

Evaluation of Bread Wheat (*Triticum aestivum* L.) Genotypes for Yield Potential and Related Traits Under High Temperature Stress Condition at Middle Awash, Ethiopia

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Abstract

Information on the extent and performance of genotypes present in a crop species under high temperature stress are essential for effective crop adaptation program. To generate such information 36 bread wheat genotypes with three released varieties (Fentallo, Amibara and Werer-2) were tested in Triple Lattice Design with three replication at Werer agricultural research center, Afar in 2017. The objective of the study were to develop best performed bread wheat genotypes that adapted to middle Awash area and to identify best performed bread wheat genotypes for yield under high temperature stress condition. The data generated from the experiment were subjected to analysis of variance. The analysis of variances of bread wheat genotypes evaluated for 15 traits revealed highly significant difference between the genotypes for most traits and significant difference among genotypes for days to emergence. It was interesting to note that genotypes identified for short grain filling period and early maturing were G-4, G-18, G-3, G-26 and G-15 with maturity days of 70, 76, 77, 77 and 79 days after sowing respectively, than the released check variety Werer-2 (84 days). Similarly genotypes G-16, G-22, G-28, G-32 and G-34 had better required low canopy temperature reading than released check varieties Fentallo, Amibara and Werer-2. The most important genotypes for showing excellent performance on grain yield per hectare obtained from G-2, G-7 and G-21 with grain yield of 2479 kh/ha, 3039 kg/ha and 2409 kg/ha respectively, than the best performed released check variety Werer-2 (2362 kilo gram per hectare). Hence, from the current results it has been observed adequate existence of traits showing adaptability in the studied genotypes and this could be exploited in future bread wheat selection and breeding for high temperature stress condition.

Keywords: Bread wheat; Yield and high temperature

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crop world-wide that grown in many areas and major staple crops with about 751.4 million tons' annual production [1]. In Sub-Saharan Africa (SSA), wheat is grown by millions of resource poor smallholder farmers predominantly under rain-fed conditions. The consumption of wheat is increasing by approximately 650,000,000 tons per year in SSA [2]. Ethiopia is the second largest wheat growing area in Sub-Saharan Africa covering about 500,000 ha [3]. Both bread wheat (*Triticum aestivum* L. em. *Thell*) and durum wheat (*Triticum turgidum* L. subsp. *durum*) are the two most important wheat species which are mainly grown in the country [4]. Bread wheat currently occupies about 65% of the total wheat area and it is fast increasing due to its higher yield and wider adaptability [5]. Directly for food and livestock feed as well as raw material for development of food processing industries in Ethiopia; Bread wheat is required at large, and it is becoming the more pressing food crops. Besides it is one of the priority crops considered to attain food security.

Bread wheat production in Ethiopia is limited in mid to highland areas, so that the practice of wheat production in lowland area is scarce or not available [6]. Breeding for tolerance to high temperature stress in lowland wheat production is a major global concern [7]. The

lowland areas in Ethiopia are characterized by higher temperature and low rainfall condition, mostly are not suitable for crop production. Lowland areas such as Werer in Afar regional state are endowed with river water that can be utilized for wheat production. However, the prevailing heat stress condition in the region affects substantially the growth and development of wheat. Hence, evaluation of the extent and performance of available genotypes present under high temperature stress are essential for effective crop adaptation program. Thus, to exploit the potential of these lowland arid and semi-arid areas, development of adaptable heat tolerant wheat genotypes is imperative. Therefore, this study was aimed to develop better performed bread wheat genotypes that can adapt to middle awash environmental condition.

Materials and Methods

The experiment was conducted at Werer Agricultural Research Center (WARC) during main cropping season in 2017. WARC is located at middle Awash of Afar National Regional state at a distance of 278 km from Addis Ababa to the east direction near to the main road from Addis to Djibouti at altitude of 740 m above sea level. The center is located at 9°16'8" N latitude and 40°9'41" E longitudes. The area has a mean maximum and minimum annual temperature of 34°C and 19°C and monthly temperature of 38.06°C and 21.06°C during main season, respectively. The precipitation in study area is

characterized by unpredictable and uneven distribution with annual average rainfall about 571 mm which is not sufficient for crop production. The main irrigation water source is from Awash River. The soil in the testing field of Werer is predominantly Fluvisols [2] while vertisol are the second dominant soil that occupies about 30% of the total area. The experiment was carried out in Triple Lattice Design consisted of 36 entries sown in three replications on 9 m² plot size which accommodated five ridge at 0.6 m spacing with two rows each

with net harvestable plot area 7.2 m². The planting date was June 24, 2017. Seeds were sown on rows with manual drilling at a rate of 100 kg ha⁻¹ basis. Fertilizer was applied at a rate of 50 kg ha⁻¹ P₂O₅ in DAP form once at sowing time and 100 kg of N (Urea) ha⁻¹ applied in split; half at seedling stage and the remaining 50% at booting stages. The irrigation water was applied at every 10-days interval using furrow method and other agronomic practices were applied for each treatment (Figure 1 and Table 1).

