Research Article

Assessment of selected elite lines from CIMMYT's semi-arid and collaborative wheat yield trials in advanced stage of testing under the agro climatic condition of Kohat, Khyber Pakhtunkhwa

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Abstract

Drastic climatic changes among the regions had seriously affected production of many crops worldwide especially wheat and considered as one of the threats to global food production and food security. Keeping in view the demand of ever-increasing population under the changing scenario of climatic changes, development of new high yielding resilient cultivars, with wider adaptation are prerequisites. In the light of such circumstances the study was conducted at Barani Agriculture Research Station Kohat to assess lines in advanced stage which was selected from CIMMYT's Semi-arid and Collaborative wheat yield trials. Analysed data showed presences of genetic variability among studied genotypes. Days to heading, plant height and grain yield varied from 121 to 129 days, 91.5 to 113.5 cm and 2266.7 kg/ha to 6541.7 kg/ha, respectively. Amongst all the lines, EBWL-18 headed earlier (121 days), EBWL-41 produced tallest (113 cm) plants and EBWL-15 gave maximum grain yield (6541.7 kg/ha). Heritability ranges from 46 % (grain yield) to 86 % (plant height). Negative selection differential was noted for days to heading (-20.67) and plant height (-15.88 cm) while positive (202.10 kg/ha) for grain yield which is favorable. Response to selection was 3.3, 8.1 cm and 542.9 kg/ha for days to heading, plant height and grain yield, respectively. Correlation analysis showed that plant height had positive significant ($P < 0.5$) correlations with grain yield. EBWL-15 performed better than check at Kohat (Khyber Pakhtunkhwa, Pakistan) in terms of phenotype and grain yield, thus it could be used in future wheat breeding program for the semi-arid region.

Keywords: CIMMYT; Collaborative; Elite Lines; Semi-arid; Wheat; Yield

Introduction

Wheat is the main food crop across the world and cultivates on millions of hectares [1].

Wheat alone meets the nutritional needs of 40% of the world population [2] All around the world, China is the largest producer of

wheat with the production of 134,250 thousand tons [3]. Wheat is one of Pakistan's four staple food and 80% of farmers grow wheat on an area of almost 9 million hectares, which is 40% of country's arable land [4]. In Pakistan, during 2020-21, wheat was grown on an area of 9177.6 thousand hectares which resulted in a production of 27293.4 thousand tons [5]. This production is still insufficient to feed the ever-growing population of Pakistan and the world. To meet the hunger of the world, it is necessary to improve the genetic potential of cereals, especially wheat, which is the main source of calories worldwide. Development of hybrid crops are usually based on 'outbreeding enhancement' and is very common for cross-pollinated species [6] but apart from traditional selection approaches for self-pollinated crops, a lot of emphasis is given to develop hybrid wheat in USA, China, Europe and India [7] as hybrids possess the potential to deliver a major lift in production. Being the staple food of developing countries, along with fulfilling the calories requirements, wheat can also be used to overcome the hidden hunger (micronutrient deficiency) in humans by incorporating the micronutrients (e.g. iron) in wheat [8]. For this reason, the testing and evaluation of the genetic potential of wheat under various agro-climatic conditions are an urgent need. Wheat has the ability to grow under wide range of agro-climatic condition. Climatic change makes the crop productivity less predictable hence rapid climate change underline the need for genetic intervention to improve crop productivity [9]. Because of the different climatic conditions in wheat growing areas, breeders recommend lines suitable for that specific environment. Therefore, selecting wheat lines with good genetic potential for the target environment is the basis of most of wheat breeding programs. On this basis, this research was conducted to assess the genetic

potential of elite lines, selected from international trials (i.e. from CIMMYT, s Semi-arid and collaborative wheat yield trials), in agro-climatic conditions of Kohat and to select the best performing lines for this environment.

Materials and Methods

This research was conducted under field condition at Barani Agriculture research station Kohat during the rabbi season of 2020-21 with the purpose of identifying the best performing line in agro-climatic conditions of Kohat. The experimental material consisted of 55 genotypes including 25 elite lines selected from 27th semi-arid wheat yield trial (27TH SAWYT 2019-20) and 24 elite lines from 2nd collaborative wheat yield trial (2nd CWYT 2019-20) as well as with six check cultivars i.e. Kohat-17, Fahim-19, Pirsabak-2015, Wadaan-2017, Gulzar-2019 and Pirsabak-2019. Detailed information is presented in (Table 1). These elite lines along with check cultivars were planted in 11 × 5 alpha lattice design with two replications on 3rd November, 2020. Each entry is planted in 4 rows of 2-meter length each with row spacing of 30 cm. Standard culture practices was followed during the season. Data were recorded on following parameters

Days to heading (no)

This data was recorded by counting the number of days from the date of sowing to the stage when 50% heads in the plot were become fully visible.

