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Research Article

Morphological and seed quality characterization of emmer wheat (*Triticum dicoccum*) germplasm

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Abstract

A set of emmer wheat germplasm lines were studied for eight (08) morphological traits viz., days to 50% flowering, days to maturity, plant height (cm), number of tillers per plant, spike length (cm), number of spikes per plant, number of grains per spikes and grain yield per plant, and eight (08) seed quality parameters viz., grain length, grain breadth, 1000 grain weight (g), standard germination (%), electrical conductivity, seed density, seed vigour index-I, seed vigour index-II. The analysis of variance (ANOVA) of germplasm lines for morphological traits revealed that the mean square for blocks were significant for all the traits except for days to 50% flowering and number of spikes per plant. The mean square value of treatments was found significant for all traits except for spike length and days to maturity. The analysis of variance (ANOVA) for eight (08) seed quality parameters depicted highly significant differences among the genotypes for all the traits under study. The study could identify seven (07) emmer wheat genotypes showing significant and variable expression for morphological traits, twelve (12) genotypes revealed significant seed quality parameters, while twenty nine (29) genotypes were resistant to leaf blight disease. Overall, the genotype EW-192 possessed significant yield traits with resistance to leaf blight, while genotypes EW-93 and EW-157 carried good seed quality parameters in combination with resistance to leaf blight. The identified sources for improvement of morphological, yield attributing seed quality traits and leaf blight resistance could be directly used in hybridization programmes, gene transfer or introgression studies aimed at genetic improvement of bread/ emmer wheats. The sources of resistance to leaf blight identified in the study could further be tested for their effectiveness and use in gene deployment studies with ultimate goal of building a long lasting and durable leaf blight resistance in wheat.

Keywords: Emmer wheat, morphological traits, Yield traits, Seed quality traits, Seed vigour index

1. Introduction

The cultivated emmer wheat (*T. dicoccum*) is a tetraploid species with AB- genome characterized by persistent enclosing hulls, tough glumes and a rachis that disarticulates above the spikelet at maturity (Humphries, 1980). Frequently pubescent leaves, pithy culms, dense compressed often awned spikes, spikelets flattened on the inner side, short narrow and pointed pedicels usually containing two flowers, and red or white, long and slender kernels are distinguishing characters of emmer wheats (Leornard and Martin, 1968). Emmer wheats are called "hulled wheats' where each kernel retains its husk during harvest and are referred as wheats with non threshable grain (Feldman, 2001). Emmer wheat is also known by regional names viz., Kapali and Samba etc. In Italy, emmer wheats are named as "farro" and its cultivation is spread over several regions of central Italy (Pagnotta, 2003). Emmer wheat includes three cultivated species namely einkorn (*Triticum monococcum L.*), emmer (*Triticum dicoccum*) and spelt (*Triticum spelta L.*). Among these, *Triticum dicoccum* is one of the first cultivated wheats (Szabo and Hammer, 1996). Emmer wheat is mainly cultivated in contries viz., Ethiopia, Iran, Eastern Turkey, Central Europe, Italy, Spain and India, which includes only 1 percent of the total world wheat area under this crop (Stall-Knecht *et al.,* 1996). The limited cultivation of emmer wheats in India has been reported covering states of Karnataka, Southern Maharashtra, Coastal Gujarat, parts of Andhra Pradesh and Tamil Nadu (Damania, 2016). The cultivation of emmer wheats is thought to come to Kashmir from the Middle East and to southern India from north eastern Africa through travellers (Luo *et al.,* 2007). Emmer wheat is high in starch, minerals, fibre, carotenoids, anti-oxidant compounds and low in lipids. Doctors often prescribe to include emmer wheats in the diet for those with allergies, diabetes and high blood cholesterol. For these reasons, genetic, agronomic, nutritional and technical qualities of emmer wheat are being assessed through research and selection programmes. Emmer wheat has ability to grow under harsh weather and climatic conditions viz., in soils with limited fertility, under low input conditions and under cold climates and as such is thought to possess genes for biotic and abiotic stress (Blanco *et al.* 1990). The advantages of dicoccum wheat are that it has been successfully used in interspecific hybridization for the improvement of *aestivum* and *durum* wheats (Gill *et al.,* 1996). *Triticum dicoccoides*, a grassy wild wheat, is regarded as good source of genes governing more number of tillers, and such traits could efficiently be exploited in wheat breeding programmes.

