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EFFECT OF PARENT PLANT GROWING TEMPERATURE ON YIELD PERFORMANCE OF WHEAT IN SUCCEEDING SEASON

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ABSTRACT

Seed of four wheat genotypes obtained from parent plant with normal and high growing temperature were grown at the research field of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during November 2016 to April 2017 to evaluate their yield performance in following season. The experiment was conducted following two factor randomized complete block design with three replications. One factor consisted of two sources of seed- i) Seeds obtained from parent plant with normal growing temperature (sowing on November 30) and ii) Seeds obtained from parent plant with high growing temperature (sowing on December 30). Another factor consisted of four wheat genotypes (BARI Gom 27, E 22, BARI Gom 30 and BARI Gom 26). Seed obtained from parent plant with normal growing temperature provided better grain and above ground biological yield (221 and 864 g m^{-2}, respectively) than seed obtained from parent plant with high growing temperature (191 and 752 g m^{-2}, correspondingly) in the succeeding season. Relative value based on grain yield indicated that seed of BARI Gom 26 obtained from parent plant with high growing temperature performed better (93%) in next growing season than the seed of BARI Gom 27 (85%), E 22 (81%) and BARI Gom 30 (85%) obtained from parent plant with high growing temperature.

Key words: Growing temperature, parent plant, wheat, yield

INTRODUCTION

In Bangladesh, about 80% of wheat is grown after harvest of Transplanted aman rice, of which above 50% area is planted late due to delayed harvesting of rice and the crop frequently encounters high temperature stress during grain filling (Baksh *et al*. 2005) causing reduction in yield and it is one of the major reasons of yield (2 t ha^{-1}) gap (Islam *et al.* 1993 and Hasan and Ahmed 2005). However, this problem will be further increased due to global warming which will push the wheat farming further into heat stressed environment and may cause reduction of present yield level.

Late planting wheat exposed to terminal heat stress, which coincides with grain development and maturation. Evidence consistently shows that exposure of the parent plant to high temperature affects the quality of seed produced. High temperature following anthesis adversely affects grain

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development in wheat (Tashiro and Wardlaw 1990, Hasan and Ahmed 2005). As a consequence, smaller and shrunken grain is produced at high temperature. Other physical properties of the seed including seed dimensions, seed coat and the final appearance of the seed are also affected by high parent plant growth temperature (Tashiro and Wardlaw 1990). Grain development at elevated temperature can affect membrane integrity and can cause increase in membrane leakage of both electrolytes and macro-molecules during germination which subsequently impair germination and seedling vigor (Girelberg *et al*. 1984, Grass and Burris 1995). Hasan *et al*. (2013) reported impair germination and decline in seed vigor in wheat reflected in reduced shoot and root dry weight and higher seed lechate conductivity due to high temperature during seed development and maturation. Utilization of the seed obtained from late seeding wheat may cause further reduction in yield. The effect of heat stress on wheat yield and yield components is well documented. But seed quality was often ignored in these studies. So, the performance of wheat seed as next crop in relation to high parent plant growing temperature should be evaluated. Therefore, the present investigation was conducted with aimed to evaluate the effect of parent plant growing temperature on yield characteristics and yield of wheat in following season.

MATERIALS AND METHODS

The experiment was set up at the research farm of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during November 2016 to April 2017. The unit plot size was 2.5 m × 2.0 m having 1 m distance between plots and between blocks. Seeds were sown in a line maintaining a row to row distance of 20 cm. The experiment was conducted following two factor randomized complete block design with three replications. One factor consisted of two sources of seed- i) Seeds obtained from parent plant with normal growing temperature (sowing on November 30) and ii) Seeds obtained from parent plant with high growing temperature (sowing on December 30). Another factor consisted of four wheat genotypes (BARI Gom 27, E 22, BARI Gom 30 and BARI Gom 26).