Plant height (cm)

Height of 5 randomly selected plants per entry was taken by measuring the length of plant from ground to tip of the spike without awns and then averaged.

Grain yield (kg/ha)

Weight of the kernels harvested from each plot was measured by using balance in kg/plot and then converted into kg/ha.

Table 1. List of the 55 studied wheat genotypes along with their pedigree

Genotype	Selection Source (2019-20)	Pedigree Information
EBWL-1	27th SAWYT Entry No .04	NADI/COPIO//NADI#2
EBWL-2	27th SAWYT Entry No 5	KUTZ//KFA/2*KACHU
EBWL-3	27th SAWYT Entry No 6	BOKOTA//KFA/2*KACHU
EBWL-4	27th SAWYT Entry No 8	SLVS/ATTILA//WBLL1*2/3/GONDO/CBRD/4/BORL14
EBWL-5	27th SAWYT Entry No 9	SLVS/ATTILA//WBLL1*2/3/GONDO/CBRD/4/BORL14
EBWL-6	27th SAWYT Entry No 12	WBLL1*2/KURUKU//HEILO/3/KANCHAN*2/JUCHI/4/PARUS/FRANCOLIN #1
EBWL-7	27th SAWYT Entry No 13	BORL14*2/7/MUU/5/WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/6/WBLL1*2/SHAMA
EBWL-8	27th SAWYT Entry No 15	WAXWING*2/TUKURU//KBIRD/3/2*BORL14
EBWL-9	27th SAWYT Entry No 17	FRET2*2/SHAMA//KIRITATI/2*TRCH/3/KFA/2*KACHU/4/FRET2*2/SHAMA//PARUS/3/FRET2*2/KUKUNA
EBWL-10	27th SAWYT Entry No 18	MUU/KBIRD//2*KACHU/KIRITATI
EBWL-11	27th SAWYT Entry No 21	ATTILA*2/PBW65*2//MURGA/3/KACHU/KIRITATI
EBWL-12	27th SAWYT Entry No 22	WBLL1*2/CHAPIO*2//MURGA/3/MUTUS/AKURI
EBWL-13	27th SAWYT Entry No 23	MUTUS/ROLF07//MUCUY
EBWL-14	27th SAWYT Entry No 24	ALTAR 84/AE.SQUARROSA (221)//3*BORL95/3/URES/JUN//KAUZ/4/WBLL1/5/MUTUS/6/SUP152/BAJ #1
EBWL-15	27th SAWYT Entry No 25	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO/5/BORL14
EBWL-16	27th SAWYT Entry No 26	PREMIO/4/CROC_1/AE.SQUARROSA (205)//KAUZ/3/PIFED/5/BORL14
EBWL-17	27th SAWYT Entry No 27	SNTL/3/KACHU//WBLL1*2/BRAMBLING
EBWL-18	27th SAWYT Entry No 28	BORL14*2//BECARD/QUAIU #1
EBWL-19	27th SAWYT Entry No 29	BORL14*2//BECARD/QUAIU #1
EBWL-20	27th SAWYT Entry No 32	FRANCOLIN #1//WBLL1*2/BRAMBLING/3/WBLL1*2/BRAMBLING/4/2*NADI#1
EBWL-21	27th SAWYT Entry No 33	KACHU #1//WBLL1*2/KUKUNA/3/BRBT1*2/KIRITATI/6/ROLF07*2/5/REH/HARE//2*BCN/3/CROC_1/AE.SQUARROSA (213)//PGO/4/HUITES/7/BORL14
EBWL-22	27th SAWYT Entry No 36	WBLL1*2/BRAMBLING*2//BAVIS/4/SWSR22T.B.//TACUPETO F2001*2/BRAMBLING/3/2*TACUPETO F2001*2/BRAMBLING
EBWL-23	27th SAWYT Entry No 37	TRCH*2//ND643/2*WBLL1/3/SWSR22T.B./2*BLOUK #1//WBLL1*2/KURUKU
EBWL-24	27th SAWYT Entry No 46	ELVIRA/5/CNDO/R143//ENTE/MEXI75/3/AE.SQ/4/2*OCI/6/VEE/PJN//KAUZ/3/PASTOR/7/KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ/8/ELVIRA/5/CNDO/R143//ENTE/MEXI75/3/AE.SQ/4/2*OCI/6/VEE/PJN//

