes. These increments were more from 24 to 32ºC than from 18 to 24ºC in all the genotypes.

Table 3. Dry weight of shoot and root of wheat seedlings as influenced by temperature Regimes

Genotypes	Temperature (ºC)	Dry weight (mg/ seedling)		
		Shoot	Root	Shoot: Root
Prodip	18	0.82i	1.92f	0.43f
	24	4.62h	4.17de	1.11de
	32	5.12gh	3.65e	1.40ae
BARI Gom-25	18	1.04i	1.93f	0.54f
	24	6.41ce	5.03b	1.21be
	32	7.15ac	4.80b	1.49ae
BARI Gom-26	18	1.06i	1.95f	0.54f
	24	6.23de	4.97b	1.25be
	32	7.40ab	4.78b	1.55ac
BAW-1143	18	1.12i	1.97f	0.57f
	24	6.33ce	6.05a	1.05e
	32	7.48ab	4.82b	1.55ac
BAW-1146	18	1.15i	2.00f	0.58f
	24	6.35ce	5.13b	1.24be
	32	7.62a	4.87b	1.56a
BAW-1147	18	0.97i	1.93f	0.50f
	24	5.41eg	4.78b	1.11de
	32	6.71bd	4.87b	1.39b
BAW-1148	18	0.98i	1.82f	0.54f
	24	6.13df	4.65bc	1.32be
	32	7.09ac	4.97b	1.43ad
Pavon-76	18	0.71i	1.88g	0.38f
	24	5.25gh	3.92ce	1.33be
	32	5.35fh	4.51bd	1.19ce
C V (%)		7.70	8.53	9.56

In a column, mean followed by the same letter(s) did not differ significantly at 5 % level by DMRT

At high temperature (32ºC), the heat sensitive genotype Pavon-76 showed significantly highest (30.13%) respiratory loss. Whereas, heat tolerant genotype BARI Gom-25 showed the lowest value (14.08%) in respiratory loss. Other heat tolerant genotypes Prodip, BAW-1143, BARI Gom-26 and BAW-1147 showed statistically similar respiratory loss (14.10% to 15.36%) at high temperature (32ºC).

In shoot development, the dry matter distributed into shoot was increased with the increase of temperature in all the genotypes. But the increments were different among the genotypes. The lowest dry matter distribution to shoot (2.35% to 2.65%) was found at 18ºC, which increased at 24ºC (12.11% to 14.56%) and then at 32ºC to highest level (13.95% to 15.72%) in all the genotypes. Therefore, these increments were greater at 18 to 24ºC than those of 24 to 32ºC.However, at highest temperature (32ºC) BARI Gom-26 and BAW-1147 showed significantly highest (15.62% and 15.72%, respectively) and Pavon-76 had the lowest (13.95 %) dry matter distribution to shoot.

In root development, the amount of dry matter accumulated in root was increased only from 18 to 24ºC and thereafter decreased from 24 to 32ºC in all the genotypes. Among the genotypes, BAW-1147 showed the highest proportion of dry matter distribution (13.06%) to root at moderate temperature (24ºC). Whereas, the lowest value (4.48%) was obtained by BAW-1148 at the lowest temperature (18ºC). Germination of seed at 5th day after placing at different temperature regimes (18, 24 and 32ºC), all the genotypes increased the loss of seed reserves due to respiration with increasing temperature from 18 to 32ºC (Table 4).

Table 4. Seed dry matter distribution (%) at 5 days after placement for germination in different wheat genotypes as influenced by temperatures

Genotypes	Temperature (ºC)	Distribution of seed dry matter (%)			
		In shoot	In root	Respired	Remaining seed
Prodip	18	2.41d	5.60hi	6.72h	85.27a
	24	14.12bc	12.72d	9.50eg	63.66ef
	32	15.16ac	10.83c	14.10d	59.91eg
BARI Gom-25	18	2.46d	4.56j	6.86h	86.12a
	24	14.32c	11.83c	9.53eg	35.68de
	32	15.25ab	10.23c	14.08d	60.44eg
BARIGom-26	18	2.51d	4.65j	7.12g	85.72a
	24	14.56bc	11.65d	9.86eg	63.93de
	32	15.62a	10.08b	15.15cd	59.15fg
BAW-1143	18	2.65d	4.65j	6.50h	86.20a
	24	13.26bc	12.63b	9.25fg	64.86e
	32	14.12bc	9.11c	14.21d	62.56ef
BAW-1146	18	2.41d	4.57j	8.13gh	84.89ab
	24	12.11c	9.77g	10.11ef	68.01cd
	32	14.25bc	9.13g	15.26cd	61.36eg
BAW-1147	18	2.35d	4.70j	8.50fg	84.45ab
	24	14.50bc	13.06a	11.12e	61.32eg
	32	15.72a	11.31d	15.36cd	57.61g
BAW-1148	18	2.42d	4.48j	9.25fg	83.85ab
	24	14.15bc	10.72f	14.96d	60.17eg
	32	15.12ab	10.57f	21.15b	53.16h
Pavon-76	18	2.35d	6.18h	11.26e	80.21b
	24	13.75c	10.33fg	15.15cd	60.77eg
	32	13.95bc	11.72e	30.13a	44.20i
C V (%)		9.56	4.33	7.60	3.51