Table 1. Characteristics of seed used in the study

Wheat genotypes	Source of seed	1000 seed weight (g)	Shriveled seed (%)	Germination (%)	Emergence (%)
BARI Gom 27	Normal parent plant temperature	44.94	0	99	92
	High parent plant temperature	42.05	37	94	80
E 22	Normal parent plant temperature	40.01	0	97	91
	High parent plant temperature	33.28	50	96	59
BARI Gom 30	Normal parent plant temperature	38.43	0	98	91
	High parent plant temperature	36.14	40	95	69
BARI Gom 26	Normal parent plant temperature	43.23	0	99	93
	High parent plant temperature	42.72	31	98	90

A fertilizer dose of 140-35-75-18-2-0.5 kg ha^{-1} N, P, K, S, Zn and B was applied in the form of urea, triple supper phosphate (TSP), murate of potash (MoP), gypsum and boric acid, respectively. After land preparation, full dose of P, K, S, Zn, B and two third of N were incorporated thoroughly into the soil as basal dose. The remaining amount of N was applied at 25 days after seedlings emergence. Seeds obtained from parent plant with normal and high growing temperature of four wheat genotypes (BARI Gom 27, E 22, BARI Gom 30 and BARI Gom 26) were sown on 24 November 2016 in rows of 20 cm apart, at the rate of 120 kg ha^{-1}. Slight irrigation was given for uniform germination after sowing. After sowing, care was taken against birds up to 15 days. The crop was kept weed free and for controlling diseases, Tilt 250 EC was sprayed for avoiding Stripe Rust when necessary.

Plant height and spike length (excluding the awn) was measured manually using scale and number of spikelet $spike^{-1}$ and number of grains per spike were counted manually from ten main stem tillers. Weight of grains per spike was recorded using electrical balance. The samples were collected from an area of 2m × 1m from the center of each plot by cutting the plant at ground level. Then tillers and spikes were counted and spikes were collected in a bag made of cotton (60 cm × 45 cm). The samples were dried in sun, threshed and cleaned manually and weight of grain and straw were taken after drying in the sun. From each plot thousand grains were taken randomly from dried sample and weighed. Relative performance was calculated using following formula-

Relative performance = (Performance of seed obtained from parent plant with high growing temperature / Performance of seed obtained from parent plant with normal growing temperature)×100

The data were analyzed by partitioning the total variance with the help of computer by using MSTAT program (Gomez and Gomez 1984). The treatment means were compared using Tukey's test at $P \leq 5\%$ level.

RESULTS AND DISCUSSION

Plant height (cm)

Plant height was not significantly influenced by parent plant growing temperature and also by the interaction effect of parent plant growth temperature and wheat genotypes but it was significantly influenced by wheat genotypes (Table 2). The tallest plant height (98.72 cm) was obtained from BARI Gom 26 (V_4) which was statistically similar to that (97.92 cm) recorded in E 22 (V_2) and the shortest plant (89.03 cm) was obtained from BARI Gom 30 (V_3) which was statistically equal to that (91.81 cm) recorded in BARI Gom 27 (V_1). High parent plant growing temperature during seed development and maturation resulted in poor seed quality in respect of seed size, seed vigour and shriveled seed (Sanyal and Joshi 2018**,** Tashiro and Wardlaw 1990, Hasan and Ahmed 2005, Girelberg *et al*. 1984, Grass and Burris 1995, Hasan *et al*. 2013). Smaller seed resulted in shorter plant of wheat in the next season (Shahwani *et al*. 2014, Keerio (2013) compared to larger seed. Luthra and Chima (1941) reported that shriveled seed obtained from high parent plant growing temperature provided shorter plant though the difference was insignificant. Camargo and Vaughn (1973) reported reduced plant height with planting low vigor seed in sorghum.

Spike length (cm)

Spike length at harvest was significantly influenced by parent plant growing temperature and wheat genotypes but it was not significantly influenced by the interaction effect of parent plant growing temperature and wheat genotypes (Table 2). Significantly the longer spike (10.86 cm) was recorded when seed obtained from parent plant with normal growing temperature than that (10.27 cm) recorded when seed obtained from parent plant with high growing temperature was sown. Significantly the longest spike (11.29 cm) was obtained in BARI Gom 26 and the shortest spike was recorded in E 22 (10.22 cm) which was statistically similar to those recorded in BARI Gom 30 (10.32 cm) and BARI Gom 27 (10.45 cm). Shahwani *et al*. (2014) showed that wheat crop sown with bolder seeds (large size seeds) produced spikes of greater in length on average as compared to the crop sown with small size seeds. This suggested that bolder seeds produced healthier seedlings and consequently greater spike length was achieved.