The quality seed ensures expected crop stand and is important for optimum growth and yield of the crop (Nelwadker *et al.,* 2017). Seed viability, germination percentage, seed vigour, moisture content, storage conditions, survival ability and seed health are all aspects that influence seed quality, but the most essential seed quality traits include germination percentage and seed vigour (Akbari *et al.,* 2004). Germination percentage, seedling emergence, tillering, seed density, spike length and yield are increased with increased seed weight (Noor-Mohammadi *et al.,* 2000; Cordazzo, 2002). Vigour is an important seed quality parameter that can influence both germination and viability of the seed (Trawatha *et al.,* 1995).

Fungal diseases of wheat contribute to loss of yield and are thought to be an important production constraint in almost all wheat growing regions (Mukhtar *et al.,* 2015) of the world. *Alternaria triticina* is a typical leaf blight fungus that has been identified in India. It is regarded as a serious wheat disease that results in large losses. In India's central, eastern, and southern wheat-growing regions, it is predominantly caused by *Bipolaris sorokiana.* In the states of Himachal Pradesh, Punjab, Jammu and Kashmir and Madhya Pradesh, *Alternaria triticina* is the dominant species causing leaf blight. *A. triticina* disease symptoms include irregularly shaped lesions on leaves that range in colour from dark brown to grey. The disease first manifests as small, oval lesions that are discoloured; however, as it progresses, these lesions combine to cause leaf mortality. Individual grain weights can be reduced by 46-75% after infection and yields can be lost by up to 60%. Over 50% of total yield losses are attributable to biotic and abiotic stresses. Although application of fungicides provides complete control on disease spread, but it adds to the cost of cultivation and is considered unfriendly to the environment. Screening of the germplasm to identify effective sources of resistance to leaf blight and their use in wheat breeding programmes is considered most effective strategy to combat this disease.

With this backdrop, it is important to study emmer wheat germplasm for morphological traits viz., days to 50%

flowering, days to maturity, plant height (cm), number of tillers per plant, spike length (cm), number of spikes per plant, number of grains per spikes and grain yield per plant; seed quality traits viz., grain length, grain breadth, 1000 grain weight (g.), standard germination (%), electrical conductivity, seed density, seed vigour index-I, seed vigour index-II and screen the germplasm for resistance to leaf blight to identify the superior emmer wheat genotypes from the study for their use in wheat improvement strategies.

2. Materials and methods

The experimental material comprised of one hundred eighty (180) emmer wheat germplasm lines procured from National Bureau of Plant Genetic Resources (NBPGR), New Delhi during year 2020. The germplasm was evaluated in Augmented Block design (ABD) with 3 checks planted in nine blocks at the research field and seed testing laboratory of Division of Genetics and Plant Breeding, Faculty of Agriculture, Wadura during year 2021. The data was recorded on eight (08) morphological traits viz., days to 50% flowering, days to maturity, plant height (cm), number of tillers per plant, spike length (cm), number of spikes per plant, number of grains per spikes and grain yield per plant and eight seed quality parameters viz. grain length, grain breadth, 1000 grain weight (g.), standard germination (%), electrical conductivity, seed density, seed vigour index-I, seed vigour index-II. The procured emmer wheat germplasm was also screened for leaf bight resistance under field tests following 0-5 scale as proposed by Conn *et al.,* (1990).