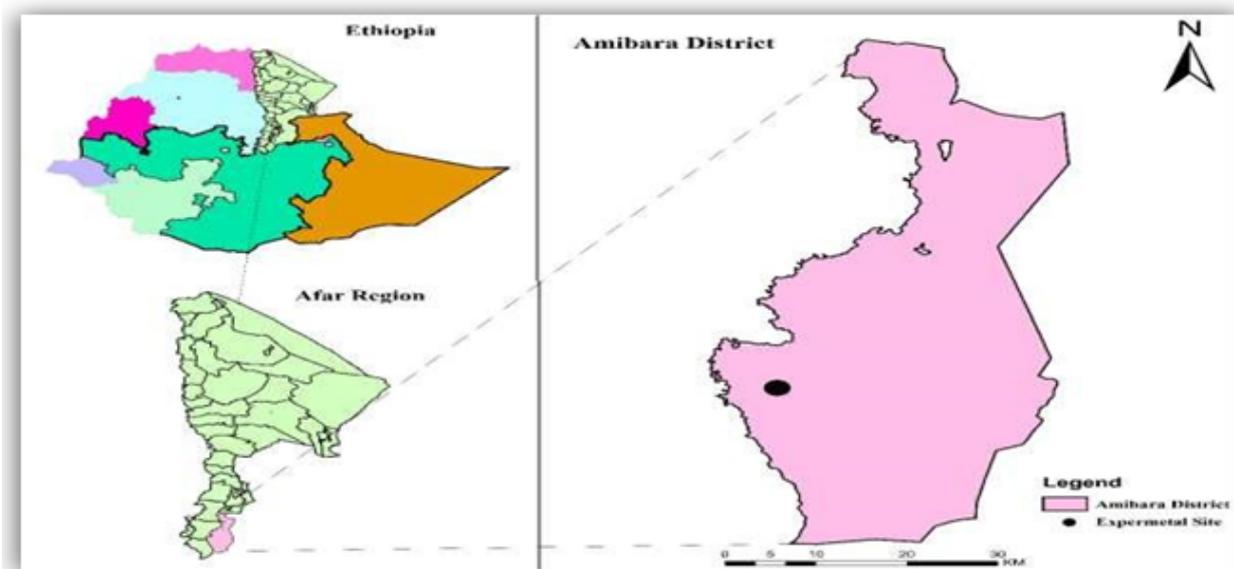


Figure 1: Map of the study area.

Trt	Genotypes	Cross/Pedigree	Origin
1	G-1	MILAN/KAUZ//PRINIA/3/BAV92/5/TRAP#1/BOW	CIMMYT/ICARDA
2	G-2	RL6043/4*NAC//PASTOR/3/BAV92/4/ATTILA/BAV92	CIMMYT/ICARDA
3	G-3	ESDA/KKTS	CIMMYT/ICARDA
4	G-4	ATTILA*2/PBW65//TAM200/TUI	CIMMYT/ICARDA
5	G-5	ATTILA/3*BCN//BAV92/3/TILHI/4/SHA7/VEE	CIMMYT/ICARDA
6	G-6	THB/KEA//PF85487/3/DUCULA/4/WBLL1*2/TUKURU	CIMMYT/ICARDA
7	G-7	ATTILA*2//CHIL/BUC*2/3/KUKUNA	CIMMYT/ICARDA
8	G-8	ATTILA*2/PBW65//KACHU	CIMMYT/ICARDA
9	G-9	FRET2/KUKUNA//FRET2/3/PARUS/5/FRET2*2/4/SNI	CIMMYT/ICARDA
10	G-10	NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR	CIMMYT/ICARDA
11	G-11	ROLF07/4/BOW/NKT//CBRD/3/CBRD/5/FRET2	CIMMYT/ICARDA
12	G-12	MUNAL#1/FRANCOLIN#1	CIMMYT/ICARDA
13	G-13	WBLL1*2/BRAMBLING/4/BABAX/LR42//BABAX	CIMMYT/ICARDA
14	G-14	BECARD/AKURI	CIMMYT/ICARDA
15	G-15	BAJ#1/AKURI	CIMMYT/ICARDA

16	G-16	ATTILA*2PBW65//MUU#1/3/FRANCOLIN#1	CIMMYT/ICARDA
17	G-17	WAXWING*2/HEILO	CIMMYT/ICARDA
18	G-18	BOHAINE	CIMMYT/ICARDA
19	G-19	SERI.IBKAUZ/HEVO/3/AMAD/4/ESD/SHWA/BCN	CIMMYT/ICARDA
20	Fentale (check)	FERROUG-2/FOW-2	CIMMYT/ICARDA
21	G-21	SOKOLL//PBW343*2//KUKUNA/3/ATTILA/PASTOR	CIMMYT/ICARDA
22	G-22	QUATU3//MILAN/AMSEL	CIMMYT/ICARDA
23	G-23	ATTILA*2/PBW65*2/4/CROC1/AE.SQUARROSA(205)	CIMMYT/ICARDA
24	G-24	ATTILA*2/PB W65*2//W485/HD29	CIMMYT/ICARDA
25	G-25	SAUAL/3/ACHTAR*3//KANZ/KS85.8.4/4/SAU	CIMMYT/ICARDA
26	G-26	ALTAR84/AE.SQUARROSA (221)//3*BORL95	CIMMYT/ICARDA
27	G-27	TACHUPETOF2001/6/OASIS/5*BORL95/5/CNDO/R143	CIMMYT/ICARDA
28	G-28	KAUZ/RAYON/3/N5732/HER//CASKOR	CIMMYT/ICARDA
29	G-29	KSAYONGENARO81//TEVEE.I./4/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/KAUZ	CIMMYT/ICARDA
30	G-30	IMAM	CIMMYT/ICARDA
31	Amibara (check)	SHUHA-8/DUCULA	CIMMYT/ICARDA
32	G-32	TUKURU//BAV92/RAYON/3/FRNCLN	CIMMYT/ICARDA
33	G-33	TACUPETOF2001*2//BRAMBLING//WBLL1*2//BRANBLING	CIMMYT/ICARDA
34	G-34	WAXWING/4/BL1496/MILAN/3/CROC-1/AE.SQUA9205//kauz/5/frncln	CIMMYT/ICARDA
35	G-35	WAXWING/2*ROLF07	CIMMYT/ICARDA
36	Werer-2 (check)	SAMAR-13/PASTOR-1	CIMMYT/ICARDA