Table 2. Effect of parent plant growing temperature and wheat genotypes on plant height and spike length in succeeding season

Treatment	Plant height (cm)	Spike length (cm)
Parent plant growing temperature		
S_1	94.60	10.86 a
S_2	94.13	10.27 b
Level of significance	NS	*
Wheat genotypes		
V_1	91.81b	10.45 b
V_2	97.92 a	10.22 b
V_3	89.03 b	10.32 b
V_4	98.72 a	11.29 a
Level of significance	*	*
Parent plant growing temperature × Wheat genotypes		
S_1V_1	91.36	10.96
S_1V_2	98.41	10.43
S_1V_3	89.15	10.63
S_1V_4	99.48	11.43
S_2V_1	92.25	9.93
S_2V_2	97.43	10.01
S_2V_3	88.92	10.00
S_2V_4	97.95	11.14
Level of significance	NS	NS
CV(%)	7.45	6.58

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$. Here, S_1= Seed obtained from parent plant with normal growing temperature, S_2= Seed obtained from parent plant with high growth temperature, V_1= BARI Gom 27, V_2= E 22, V_3= BARI Gom 30, V_4= BARI Gom 26, ^{NS} indicates insignificant, * indicates significant at 5% level of probability.

Tillers m^{-2}

Tillers m^{-2} was significantly influenced by parent plant growth temperature and wheat genotypes but it was not significantly influenced by the interaction effect of parent plant growing temperature and wheat genotypes (Table 3). Significantly greater number of tillers m^{-2} (202) was recorded when seed obtained from parent plant with normal growing temperature than that (180) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest number of tillers m^{-2} (206) was obtained in BARI Gom 26. The lowest number of tillers m^{-2} was recorded in E 22 (184) which was statistically similar to those recorded in BARI Gom 30 (185) and BARI Gom 27 (188). Grass and Burris (1995) reported that seed harvested from the crop exposed to medium or high temperature stress during grain development exhibited lower tiller as compared to control during following wheat season. Our results also showed that seed harvested from crop sown on high parent plant growth temperature exhibited low tillering capability. More tillers per plant from the seeds harvested from normal growing temperature might be due to vigorous start of seedling taking more food reserves from the seeds at early seedling stage. Seeds with higher protein, carbohydrate and minerals contents showed higher tiller rate which was found in seed harvested from normal growing temperature (Ries *et al.* 1970).

Spikes m^{-2}

Spikes m^{-2} was significantly influenced by parent plant growth temperature and wheat genotypes but it was not significantly influenced by the interaction effect of parent plant growing temperature and wheat genotypes (Table 3). Significantly greater number of spikes m^{-2} (196) was recorded when seed obtained from parent plant with normal growing temperature than that (175) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest number of spikes m^{-2} (202) was obtained in BARI Gom 26. The lowest number of spikes m^{-2} was recorded in E 22 (177) which was statistically similar to those recorded in BARI Gom 30 (178) and BARI Gom 27 (184). Greater number of spikes m^{-2} might be due to greater number of tillers per m^2 in the respective treatment which was also reported by Ries *et al.* (1970) and Luthra and Chima (1941).

Spikelets spike^{-1}

Spikelets spike^{-1} was significantly influenced by parent plant growth temperature and wheat genotypes and also by their interaction effect (Table 3). Significantly greater number of spikelets spike^{-1} (22.71) was recorded when seed obtained from parent plant with normal growing temperature than that (19.09) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest number of spikelets spike^{-1} (24.66) was obtained in BARI Gom 26. The lowest number of spikelets spike^{-1}plant was recorded in BARI Gom 30 (19.08) which was statistically similar to those recorded in E 22 (19.56) and BARI Gom 27 (20.33). Among the treatment combinations, the highest number of spikelets spike^{-1} (25.26) was observed when seed of BARI Gom-26 obtained from parent plant with normal growing temperature was sown (V_4S_1) which was statistically at par with those recorded in V_4S_2 (24.06) and V_3S_1 (22.16). The lowest number of spikelets spike^{-1} (16.00) was observed in BARI Gom 30 when seed obtained from parent plant with high growing temperature was sown (V_3S_2) which was statistically at par with those recorded in V_2S_2 (17.33) and V_1S_2 (19.00). Lower spikelets spike^{-1} produced by the seed obtained from parent plant with high growing temperature might be due to lower spike length. The results are in accordance with the results of Luthra and Chima (1941), Spinks *et al*. (2000) and Shahzad *et al*. (2002).