3. Results and Discussion

3.1 Evaluation of morphological and yield related traits

The emmer wheat germplasm lines evaluated for eight (8) morphological traits revealed significant variability among genotypes as observed in terms of wide range of mean values (Table 1) and coefficient of variability (CV). The days to 50% flowering among genotypes varied from 143 to 187 days, with its mean performance recorded as 197.92 days and coefficient of variance observed as 8.95 per cent. Days to maturity ranged from 221.44 to 246 days with mean of 224.12 days and coefficient of variance was found 7.21 per cent. The range of plant height varied from 30.04 cm to 116.04 cm with mean of 91.92 cm and coefficient of variance observed as 6.97 per cent. Number of productive tillers per plant varied from 3.41 to 9.41 with a mean of 6.89 and coefficient of variance was recorded as 11.96 per cent. For spike length the mean value was 11.97 cm that ranged from 7.95 to 18.34 cm and coefficient of variance was found 12.66 per cent. The number of spikes per plant was observed between 10.88 to 22.95 with mean of 8.89 and coefficient of variance observed as 10.38 per cent. The number of grains per spike was found between 11.11 to 48.44 with an average value of 30.24 grains per spike and coefficient of variance of 8.15 per cent. The average grain yield per plant was 24.43 g that ranged from 12.78 to 33.62 g and coefficient of variance for grain yield per plant was 9.96 per cent. The frequency distribution for various agro-morphological and yield related traits are presented in Figure 1, which showed more or less normal distribution for all the traits under study. For days to 50% flowering out of total 180 genotypes, highest 50 genotypes were found in the range of 164.5-168.4 days, maximum number of genotypes matured in 236.8- 239.1 days, the highest plant height ranged from 96-105cm in 55 plants, 52 genotypes had maximum number of tillers as 7.21-7.81, 55 genotypes has maximum spike length in the range of 10.75-11.75, majority of the genotypes has spikes per plant ranging from 15.4-17.4, maximum number of grains per spike (34.6-38.6) was observed for 56 genotypes, while maximum grain yield per plant was recorded for 52 genotypes as 25.51-27.41g. The variability parameters such as, coefficient of variation (CV), genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for morphological and yield related traits are presented in Table 1. The highest coefficient of variation as per cent mean was recorded for spike length (12.66 %) followed by number of tillers per plant (11.65 %), number of spikes per plant (10.38 %), grain yield per plant (9.96 %), days to 50% flowering (8.95 %), number of grains per spike (8.15 %), days to maturity (7.21 %) and plant height (6.97 %). The highest phenotypic coefficient of variation (PCV) was recorded for number of grains per spike (24.47), whereas lowest value was recorded for days to maturity (1.71). The highest genotypic coefficient of variance (GCV) was recorded for number of grains per spike (23.01) and number of tillers per plant (18.67), whereas, lowest values recorded for number of spikes per plant (1.04) and days to maturity (1.21). The trait variability is a key feature for making successful selections in the breeding material. More significant the variability among traits, more reliable could be selection. The significance of variability among emmer wheat germplasm justifies the appropriation of the material for its use for the genetic studies, which is further justified by their values of coefficient of variation. Coskun *et al.*, (2019) could find significant variation for different morphological and yield related traits among a set of wheat genotypes. The number of tillers per plant is related to the number of spikes and consequently the number of seeds produced. The grain yield is a complex quantitative trait and is directly and indirectly influenced by other plant traits termed as yield attributing traits viz., number of tillers per plant, spike length, number of spikes per plant, number of grains per spike and 1000 grain weight (Coskun *et al.*, 2019).

Table 1. Descriptive statistics for morphological and yield related traits in emmer wheat

S. No.	Traits	Mean	Min.	Max.	C. V.	PCV	GCV
1	Days to 50% flowering	197.92	143.33	187	8.95	3.89	2.53
2.	Days to maturity	224.12	221.44	246.11	7.21	1.71	1.21
3.	Plant height (cm)	91.92	30.04	116.04	6.97	16.43	15.56
4.	Number of tillers per plant	6.89	3.41	9.41	11.96	22.23	18.67
5.	Spike length (cm)	11.97	7.95	18.34	12.66	14.21	6.3
6.	Number of spikes per plant	8.89	10.88	22.95	10.38	10.47	1.04
7.	Number of grains per spike	30.24	11.11	48.44	8.15	24.47	23.01
8.	Grain yield per plant (g)	24.43	12.78	33.62	9.96	13.42	8.89