CIMMYT=International Maize and Wheat Improvement Center, ICARDA=International Center for Agricultural Research in the Dry Land Areas.

Table 1: The evaluated bread wheat genotypes are listed below. G=Genotypes of bread wheat used for the study.

Observations were recorded for Days to heading, Days to maturity (the number of days from the sowing date to the date when 85% physiological maturity achieved was recorded for each genotype in each plot by checking the maturity of seed from sample plants), Grain filling period, Plant height (measured at physiological maturity from the soil surface to the top of the spike (awns excluded) from randomly selected plants), Spike length, Canopy temperature (measured with an infrared thermometer during grain filling stage and time of measurement was from 11:00 am to 2:00 pm during the peak noon at middle awash case with expected high intensity time for temperature), Chlorophyll content (a flag leaf per plant from sample plants per plot was measured using a portable chlorophyll meter SPAD-502 plus at grain filling period), 1000 grain weight, Number of spikelet/spike, Number of seed/spike, Grain yield (measured in gram for each plot of each entry from central rows and then converted to kilogram per hectare for analysis), Spike fertility, biomass yield (weighing the total above ground biomass harvested from each experimental plot after it was dried under open sunlight) and Harvest index. Analysis of variance mean comparison between genotypes based on Duncan's Multiple Range Test (DMRT) and Pearson's correlation analysis was performed using SAS Software (Version 9.0).

Results and Discussion

Performance of genotypes for pheno-morphological and physiological traits

Analysis of variance showed that there was highly significance difference ($P \leq 0.01$) between the wheat genotypes for days to heading, days to maturity and grain filling period (Table 2). The mean value for days to heading ranged from 41 to 64 days after sowing (das) with an average value of 55 days. There were two genotypes (G-4 and G-18) headed before the check variety Amibara and twenty-two genotypes also headed before the check variety Werer-2 (58 days) with similar findings. The variation in days to heading in different genotypes was also reported by Bhattarai et al. [8]. Similar to days to heading, genotype G-4, Fentalle, G-18, G-3 and G-26 were early maturing genotypes in 70, 76, 76, 77 and 78 days, respectively. The mean number of days to maturity was 87 days (Table 2). There were four genotypes matured earlier than the check variety Amibara 78 days and eight genotypes matured before check variety Werer-2 (84 days) while genotype G-25 was the late maturing with 98 days followed by genotype G-28, 97 days and G-34, 97 days. Genotype G-3, G-4,

Fentalle and G-18 shown to head and mature early, indicating to escape high temperature stress condition. With agreement to this study Jagadish, [9] found that escaping heat stress had been the major strategy to develop high temperature tolerant genotypes and the focus of crop improvement was on developing short duration varieties for high temperature environment. Variation in days to maturity in different genotypes was also been reported by Sabouri et al. [10]. The mean value for grain filling period was 33 days. Genotype G-21 had longest grain filling period of 38 days followed by G-19 (37 days) and G-28 (37 days) and Werer-2 had the shortest i.e., 26 days (Table 2). Similar findings for grain filling period were reported by Bhattarai et al. [8]. Genotypes G-3, G-4 and G-26 matured early and had short grain filling period than the released variety Amibara. Therefore, genotypes that are characterized by an early maturity and short grain filling period could be promising because this adaptation approach is associated with an escape mechanism for high temperature stress condition.

There were highly significant variations among genotypes for plant height and ranged between 47.7 cm and 74.7 cm with an average value

of 61.9 cm. Genotype G-22 and G-28 were the tallest with similar height of 74.7 cm followed by G-6 (71 cm) and G-7 (70 cm), while G-14 (47 cm) had the least plant height (Table 2). Spike length varied from 5.3 cm to 10.3 cm and the maximum spike length was observed on G-22 and minimum spike length was obtained from G-30. Similarly, Bhattarai et al. [8] also reported highly significant difference among genotypes for spike length.