		KAUZ/3/PASTOR/9/BORL14
EBWL-25	2nd CWYT Entry No 3	KACHU/SAUAL/4/ATTILA*2/PBW65//PIHA/3/ATTILA/ 2*PASTOR
EBWL-26	2nd CWYT Entry No 5	MUNAL*2/WESTONIA
EBWL-27	2nd CWYT Entry No 6	UP2338*2/SHAMA/3/MILAN/KAUZ//CHIL/CHUM18/4/ UP2338*2/SHAMA*2/5/PBW343*2/KUKUNA*2//FRTL/PIFED
EBWL-28	2nd CWYT Entry No 7	BECARD/AKURI*2/3/PBW343*2/KUKUNA*2//FRTL/PIFED
EBWL-29	2nd CWYT Entry No 10	KASUKO
EBWL-30	2nd CWYT Entry No 11	WBLL1/FRET2//PASTOR*2/3/MURGA/5/ND643//2*ATTILA *2/PASTOR/3/WBLL1*2/KURUKU/4/WBLL1*2/BRAMBLING
EBWL-31	2nd CWYT Entry No 17	FRET2/TUKURU//FRET2/3/MUNAL #1/4/SUP152 /AKURI//SUP152
EBWL-32	2nd CWYT Entry No 18	NADI/COPIO//NADI#2
EBWL-33	2nd CWYT Entry No 19	SUP152/6/OASIS/5*BORL95/5/CNDO/R143//ENTE/ MEXI75/3/AE.SQ/4/2*OCI
EBWL-34	2nd CWYT Entry No 20	WBLL1*2/BRAMBLING/4/BABAX/LR42//BABAX* 2/3/SHAMA*2/5/PBW343*2/KUKUNA*2//FRTL/PIFED
EBWL-35	2nd CWYT Entry No 21	WAXWING/KIRITATI*2/3/C80.1/3*BATAVIA// 2*WBLL1/4/COPIO/5/ND643//2*ATTILA*2/ PASTOR/3/WBLL1*2/KURUKU/4/WBLL1*2/BRAMBLING
EBWL-36	2nd CWYT Entry No 23	LIVINGSTON/6/2*MTRWA92.161/PRINIA/5/ SERI*3//RL6010/4*YR/3/PASTOR/4/BAV92
EBWL-37	2nd CWYT Entry No 24	PBW343/TONI//ELVIRA/7/CNO79//PF70354 /MUS/3/PASTOR/4/BAV92/5/FRET2/KUKUNA //FRET2/6/MILAN/KAUZ//PRINIA/3/BAV92
EBWL-38	2nd CWYT Entry No 27	TACUPETO F2001/6/CNDO/R143//ENTE/MEXI_ 2/3/AEGILOPS SQUARROSA (TAUS)/4/WEAVER /5/PASTOR/7/ROLF07*2/8/SAUAL/YANAC//SAUAL
EBWL-39	2nd CWYT Entry No 28	KASUKO
EBWL-40	2nd CWYT Entry No 29	68.111/RGB-U//WARD/3/FGO/4/RABI/5/AE.SQUARROSA (784)/6/BECARD
EBWL-41	2nd CWYT Entry No 30	68.111/RGB-U//WARD/3/FGO/4/RABI/5/ AE.SQUARROSA (778)/7/2*CHWL86/6/ FILIN/IRENA/5/CNDO/R143//ENTE/ MEXI_2/3/AEGILOPS SQUARROSA (TAUS)/4/WEAVER
EBWL-42	2nd CWYT Entry No 32	CHEN/AE.SQ//2*OPATA/3/FINSI/5/ W15.92/4/PASTOR//HXL7573/2*BAU/3/WBLL1
EBWL-43	2nd CWYT Entry No 39	KAUZ/SERI//PFAU/MILAN
EBWL-44	27th SAWYT Entry No 47	BAVIS/NAVJ07//BORL14
EBWL-45	2nd CWYT Entry No 44	MEX94.27.1.20/3/SOKOLL//ATTILA/3*BCN/4/ NESMA*2/14-2//2*SAFI-3
EBWL-46	2nd CWYT Entry No 45	PFAU/MILAN//FUNG MAI 24/3/ACHTAR/ INRA 1764
EBWL-47	2nd CWYT Entry No 49	WORRAKATTA/PASTOR//ACSAD- 981
EBWL-48	2nd CWYT Entry No 50	REBWAH-13/3/CMH81.38/2*KAUZ// ATTILA/4/URES/BOW//OPATA/3/HD2206/HORK