Grains spike^{-1}

Grains spike^{-1} was significantly influenced by parent plant growing temperature and wheat genotypes but it was not significantly influenced by the interaction effect of parent plant growing temperature and wheat genotypes (Table 3). Significantly greater number of grains spike^{-1} (46.80) was recorded when seed obtained from parent plant with normal growing temperature than that (38.00) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest number of grains spike^{-1} (49.84) was obtained in BARI Gom 26 which was statistically similar to that found in BARI Gom 27 (42.64). The lowest number of grains spike^{-1} was recorded in E 22 (32.28) which was statistically similar to those recorded in BARI Gom 30 (39.84) and BARI Gom 27 (42.64). Lower number of grains spike^{-1} might be due to shorter spike and lower number of spiklets spike^{-1} in the respective treatment which was found in the present study. Similar results were recorded by Shahwani *et al.* (2014), Keerio (2013) and Luthra and Chima (1941) who found that shriveled and smaller seed obtained from high parent plant growing temperature provided lower number of grain spike^{-1} in next season.

Table 3. Effect of parent plant growing temperature and wheat genotypes on tillers per m^{-2}, spikes m^{-2}, spikelet spike^{-1} and grains spike^{-1} in succeeding season

Treatment	Tillers m^{-2}	Spikes m^{-2}	Spikelet spike^{-1}	Grains spike^{-1}
Parent plant growing temperature				
S_1	202 a	196 a	22.71 a	46.80 a
S_2	180 b	175 b	19.09 b	38.00 b
Level of significance	**	**	**	**
Wheat genotypes				
V_1	188 b	184 b	20.33 b	42.64ab
V_2	184 b	177 b	19.56 b	37.28 b
V_3	185 b	178 b	19.08 b	39.84 b
V_4	206 a	202 a	24.66 a	49.84 a
Level of significance	**	**	**	**
Parent plant growing temperature × Wheat genotypes				
S_1V_1	197	196	21.66 bc	46.72
S_1V_2	199	190	21.79 bc	40.40
S_1V_3	194	187	22.16 ac	49.04
S_1V_4	216	211	25.26 a	51.04
S_2V_1	179	173	19.00 cd	38.56
S_2V_2	170	165	17.33 d	34.16
S_2V_3	175	170	16.00 d	30.64
S_2V_4	196	193	24.06 ab	48.72
Level of significance	NS	NS	**	NS
CV(%)	4.08	4.27	5.82	11.87

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at P ≤ 5%. Here, S_1= Seed obtained from parent plant with normal growing temperature, S_2= Seed obtained from parent plant with high growth temperature, V_1= BARI Gom 27, V_2= E 22, V_3= BARI Gom 30, V_4= BARI Gom 26, ^{NS} indicates insignificant, ** indicates significant at 1% level of probability.

Grain weight spike^{-1} (g)

Parent plant growing temperature and wheat genotypes influenced the grain weight spike^{-1} significantly but the interaction of parent plant growing temperature and wheat genotypes did not influence the grain weight spike^{-1} significantly (Table 4). Significantly greater grain weight spike^{-1} (2.07 g) was recorded when seed obtained from parent plant with normal growing temperature than that (1.82 g) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest grain weight spike^{-1} (2.43 g) was obtained in BARI Gom 26 which was statistically similar to that found in BARI Gom 27 (1.98 g). The lowest grain weight spike^{-1} was recorded in BARI Gom 30 (1.71 g) which was statistically similar to those recorded in E 22 (1.80) and BARI Gom 27 (1.98 g). Lower grain weight per spike might be due to shorter spike, lower number of spiklets and grains spike^{-1} in the respective treatment. Similar results were recorded by Shahwani *et al*. (2014), Keerio (2013) and Luthra and Chima (1941) who found that shriveled and smaller seed obtained from high parent plant growing temperature provided lower grain weight spike^{-1} in next season.