There were highly significant differences among genotypes for canopy temperature and chlorophyll content (Table 3). Canopy temperature ranged from 30.2°C to 38.5°C with average value of 34°C. The highest canopy temperature was recorded from G-4 (38.5°C) followed by G-31 (38.2°C), G-20 (38.1°C), G-3 (37.4°C), G-26 (37.2°C) and G-1 (37°C) while G-28 had the lowest canopy temperature (Table 3). Among the studied genotypes there were eighteen genotypes with low canopy temperature reading than the average mean values. It is interesting to note that genotypes G-16, G-22, G-28 and G-32 with better required low canopy temperature reading than check varieties of Fentalle and Amibara. The study result indicated that the highest canopy temperature relatively produced low yield and vice versa.

Trt	Genotypes	DE	DH	DM	GFP	PH	SL	NSSP
1	G-1	7 ^{ab}	52.33 ^l	80.66 ^{h-o}	28.33 ^{hi}	57.33 ^{f-m}	8.46 ^{cde}	15.33 ^{b-f}
2	G-2	6.66 ^{ab}	54 ^{h-k}	89 ^{f-i}	35 ^{a-e}	63.2 ^{c-j}	8.26 ^{c-g}	15.53 ^{b-f}
3	G-3	6.33 ^b	46 ^{pqr}	77 ^{no}	31 ^{d-i}	62.6 ^{c-k}	8.4 ^{c-f}	15.8 ^{b-e}
4	G-4	7 ^{ab}	41 ^s	70 ^p	29 ^{f-i}	52.73 ^{klm}	8.33 ^{c-g}	16.06 ^{a-d}
5	G-5	6.33 ^b	54.66 ^{ghi}	88.33 ^{g-j}	33.66 ^{a-g}	53.86 ^{j-m}	8.13 ^{c-h}	13.93 ^{efg}
6	G-6	6.66 ^{ab}	55.33 ^{f-i}	91 ^{c-h}	35.66 ^{a-d}	71.4 ^{abc}	8 ^{c-i}	14.2 ^{efg}
7	G-7	6.33 ^b	57 ^{e-h}	89.66 ^{d-h}	32.66 ^{b-h}	70.06 ^{a-d}	8.86 ^{bcd}	13.8 ^{fg}
8	G-8	6.33 ^b	51.33 ^{kl}	84.33 ^{h-l}	33 ^{b-h}	64.93 ^{a-g}	7.06 ^{g-k}	14.06 ^{efg}
9	G-9	8 ^a	54.66 ^{ghi}	88.66 ^{ghi}	34 ^{a-f}	58.26 ^{e-l}	8.8 ^{bcd}	15 ^{d-g}
10	G-10	6.66 ^{ab}	54 ^{h-k}	88.66 ^{ghi}	34.66 ^{a-e}	64.13 ^{b-i}	8.733 ^{bcd}	15.4 ^{b-f}
11	G-11	7 ^{ab}	57 ^{e-h}	87.33 ^{h-k}	30.33 ^{d-i}	53.46 ^{j-m}	7.8 ^{c-i}	14.7 ^{d-g}
12	G-12	7 ^{ab}	61.66 ^{abc}	94 ^{ab-f}	32.33 ^{c-h}	64.33 ^{a-h}	8.66 ^{bcd}	15.53 ^{b-f}
13	G-13	6.66 ^{ab}	50 ^{l-o}	83.33 ^{j-m}	33.33 ^{a-h}	60.4 ^{d-e-k}	8 ^{c-i}	14.9 ^{d-g}
14	G-14	7.33 ^{ab}	60 ^{cde}	94.66 ^{a-d}	34.66 ^{a-e}	47.66 ^m	7.6 ^{d-j}	14.6 ^{d-g}
15	G-15	6 ^b	48 ^{m-p}	79.33 ^{l-o}	31.33 ^{d-h}	63.46 ^{c-j}	7.2 ^{e-k}	14.06 ^{efg}
16	G-16	6.33 ^b	54.66 ^{ghi}	88.33 ^{g-j}	33.66 ^{a-g}	67.8 ^{a-f}	7.66 ^{d-i}	14.8 ^{d-g}
17	G-17	6.33 ^b	62.66 ^{abc}	92.66 ^{b-g}	30 ^{e-i}	68.26 ^{a-e}	7.86 ^{c-i}	16.2 ^{a-d}
18	G-18	6 ^b	43 ^{rs}	76.33 ^o	33.33 ^{a-h}	52.26 ^{klm}	6.2 ^{kl}	14.2 ^{efg}
19	G-19	6.66 ^{ab}	45 ^{pqr}	82.66 ^{klm}	37.66 ^{ab}	58.66 ^{e-l}	6.93 ^{h-k}	16.06 ^{a-d}
20	Fentalle	7 ^{ab}	44.66 ^{qr}	76 ^o	31.33 ^{d-h}	57.8 ^{e-m}	7.86 ^{c-i}	14.13 ^{e-g}
21	G-21	6.33 ^b	50.33 ^{lmn}	88.66 ^{ghi}	38.33 ^a	64.8 ^{a-g}	7.26 ^{e-k}	13.2 ^g
22	G-22	6.66 ^{ab}	63.33 ^{ab}	95.66 ^{abc}	32.33 ^{c-h}	74.53 ^a	10.2 ^a	17 ^{abc}
23	G-23	6.66 ^{ab}	63.66 ^{ab}	96.66 ^{ab}	33 ^{b-h}	70.2 ^{a-d}	9.86 ^{ab}	17.66 ^a