In a column, mean followed by the same letter(s) did not differ significantly at 5 % level by DMRT

At the highest temperature, HS genotype Pavon-76 and HT genotype BARI Gom-25 showed the highest (30.13%) and lowest (14.08%) respiratory loss, respectively. In shoot development, the dry matter distribution in shoot, all the genotypes increased their per cent dry matter distribution in shoot with increasing temperature from 18 to 32ºC. But in root development, the amount of dry matter accumulated in root was increased up to 24ºC from 18ºC and thereafter decreased at 36ºC in all the genotypes. These results indicated that the optimum temperature for root growth was lower compared to that for shoot growth. Therefore, root failed to continue to increase dry matter accumulation at high temperature (32ºC) while the shoot was able to continue to gain dry matter showing its higher temperature than root. Root of seedlings of different wheat varieties failed to continue to increase dry matter at higher temperature (32ºC) but at 24ºC all the varieties increased their root dry weight compared to 18ºC [17]. Whereas, the shoot was able to continue to gain dry weight up to 32ºC from 18ºC.

But the dry matter accumulation in root was increased over a smaller increase in temperature (from 18º to 24ºC) and thereafter decreased at 32ºC.

3.6. Seed metabolic efficiency

The seed metabolic efficiency (SME) of eight genotypes at different temperature regimes is presented in Figure1. Temperature had a profound effect on seed metabolic efficiency in all the genotypes. At moderate temperature (24ºC), all the genotypes showed the highest SME than those at the lowest (18º C) and the highest temperature (32ºC). At 24ºC, the heat tolerant genotype BAW-1143 attained the highest SME (2.88 g/g) which was closely followed by other heat tolerant genotypes BARI Gom-25 (2.75 g/g), BARI Gom-26 (2.50 g/g), Prodip and BAW-1147 (2.50 g/g). Whereas, heat sensitive genotype BAW-1148 showed the lowest SME (1.60 g/g) which was followed by other heat sensitive genotype Pavon-76 (1.61 g/g).

In this study, wheat genotypes differed significantly for germination and related traits. In the lowest (18ºC) and highest (32ºC) temperatures, the heat tolerant genotypes (BAW-1143, BARI Gom-25, BARI Gom-26, Prodip and BAW-1147) also maintained their better performance over heat sensitive genotypes (BAW-1148 and Pavon-76) in seed metabolic efficiency.

Thermal stress influence morphology and physiology of the root system which may influence water movement through the plant [19]. Moreover, roots are an important sink for assimilates in wheat. Since remobilization of assimilates occurs after anthesis, assimilates from roots may supplement primary sources from the leaf and stem [20]. Some of the genetic variation in heat tolerance that exists between wheat genotypes to temperature stress, consideration must be given to the duration of the heat stress and the criteria used for evaluating tolerance [21].

4. CONCLUSION

At 18º C, all the genotypes showed the lowest rate of germination. Therefore, at 32ºC temperature, all the genotypes reached their rate of germination. However, at 24ºC temperature, all the genotypes showed a moderate rate of germination. The overall highest co-efficient of germination was found at 32º C temperature. At 18º C, all the genotypes showed the lowest values of germination vigor index which increased to moderate level at 24º C and then to the highest level at 32º C in all the genotypes. At 18º C, all the genotypes showed their lowest shoot length. In this lowest temperature (18º C), and the lowest shoot length at the highest temperature (32º C).For root length, all the genotypes attained their lowest value at 18º C and it was increased at 32º C. At 18º C, the shoot dry weights were lowest than those at 24º C and 32º C. At moderate temperature (24º C), all the genotypes showed the highest SME than those of the lowest (18º C) and highest temperature (32º C). Heat tolerant genotype BAW-1143 attained the highest SME and heat sensitive genotype Pavon-76 and MHT genotype BAW-1148 attained lowest SME.