Table 4. Effect of parent plant growing temperature and wheat genotypes on grain weight spike^{-1}, thousand grain weight, grain yield and above ground biological yield in succeeding season

Treatment	Weight of grains spike^{-1} (g)	Thousand grain weight (g)	Grain yield (g m^{-2})	Above ground Biological yield (g m^{-2})
Parent plant growing temperature				
S_1	2.07 a	44.32 a	221a	868 a
S_2	1.82 b	40.53 b	191b	752 b
Level of significance	**	**	**	**
Wheat genotypes				
V_1	1.98ab	41.98 b	204 b	783 b
V_2	1.80 b	41.45 b	190 c	753 b
V_3	1.71 b	38.98 b	184 c	803 b
V_4	2.43 a	47.29 a	246 a	902 a
Level of significance	**	**	**	**
Parent plant growing temperature × Wheat genotypes				
S_1V_1	2.25	44.31 ab	220 bc	861 ab
S_1V_2	1.98	43.44 ab	210 cd	815 bc
S_1V_3	1.80	41.64 ac	200 de	882 ab
S_1V_4	2.52	47.91 a	256 a	916 a
S_2V_1	1.80	39.66 bc	188 e	704 d
S_2V_2	1.62	39.47 bc	170 f	692 d
S_2V_3	1.71	36.33 c	169 f	724 cd
S_2V_4	2.34	46.68 a	237 b	888 ab
Level of significance	NS	**	*	*
CV(%)	10.07	5.59	3.11	4.47

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at P ≤ 5%. Here, S_1= Seed obtained from parent plant with normal growing temperature, S_2= Seed obtained from parent plant with high growth temperature, V_1= BARI Gom 27, V_2= E 22, V_3= BARI Gom 30, V_4= BARI Gom 26, ^{NS} indicates insignificant, * indicates significant at 5% level of probability ** indicates significant at 1% level of probability.

Thousand grains weight (g)

Thousand grains weight was significantly influenced by parent plant growing temperature and wheat genotypes and also by their interaction effect (Table 4). Significantly greater thousand grains weight (44.32 g) was recorded when seed obtained from parent plant with normal growing temperature than that (40.53 g) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest thousand grains weight (47.29 g) was found in BARI Gom 26 and the lowest thousand grain weight was recorded in BARI Gom 30 (38.98 g) which was statistically similar to those recorded in E 22 (41.45 g) and BARI Gom 27 (41.98 g). Among the treatment combinations, the highest thousand grains weight (47.91 g) was observed when seed of BARI Gom-26 obtained from parent plant with normal growing temperature (V_4S_1) which was statistically at par with those recorded in V_4S_2 (46.68 g), V_1S_1 (44.31 g), V_2S_1 (41.64 g) and V_3S_1 (41.64 g). The lowest thousand grains weight (36.33 g) was observed in BARI Gom 30 when seed obtained from parent plant with high growing temperature (V_3S_2) which was statistically at par with those recorded in V_2S_2 (39.47 g), V_1S_2 (39.66 g) and V_3S_1 (41.64 g). Hussain *et al.* (2015), Shahwani *et al*. (2014), Keerio (2013) and Luthra and Chima (1941) also reported that shriveled and smaller seed obtained from high parent plant growing temperature provided smaller wheat grain in next season.

Grain yield (g m^{-2})

Grain yield was significantly influenced by parent plant growth temperature and wheat genotypes and also by their interaction effect (Table 4). Significantly greater grain yield (221 g m^{-2}) was recorded when seed obtained from parent plant with normal growing temperature than that (191 g m^{-2}) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest grain yield (246 g m^{-2}) was found in BARI Gom 26 which was followed by that recorded in BARI Gom 27 (207 g m-2). The lowest grain yield was recorded in BARI Gom 30 (184 g m^{-2}) which was statistically similar to that recorded in E 22 (190 g m^{-2}). Among the treatment combinations, the highest grain yield (256 g m^{-2}) was observed when seed of BARI Gom 26 obtained from parent plant with normal growing temperature (V_4S_1) which was followed by V_4S_2 (237 g m^{-2}), V_1S_1 (220 g m^{-2}), V_2S_1 (210 g m^{-2}) and V_3S_1 (200 g m^{-2}). The lowest grain yield(169 g m^{-2}) was observed in BARI Gom 30 when seed obtained from parent plant with high growing temperature (V_3S_2) which was statistically at par with that recorded in V_2S_2 (170 g m^{-2}) and followed by that recorded in V_1S_2 (188 g m^{-2}).