24	G-24	6 ^b	60.66 ^{bcd}	89.33 ^{e-i}	28.66 ^{ghi}	67.4 ^{a-f}	8.4 ^{cdef}	14.06 ^{efg}
25	G-25	6.33 ^b	64 ^a	98.33 ^a	34.33 ^{a-f}	65.06 ^{a-g}	8.2 ^{c-h}	15.26 ^{b-f}
26	G-26	6.33 ^b	47 ^{opq}	77.66 ^{no}	30.66 ^{d-i}	54.2 ^{h-m}	8.2 ^{c-h}	17.06 ^{ab}
27	G-27	7.33 ^{ab}	57 ^{e-h}	89.66 ^{d-h}	32.66 ^{b-h}	58.53 ^{e-l}	8.4 ^{cdef}	14.7 ^{d-g}
28	G-28	6.66 ^{ab}	60 ^{cde}	97.33 ^{ab}	37.33 ^{abc}	73.86 ^{ab}	8.06 ^{c-i}	15.66 ^{b-f}
29	G-29	7 ^{ab}	54.33 ^{g-j}	89.66 ^{d-h}	35.33 ^{a-e}	57.73 ^{f-m}	7.133 ^{f-k}	13.26 ^g
30	G-30	6.66 ^{ab}	47.33 ^{n-q}	81.66 ^{lmn}	34.33 ^{a-f}	48.53 ^{lm}	5.26 ^l	11.33 ^h
31	Amibara	6.66 ^{ab}	45.33 ^{pqr}	78.66 ^{mno}	33.33 ^{a-h}	57.46 ^{f-m}	7.66 ^{d-i}	13.86 ^{fg}
32	G-32	6 ^b	63.66 ^{ab}	94.33 ^{a-e}	30.66 ^{d-i}	64.8 ^{a-g}	7.73 ^{d-i}	15.4 ^{b-f}
33	G-33	6.33 ^b	57.33 ^{efg}	89 ^{f-i}	31.66 ^{d-h}	61.66 ^{c-k}	9.73 ^{ab}	16.06 ^{a-d}
34	G-34	6.66 ^{ab}	63 ^{abc}	97.66 ^{ab}	34.66 ^{a-e}	65.13 ^{a-g}	9.06 ^{abc}	15.2 ^{c-f}
35	G-35	6.66 ^{ab}	51 ^{klm}	84.33 ^{j-l}	33.33 ^{a-h}	56.89 ^m	6.4 ^{jk}	14.7 ^{d-g}
36	Werer-2	6.66 ^{ab}	58.33 ^{def}	84.33 ^{j-l}	26 ⁱ	62.6 ^{c-k}	6.8 ^{ijk}	14.06 ^{efg}
Grand Mean		6.67	54.52	87.39	32.97	61.91	8.04	14.99
CV (%)		12.07	3.16	3.09	8.07	8.5	8.06	6.21
Significance level _(CR at .05)		*	**	**	**	**	**	**

G=Genotypes, CV=Coefficient of variation, DE=Days to emergence, DH=Days to heading, DM=Days to maturity, GFP=Grain filling period, PH=Plant height, SL=Spike length, TT=Total tillers, ET=Effective tillers, NSSP=Number of spikelets per spike.

Table 2: Mean values of 15 traits of 36 bread wheat genotypes tested at Werer in 2017.

Low canopy temperature under high temperature stress is associated with tolerance in wheat. Therefore, low canopy temperature reading genotypes in this study might be promising for developing heat stress tolerant variety. Similarly, the result also agreed with the earlier study that showed the lower canopy temperature has been used as a selection criterion for tolerance in drought and high temperature stresses conditions [11]. The mean chlorophyll content SPAD value of genotypes was 48.98 (Table 3). It varied from 42.6 to 53.2. G-7 had the highest chlorophyll content while werer-2 had the least. There were four genotypes G-7, G-17, G-19 and G-26 had relatively more chlorophyll content than check varieties of Fentalle and Amibara. This result could indicate that genotypes with high chlorophyll content might be selected to develop heat stress tolerant genotypes. The result of this study supported by the study report indicated resistant genotypes of wheat had higher chlorophyll content than sensitive genotypes under abiotic stress [12].

Performance of genotypes for yield and yield related traits

Number of spikelet per spike, Number of kernels per spike and Spike fertility: The maximum and minimum number of spikelet per spike was recorded for G-23 and G-30 respectively. Similarly, the high value for number of kernel per spike was for G-19 and the lowest number of kernel per spike was registered for G-18. There was a variation among genotypes for the number of kernel per spike. These findings were in agreement with Bhattarai et al. [8] who reported significant variations among genotypes for number of kernels per spike. Spike fertility was ranged from 76% (G-14) to 97% (G-18) with average value of 87% (Table 3). There were four genotypes G-3, G-18, G-19 and G-30 had higher spike fertility than the best check variety Werer-2. Majority of the genotypes had spike fertility in the range of 80 to 90%, two genotypes had below 80% spike fertility and seven genotypes had above 90% spike fertility.