Check Cultivar No 1	KT-2017	SOKOLL/WBLLI
Check Cultivar No 2	Fahim-2019	MILLAN/KAUZ//PRINIA/3/BAV92/4/2*SOKOLL
Check Cultivar No 3	Pirsabak-2015	MILAN/S87230//BABAX
Check Cultivar No 4	Wadaan-2017	YAV79//DACK/RABI/3/SNIPE/4/ AE. SQUARROSA
EBWL-49	SAWYT V-03	SOKOLL/3/PASTOR//HXL7573/2*BAU*2/6/OASIS/5 *BORL95/5/CNDO/R143//ENTE/MEXI75/3/AE.SQ/4/2*OCI
Check Cultivar 5	Gulzar- 2019)	MILLAN/S87230//BAV92*2/3/AKURI
Check Cultivar 6	Pirsabak-2019)	PASTOR//HXL7573/2*BAU/3/SOKOLL/WBLLI/4/HUW234- LR34/PRINIA/PBW343*2/KAKUNA/3/ROLF07/5/WHEAR/SOKOLL

Data was subjected to R software (individual environment) for analysis. Formula proposed by [10] was used to calculate broad sense heritability ($h^2_{(BS)}$) of each trait.

$$h^2_{(BS)} = V_g / (V_g + V_e / r)$$

Where

V_g = genetic variance

V_e = environmental Variance

r = number of replication

Selection differential (S) is calculated as the difference between the means of top 20% selected lines and overall mean of 49 selected elite lines by the method given by [11].

$$S = X_s - X$$

Where X_s = mean of top 20% selected lines

X = overall mean of tested lines

Response to selection (R_e) was calculated as the product of selection intensity, square root of phenotypic variance and heritability of the trait x by following the method proposed by [12].

$$R_e = i_x \times \sqrt{V_p} \times h^2$$

Where

i = selection intensity

$\sqrt{V_p}$ = phenotypic variation

h^2 = heritability

Correlation analysis was done through MVApp (Multivariate Analysis Application) [13].

Results and Discussion

Days to Heading (no)

Days to heading is an important trait in wheat as early heading provides sufficient time for

grain filling, resulting in bold grain and ultimately in high yield. Minimum days to heading is favorable as it can lead to early maturity which help crop to escape from various biotic and abiotic stresses. Analyzed data of days to heading revealed significant ($P < 0.1$) differences among the studied wheat genotypes with the genetic variance of 4.18 and residual variance of 1.88, respectively (Table 2). Similar results were also reported by [14] while finding genetic diversity among wheat genotypes for breeding strategies. Overall mean values of genotypes range from 121 (EBWL-18) to 129 (Pirsabak-15, EBWL-47) days (Fig. 1) with the grand mean of 126 days (Table 2). Mean values of elite lines and check cultivar were 125.9 and 127 days, respectively. While the average mean of best 20% elite lines was 105.25 days (Table 3). High heritability (0.82) was estimated for the said trait which is a positive indication that trait is in the control of gene (Table 2). Heritability of same range was observed by [15, 16] during assessment of spring wheat genotypes. Response to selection for days to heading was 3.3 and selection differential was negative (-20.67) similar to [17, 18] which is desirable because there is possibilities to reduce heading days which lead to early maturity (Table 3).

Plant height

Plant height has given special attention by plant breeders because due to lodging it can

significantly affect grain yield in case of taller plants. Therefore, plants with medium height are preferred in breeding programs. The analysis result confirmed the presence of significant ($P < 0.1$) differences among the experimental material having the genetic variance of 23.9 and residual variance of 8.8 (Table 2). Results of [19, 20] are in alliance with our study. Means for plant height of all wheat genotypes ranged from 91.5 (Pirsabak 15) to 113.5 (EBWL-41) (Fig. 2) with grand mean of 101.2 cm (Table 2). While the average means for elite lines, check cultivars and 20% top selected lines were 101.2, 85.29, and 101.3 cm, respectively (Table 3). Heritability was high (0.84) for plant height (Table 2) with response to selection of 8.1 cm (Table 3). High heritability estimate was also stated by [20, 21]. Negative selection differential (-15.88 cm) was estimated for said trait (Table 3) and it is favorable for taller genotypes as there is chances that in next breeding cycle the height will reduce to desirable range. This result is in complete alliance with [18].