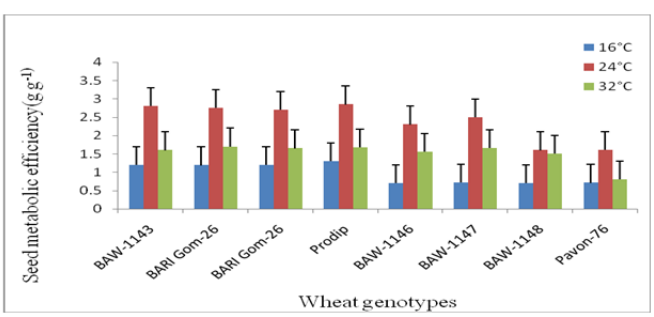

Fig. 1: Seed metabolic efficiency in wheat genotypes as influenced by temperature regimes. Vertical bars indicate ± SE value

REFERENCES

[1] Reynolds, M. P., Nagrajan, S., Razzaque, M. A. and Ageeb, O. A. A., 2001. Heat tolerance. In: Application of Physiology in Wheat Breeding, M. P. Reynolds, J. I. Ortiz-Monasterio and A. McNab (Eds), pp.124-135. CIMMYT, Mexico, D.F.

[2] Battisti, D. S., and Naylor, R. L., 2009. Historical warning of future food insecurity with unprecedented seasonal heat . Science. 323 (5911): 240-244.

[3] Stone, P. J. and Nicolas, M. E.,1994. Wheat cultivars vary widely in their responses of grain yield and quality to short periods of post anthesis heat stress. Aust. J. Plant Physiol. 21: 887-900.

[4] Elbashier, E.M.E., Tahir, I. A. S., Saad ,A. S. I. and Ibrahim, A. S.,2012. Wheat genotypic variability in utilizing nitrogen fertilizer for cooler canopy under a heat stressed environment. African J. Agri. Res. 7(3):385-392.

[5] Girelberg, A., Horowitz, M. and Poljakoff-Mayer, A., 1984.Solute leakage from Solanum nigram (L) seeds exposed to high temperature during imbibitions .J.Exp.Bot.35:1754-1763.

[6] Grass, L., and Burris, S., 1995. Effect of heat stress during seed development and maturation on wheat seed quality.I.Seed germination and seedling vigor. Canadian J. Plant. Sci.75(4): 821-829.

[7] Penning de Vries, F. W. T., Witlage, J. M.. and Kremer, D.,1979. Rate of respiration and increase in structural dry matter in young wheat, ryegrass and maize plants in relation to temperature, water stress and their sugar content. Ann. Bot. 44: 595-609.

[8] Wanjura D. F. and D. R. Buxter. 1972. Hypocotyle and radical elongation of cotton as affected by soil environment. Agron. J. 64: 431-435.

[9] Sikder, S., 2011. Physiological basis of heat tolerance in wheat. LAP LAMBERT Acad. Pub. Germany1-269 pp.

[10] Krishnasamy, V., and Seshu, D. V., 1990. Germination after accelerated aging and associated characters in rice varieties. Seed Sci. Tech. 18: 353-359.

[11] Rao, D. G., and Sinha, S. K.,1993. Efficiency of mobilization of seed reserves in sorghum hybrids and their parents as influenced by temperature. Seed Res. 21 (2): 97-100.

[12] Russell O. F. 1994. MSTAT-C v. 2. 1 (A computer based data analysis software. Crop Soil Sci. Dep. Michigan State Univ. USA.

[13] Khodabandeh, N., 2003. Cereals. 7th ed. Tehran Univ.Press.pp.78-111.

[14]Al-Qasem, H., Kafawin O. and Duwayri, M., 1999. Effects of seed size and temperature on germination of two wheat cultivars. Dirasat Agric. Sci. 26(1): 1-7.

[15] Sikder, S., and Paul, N. K., 2010. Evaluation of heat tolerance of wheat cultivars through physiological approaches. Thai J. Agric. Sci. 43(4): 251-258.

[16] Buriro, M., Cad, F. C., Keerio, M.I., Tunio, S., Gandahi, A. W., Hassan ,S.W. W. and Oad, S. M., 2011. Wheat seed germination under the influence of temperature regimes. Sarhad J. Agric. 27 (4): 539-543.

[17] Sikder, S. and Ahmed, J. U., 2007. Mobilization of seed reserves in wheat varieties as influenced by temperature regimes. J. Asiat. Soc. Bangladesh Sci. 33(1): 29-35.

[18] Hasan, M. A., Ahmed, J. U., Hossain, T., Hossain, M. M. and Ullah ,M. A., 2004. Germination Characters and seed reserves mobilization during germination of different wheat genotypes under variable temperature regimes. J. Natn. Sci. Found. Sri Lanka. 32(3&4): 97-107.

[19] Mahan, J. R., McMichaes, B. L. and Wanjura, W. F., 1995. Methods of reducing the adverse effects of temperature stress on plants: a review. Envir. Expt. Bot. 35: 251-258.
[20] Hay, R. K. M.,1986. Sowing date and the relationships between plant and apex development in winter cereals. Field Crops Res.14: 321-337.
[21] Rawson, H. M., 1986. High temperature tolerant wheat: a description of variation and a search for some limitation of productivity: Field Crops Res.14: 197-212.