Trt	Genotypes	NKSP	SPF	CT	CLC	BMS	TKW	YLD	HI
1	G-1	34.06 ^{b-h}	86.96 ^{b-f}	37 ^{a-d}	49.4 ^{b-i}	4537 ^l	29.33 ^{c-g}	1451.8 ^{ghi}	31.96 ^{a-e}
2	G-2	37.73 ^{b-f}	88.03 ^{a-f}	33.19 ^m	45.43 ^{kl}	7963 ^{a-e}	29 ^{c-g}	2479.9 ^b	31.2 ^{a-e}
3	G-3	39.46 ^{b-e}	96.76 ^a	37.43 ^{a-d}	50.5 ^{a-g}	6018.5 ^{e-l}	27.66 ^{d-i}	1919.3 ^{b-i}	31.76 ^{a-e}
4	G-4	28.89 ^h	88.93 ^{a-f}	38.53 ^a	49.33 ^{b-i}	5138.9 ^{i-l}	26.26 ^{f-k}	1572.3 ^{e-i}	30.76 ^{a-e}
5	G-5	32.4 ^{d-h}	83.96 ^{b-g}	33.5 ^{e-l}	46.83 ^{g-k}	5833.3 ^{f-l}	27.5 ^{d-j}	1373.5 ^{hi}	23.43 ^{f-j}

6	G-6	34.867 ^{b-h}	79.43 ^{fg}	32.5 ^{h-m}	47.6 ^{e-k}	6666.7 ^{d-k}	31 ^{bcd}	14219 ^{ghi}	21.36 ^{ij}
7	G-7	35.4 ^{b-h}	89.73 ^{a-e}	32.76 ^{h-m}	53.16 ^a	9166.7 ^{ab}	29.93 ^{c-f}	3039.1 ^a	33.66 ^{abc}
8	G-8	36.53 ^{b-h}	88.26 ^{a-f}	35.03 ^{c-i}	51.5 ^{a-d}	6481.5 ^{e-l}	28.76 ^{c-g}	2032.4 ^{b-g}	30.83 ^{a-e}
9	G-9	30.33 ^{gh}	83.6 ^{b-g}	34.36 ^{d-k}	50.43 ^{a-g}	6111.1 ^{e-l}	34 ^{ab}	2156.4 ^{b-f}	36.13 ^a
10	G-10	39.2 ^{b-e}	86.7 ^{b-f}	33.19 ^m	45.6 ^{kl}	7592.6 ^{a-g}	29.03 ^{c-g}	2356.4 ^{bc}	31.13 ^{a-e}
11	G-11	40.06 ^{a-e}	90.06 ^{a-e}	32.4 ^{h-m}	48.16 ^{d-k}	6481.5 ^{e-l}	29.53 ^{c-f}	2313.2 ^{bc}	35.93 ^a
12	G-12	41.06 ^{a-d}	86.36 ^{b-f}	33.36 ^{e-m}	50 ^{a-h}	6296.3 ^{e-l}	23.56 ^{kl}	2153.1 ^{b-f}	35.9 ^a
13	G-13	35.46 ^{b-h}	91.66 ^{abc}	35.23 ^{b-h}	48.9 ^{b-j}	5555.6 ^{h-l}	32.56 ^{abc}	1607.4 ^{d-i}	28.83 ^{b-h}
14	G-14	28.86 ^{gh}	75.76 ^g	36.36 ^{a-f}	45.23 ^{kl}	4861.1 ^{kl}	25.46 ^{g-l}	1550 ^{f-i}	31.83 ^{a-e}
15	G-15	32.26 ^{e-h}	88.96 ^{a-f}	35.03 ^{c-i}	46.06 ^{i-l}	7222.2 ^{b-h}	29.76 ^{c-f}	2364.7 ^{bc}	33.06 ^{a-d}
16	G-16	38.26 ^{b-f}	89.40 ^{a-e}	31.66 ^{i-m}	50.9 ^{a-e}	8796.3 ^{abc}	27.56 ^{d-j}	2287.1 ^{bc}	26.5 ^{d-i}
17	G-17	41.26 ^{abc}	85.2 ^{b-g}	32.3 ^{h-m}	52.03 ^{abc}	7870.4 ^{a-e}	24.43 ^{h-l}	2056 ^{b-g}	25.8 ^{e-i}
18	G-18	28.13 ^h	97.36 ^a	36.5 ^{a-e}	47.1 ^{f-k}	6759.2 ^{d-j}	30.33 ^{b-e}	2263.7 ^{bc}	33.46 ^{a-d}
19	G-19	47.8 ^a	93.03 ^{ab}	34.93 ^{d-i}	52.5 ^{ab}	5833.3 ^{f-l}	27.53 ^{d-j}	1844.9 ^{b-i}	31.73 ^{a-e}
20	Fentalle	34.6 ^{b-h}	83.46 ^{b-g}	38.13 ^{abc}	51.93 ^{abc}	5092.6 ^{kl}	26.86 ^{e-k}	1550.4 ^{f-i}	30.83 ^{a-e}
21	G-21	37.067 ^{b-g}	85.86 ^{b-f}	35.16 ^{b-i}	50.6 ^{a-f}	7777.8 ^{a-f}	26.63 ^{e-k}	2409.4 ^{bc}	31.26 ^{a-e}
22	G-22	42.6 ^{ab}	85.83 ^{b-f}	31.1 ^{lm}	51.2 ^{a-e}	7777.8 ^{a-f}	25.96 ^{f-l}	2005.3 ^{b-h}	26 ^{e-i}
23	G-23	37.6 ^{b-f}	84.33 ^{b-g}	33.4 ^{e-m}	50 ^{a-h}	9351.8 ^a	24.4 ^{h-l}	2212.9 ^{b-e}	23.86 ^{f-j}
24	G-24	33.2 ^{c-h}	80.4 ^{efg}	34.76 ^{d-j}	47.96 ^{d-k}	7129.6 ^{c-i}	24.4 ^{h-l}	1832.7 ^{b-i}	25.56 ^{e-i}
25	G-25	38.13 ^{b-f}	81.76 ^{c-g}	33.2 ^{f-m}	51.2 ^{a-e}	8796.3 ^{abc}	27.33 ^{d-j}	1562.6 ^{f-i}	17.93 ^{jk}
26	G-26	41.86 ^{abc}	86.86 ^{b-f}	37.23 ^{a-d}	52.46 ^{ab}	6481.5 ^{e-l}	27.26 ^{d-j}	2044.4 ^{b-g}	31.66 ^{a-e}
27	G-27	33.73 ^{c-h}	81.63 ^{d-g}	34.5 ^{d-k}	46.43 ^{h-k}	5694.4 ^{g-l}	27.43 ^{d-j}	1281.8 ⁱ	22.5 ^{hij}
28	G-28	28.73 ^{gh}	83.53 ^{b-g}	30.23 ^m	48.46 ^{c-k}	9212.9 ^{ab}	35.16 ^a	2102.3 ^{b-f}	22.99 ^j
29	G-29	38.93 ^{b-f}	84.76 ^{b-g}	32.93 ^{g-m}	46.26 ^{h-k}	6203.7 ^{e-l}	24.1 ^{i-l}	2229.6 ^{bcd}	29.53 ^{a-g}
30	G-30	31.33 ^{e-h}	92.33 ^{ab}	34.96 ^{d-i}	48.56 ^{a-j}	6203.7 ^{f-l}	26.1 ^{f-l}	2214.4 ^{b-e}	35.53 ^{ab}
31	Amibara	32.06 ^{e-h}	84.2 ^{b-g}	38.23 ^{ab}	50.33 ^{a-g}	5231.5 ^{h-l}	28.3 ^{d-h}	1550.3 ^{f-i}	30.13 ^{a-f}
32	G-32	38.2 ^{b-f}	86.1 ^{b-f}	31.5 ^{klm}	49.7 ^{a-i}	8518.5 ^{a-d}	23 ^{kl}	1832.7 ^{b-i}	21.43 ^{ij}
33	G-33	32.2 ^{e-h}	81 ^{d-g}	33.26 ^{f-m}	47.86 ^{d-k}	7685.2 ^{a-g}	32.63 ^{abc}	1760.6 ^{c-i}	22.76 ^{g-j}
34	G-34	36.6 ^{b-h}	80.26 ^{efg}	31.96 ^{i-m}	47.9 ^{d-k}	8981.5 ^{abc}	22.2 ^l	1317 ⁱ	14.56 ^k
35	G-35	36.33 ^{b-h}	83.73 ^{b-g}	36.13 ^{a-g}	44.9 ^{kl}	4722.2 ^{kl}	23.06 ^{kl}	1313.5 ⁱ	27.83 ^{c-i}
36	Werer-2	34.13 ^{b-h}	90.76 ^{a-d}	32.1 ^{h-m}	42.63 ^l	7777.8 ^{a-f}	27.46 ^{d-j}	2362.2 ^{bc}	30.1 ^{a-f}
Grand Mean		36.14	86.61	34.39	48.98	6988.23	28.19	1969.25	28.81
CV (%)		12.15	5.69	4.72	3.85	14.62	7.3	16.76	12.32
Significance level _(CR at 0.5%)		**	*	**	**	**	**	**	**