Grain Yield

The ultimate goal of most of the breeding programs is the increased grain yield and

breeders are working consistently to develop new diverse germplasm to get the genotype having stable and high yield. Genotypes were significantly ($P < 0.1$) different for grain yield having the genotypic and error variance of 302940.5 and 724567.4, respectively (Table 2) [22, 23]. Average values for said trait among wheat genotypes ranged between 2266.7 kg/ha (Wadaan-2017) and 6541.7 kg/ha (EBWL-15) (Fig. 3) with grand mean of 4506.4 kg/ha (Table 2) whereas 4708.50 and 3380.6 kg/ha are the mean values of 20% selected lines and check cultivars, correspondingly (Table 3). Heritability of grain yield was moderate (0.46) (Table 2) because of more environmental variance which is evidence by high estimate of error variance over genotypic variance. Moderate heritability was reported by [17] for grain yield under normal condition. Expected response to selection and selection differential for grain yield were 542.9 kg/ha and 202.10 kg/ha (Table 3). Related findings were also documented by [24] while [25] also calculated selection differential and response to selection.

Table 2. Heritability, genotypic variance, residual variance, grand mean, least significant difference (LSD), coefficient of variance (CV) and genotypic variance of days to heading, plant height and grain yield for the studied traits of 55 wheat genotypes

Parameters	Days to heading	Plant height	Grain Yield
Heritability	0.82	0.84	0.46
Genotype Variance	4.18	23.9	302940.5
Residual Variance	1.88	8.84	724567.4
Grand Mean	126	101.2	4506.4
LSD	1.76	3.88	832.7
CV	1.09	2.94	18.9
Genotype Significance	**	**	**

* Significant at 5%, ** significant at 1 %

Table 3. Means of lines, mean of 20% selected lines, means of checks, selection differential and expected response to selection for the studied traits of 55 wheat genotypes

Traits	Mean of Lines	Mean of 20% selected lines	Mean of checks	Selection differential	Expected Response (Re)
Days to heading	126.0	105.25	127	-20.67	3.3
Plant height	101.2	85.29	101.3	-15.88	8.1
Grain Yield	4506.4	4708.50	3380.6	202.10	542.9

Figure 1. Mean values for days to heading of 55 wheat genotypes

Figure 2. Mean values for plant height of 55 wheat genotypes

Figure 3. Mean values for grain yield of 55 wheat genotypes

Correlation analysis

Days to heading has shown a statistically significant positive correlation ($P < 0.5$) with plant height. Whereas, days to heading has shown a non-significant positive correlation with grain yield. On the other hand, plant height has shown a significant positive correlation ($P < 0.5$) with grain yield (Table

4). Our results are in agreement with previous study conducted by [26].

The color and size of the circle reflect the strength of the correlation. The non-significant correlations, with the p-value above 0.05 are indicated with a cross in the individual cells. DH= days to heading, PH= plant height, G. Yield= grain yield in kg/ha (Fig. 4).

Table 4 Pearson's correlation among studied phenotypic traits ($P < 0.5$)

Trait 1	Trait 2	Correlation coefficient	P value	Significance
DH	PH	0.315474	0.000788	*
DH	G. Yield	0.046198	0.631759	ns
PH	G. Yield	0.193557	0.04276	*

*Significant at 5%, DH= days to heading, PH= plant height, G.Yield= grain yield in kg/ha

Figure 4. The figure shows the Pearson's correlation coefficients between studied traits

Conclusion and Recommendations

Analyzed data revealed significant variation among the genotypes for the studied traits indicated that sufficient variability existed among the genotypes. (i.e. 25 elite lines selected from 27th semi-arid wheat yield trial (27TH SAWYT 2019-20) and 24 elite lines from 2nd collaborative wheat yield trial (2nd CWYT 2019-20) along with six check cultivar i.e. Kohat -17, Fahim -19, and Pirsabak 2015, Wadaan-2017, Gulzar-2019 and Pirsabak-2019. Days to heading, plant height, and grain yield ranged from 121 (EBWL-18) to 129 (Pirsabak-15, EBWL-47) days, 91.5 (Pirsabak 15) to 113.5 (EBWL-41) cm and 2266.7 kg/ha (Wadaan-2017) to 6541.7 kg/ha, respectively. EBWL-15 performed better than check at Kohat (Khyber Pakhtunkhwa, Pakistan) in terms of phenotype and grain yield, thus it could be used in future wheat breeding program for the semi-arid region.

Author's contributions

Conceived and design the experiment: S Hameed, M Ishaq & N Muhammad, Performed the experiment: S Hameed, M Ishaq, Z Iqbal, & Z Saleem, Analyzed the data: S Hameed, Contributed material /analysis /tools: S. Mukhtiar, S Qurashi, J Iqbal, A Samad, Q Jan, G Hayat, & TU Rahman, Wrote the paper: S Hameed & M Ishaq.

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