The seed obtained from parent plant with high growing temperature provided lower grain yield compared to that obtained from parent plant with normal growing temperature in the present study. Lower grain yield in this treatment was mainly contributed by shorter spike and lower tillers m^{-2}, spikes m^{-2}, spikelet spike^{-1}, grains spike^{-1} and thousand grains weight. Spinks *et al*. (2000) and Shahzad *et al*. (2002) also reported that timely planted wheat has longer growing period and produces good quality seeds which ensure better yield during following season. Hussain *et al.* (2015) found that delay in sowing influenced the grain development resulting in grains of poor quality, if used as seeds for next crop, suppressed the performance of crop and grain quality. Shahwani *et al*. (2014), Keerio (2013), Mian and Nafziger (1994) and Zareian *et al*. (2013) showed smaller seed caused significant yield reduction in wheat compared to larger seed. Luthra and Chima (1941) reported that shriveled seed obtained from high parent plant growing when used in succeeding season caused significant reduction in yield and yield contributing traits of wheat.

Relative value based on grain yield indicated that seed of BARI Gom 26 obtained from parent plant with high growing temperature performed better (93%) in next growing season than the seed of BARI Gom 27 (85%), E 22 (81%) and BARI Gom 30 (85%) obtained from parent plant with high growing temperature (Figure 1). Shahwani *et al*. (2014) also found the variation in genotypic behavior response to these treatments.

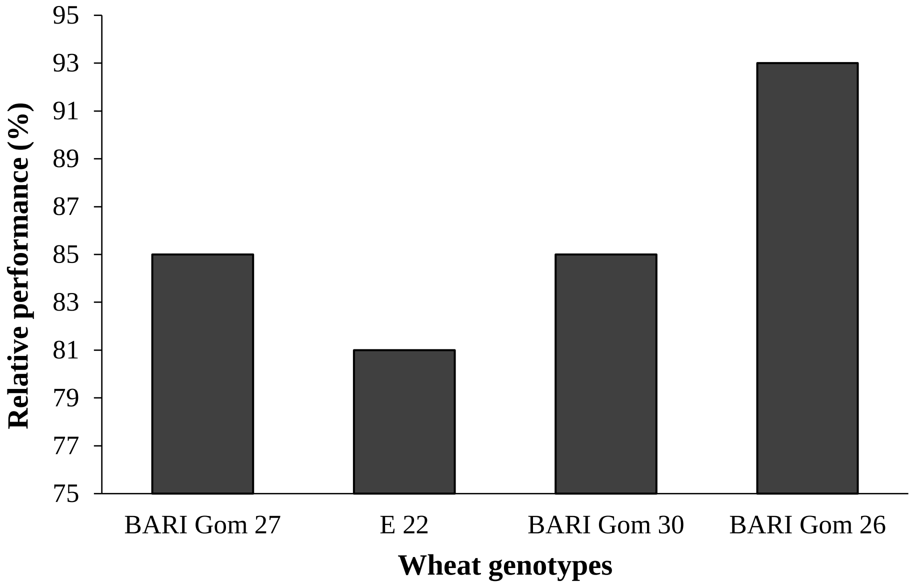

Figure 1. Relative performance of seed obtained from parent plant with high growing temperature compared to seed obtained from parent plant with normal growing temperature based on grain yield.

Above ground biological yield (g m^{-2})

Above ground biological yield was significantly influenced by parent plant growing temperature and wheat genotypes but it was not significantly influenced by their interaction effect (Table 4). Significantly greater above ground biological yield (868 g m^{-2}) was recorded when seed obtained from parent plant with normal growing temperature than that (752 g m^{-2}) recorded when seed obtained from parent plant with high growing temperature. Among the wheat genotypes, significantly the highest above ground biological yield (902 g m^{-2}) was found in BARI Gom 26 and the lowest above ground biological yield was recorded in E 22 (753 g m^{-2}) which was statistically similar to those recorded in BARI Gom 27 (783 g m^{-2}) and BARI Gom 30 (803 g m^{-2}). Lower above ground biological yield was attributed to shorter plant, lower tillering behaviour and lower grain yield of the respective treatment. Hussain *et al.* (2015), Shahwani *et al*. (2014), Keerio (2013) and Luthra and Chima (1941) also reported that shriveled and smaller seed obtained from high parent plant growing temperature provided lower biological yield in next season.

CONCLUSION

Based on the results of the present study it may be concluded that seed obtained from parent plant with normal growing temperature performed better than seed obtained from parent plant with high growing temperature. Better grain yield in this treatment was mainly contributed by greater spike length, tillers m^{-2}, spikes m^{-2}, spikelet spike^{-1}, grains spike^{-1} and thousand grains weight.

Among the wheat genotypes, seed of BARI Gom 26 obtained from parent plant with high growing temperature performed better in next growing season.

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