G=Genotypes, CV=Coefficient of variation, NKSP=No. of kernel per spike, SPF=Spike fertility, CT=Canopy temperature, CLC=Chlorophyll content, BMS=Biomass (kg/ha), TKW=Thousands Kernel Weight, YLD=Yield/Ha, HI=Harvest index.

Table 3: Mean values of 15 traits of 36 bread wheat genotypes tested at Werer in 2017.

Biomass yield, grain yield, harvest index and thousand kernel weight: The mean biomass yield ranged between 4537 kg/ha and 9352 kg/ha with average of 6988 kg/ha. Genotype G-23 and G-1 had the highest and the lowest biomass yield respectively (Table 3). There were seven genotypes G-2, G-7, G-16, G-17, G-23, G-28 and G-32 that scored higher biomass yield than the best released check variety Werer-2. Biomass yield is one of the required traits by agro-pastoral community for their livestock feed during dry season where forage is inadequate. Therefore, identification of higher biomass yield genotypes might fit with the need of agro-pastoral community of study area.

Grain yield was ranged from 1282 kg/ha (G-27) to 3039 kg/ha (G-7) with mean value of 1969 kg/ha (Table 3). Grain yield had the most important traits in any bread wheat evaluation program especially under high temperature stress condition. From the current findings there were three genotypes G-2, G-7 and G-21 which had higher grain yield than the best performed check variety Werer-2 and majority of the genotypes had also high yielded than check varieties Fentalle and Amibara. These results revealed that promising genotypes for yield under high temperature stress condition.

The highest computed harvest index for genotypes was ranged from 15% to 36% with average value of 29% (Table 3). The highest harvest index was recorded from G-9 (36%) followed by G-11 (35.9%), G-12 (35.9) and G-30 (35.5%) and the least harvest index were recorded from G-34 (14.6%) followed by G-25 (17.9%). Harvest index (HI) has been used to describe the proportion of harvestable biomass. There were seven genotypes that had greater value of harvest index than check varieties Amibara, Fentalle and Werer-2 and also high yielder than the low recorded harvest index. Hence it is more efficient when these genotypes were selected so as to promote the harvest index. The mean thousand kernel weight was 28 g with range of 22 g (G-34) to 35 g (G-28) (Table 3). There were thirteen genotypes that had higher thousand kernel weight than the involved released check varieties Fentalle, Amibara and Werer-2. Genotypes able to maintain high thousand-kernel weight under high temperature stress may possess a high level of heat tolerance [13].

Correlation coefficients

Grain yield of wheat is a complex traits which is affected by different components such as plant height, spike length, number of spikelet per

spike, Number of kernel per spike, biomass yield and thousands kernel weight. The information about association among different traits is an important aspect to start a breeding program as it offers various opportunities for the selection of superior genotypes having attractive qualities Ali et al. [14]. Correlation coefficient for different traits present in Table 4. Days to heading showed positive and highly significant correlation with days to maturity, plant height, spike length, biomass yield which had indicated simultaneous improvement of these traits is possible. However, this trait revealed negative and highly significant association with harvest index and also non-significant correlation with the rest of the traits. Highly significant association between days to heading and plant height was also reported by Ali et al. [15]. Whereas, Degewione et al. [16] reported non-significant association of days to heading with different traits.

Days to maturity displayed positive and highly significant correlation with plant height, spike length, and biomass yield. Whereas negative and highly significant association with harvest index and positive non-significant correlation with number of spikelet per spike, number of kernel per spike and yield/ha. However, this trait is negative non-significant correlation with thousand kernel weight. Our study result contradicted by findings of kabir et al. [17]. Plant height showed positive and highly significant association with spike length and biomass yield and significant correlation with number of spikelet per spike. Spike length showed positive and highly significant association with number of spikelet per spike. While negative and significant correlation was found with harvest index. Positive and significant correlation of number of spikelet per spike was observed with number of kernel per spike and positive non-significant with biomass yield. Number of kernel per spike showed negative and highly significant association with thousand kernel weights but non-significant association with rest of the traits. Biomass yield showed negative and highly significant correlation with harvest index and non-significant association with thousand kernel weight and yield/ha. Generally, yield per hectare showed positive and highly significant correlation with harvest index and positive association with days to heading, days to maturity, plant height, number of kernel per spike, biomass yield and thousand kernel weights implies that improvement in any one of these traits have positive effects and an increase in these traits ultimately results increase in yield. Similar results were also reported by Hussien et al. [18] and Chimdesa [19].

Traits	DH	DM	PH	SL	NSSP	NKSP	BY	TKW	YLD	HI
DH										
DM	0.93**									
PH	0.55**	0.56**								
SL	0.50**	0.41*	0.51**							
NSSP	0.27	0.2	0.34*	0.65**						
NKSP	0.18	0.2	0.32	0.19	0.41*					
BMS	0.59**	0.62**	0.70**	0.3	0.2	0.2				
TKW	-0.12	-0.05	-0.05	0	-0.02	-0.45**	-0.07			
YLD	0.03	0.04	0.26	-0.06	-0.1	0.17	0.52	0.12		
HI	-0.54**	-0.56**	-0.45	-0.35*	-0.26	-0.02	-0.44**	0.18	0.52**	

DH=Days to Heading, DM=Days to Maturity, GFP=Grain Filling Period, PH=Plant Height, SL=Spike Length, NSSP=Number of Spiklets Per Spike, NKSP=No. of Kernel per Spike, BY=Biomass Yield Kg/ha, TKW=Thousands Kernel Weight, YLD=Yield Kg/ha, HI=Harvest Index.

Table 4: Pearson's correlation coefficient among different traits of bread wheat genotypes.

Conclusion

Based on this study performance of bread wheat genotypes under high temperature stress condition evaluated for their traits revealed highly significant difference between the genotypes for most traits and significant difference among genotypes were observed. In current results early genotypes with short grain filling period obtained that could be promising to escape high temperature stress condition. In addition to this low canopy temperature reading genotypes G-16, G-22, G-28 and G-32 in this study might be promising for developing heat stress tolerant variety. Among the studied genotypes the highest mean of grain yield/ha obtained from G-2, G-7 and G-21 were the most important genotypes for showing excellent performance on grain yield/ha 2479 kg/ha, 3039 kg/ha, 2409 kg/ha respectively than the best performed released check variety Werer-2 (2362 kg/ha). Therefore, the availability of high yielding genotypes might be promising for development of heat stress tolerant genotype that could be exploited in future bread wheat breeding for high temperature stress condition.

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