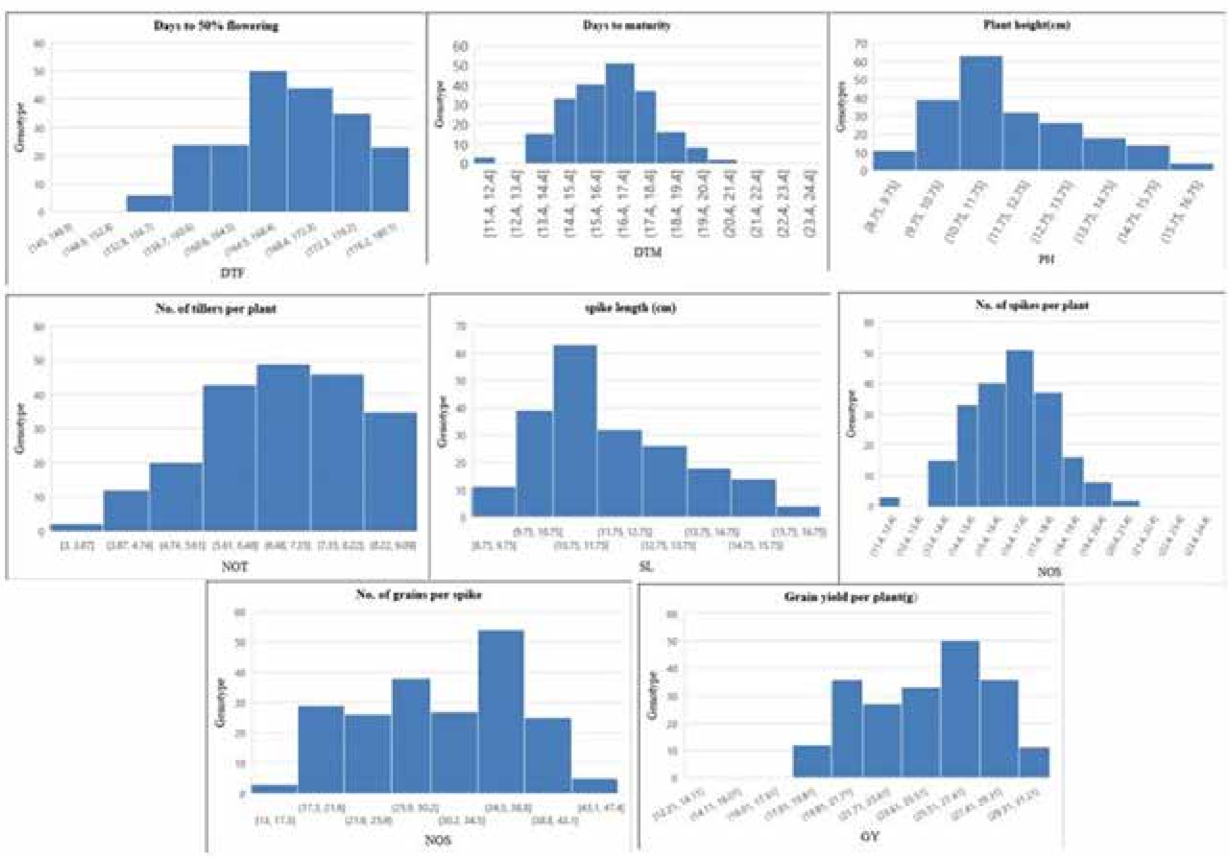

Figure 1. Frequency distribution of morphological and yield related traits in emmer wheat germplasm

Figure 2. Variability of emmer wheat germplasm for spike morphology (a &b)

The morphological characterization of germplasm lines is the first step towards the study of its diversity and conservation. To examine the variation between germplasm lines diversity with respect to morphological traits such as plant height, days to 50% flowering, number of tillers per plant, spike length (Figure 2), number of spikes per plant, number of grains per spike, days to maturity and 1000 grain weight are important as they affect wheat grain production (Pecetti and Damania, 1996). Elzevir and Aluizio (1999) and Karagoz *et al.*, (2006) and Gharib *et al.*, (2021) also reported the importance of study of these morphological traits in wheat. The findings of the study are also in agreement with the reports of Kalimullah *et al.* (2012), Bode *et al.*, (2017) and Safi *et al.*, (2017) and Rani *et al.*, (2018) who could find that the number of grains per spike, number of tillers per plant, grain yield per plant and various seed traits showed significant differences among genotypes. The high yielding wheat genotypes possessed better agronomic performance for all yield related attributes such as spike length, number of tillers per plant and 1000 grain weight. The emmer wheat genotypes have better performance for different yield and yield attributing traits could be used in hybridization programmes in transfer of economically important traits and utilized in future wheat breeding programmes of the country.

3.2 Evaluation of seed quality traits

The evaluation of emmer wheat genotypes revealed significant variability among genotypes for seed traits viz., grain length, grain breadth, grain colour, test weight, germination percentage, seed vigour index-I, seed vigour index-II, electrical conductivity and seed density, as depicted by wide range of mean values (Table 2) and coefficient of variability (CV). The mean value of grain length was found lowest in genotypes EW-32 and EW-66 (7.25) and highest in genotype EW-110 (9.56) mm. The mean value of grain breadth was lowest in genotypes EW-118(1.56) and highest was found in genotypes EW-169, EW-159, EW-134 (3.56). The lowest value for test weight was found in genotypes EW-174 (51g) and highest was in genotypes EW-117(83.25g). Electrical conductivity was found lowest for genotypes-EW-58(60), EW-57(57) and highest for genotypes EW-49(185), EW-40(175). A mean value for germination percentage was lowest in genotypes EW-75(80%), EW-113(82.25%) and highest was in genotypes EW-57(97%), EW-110 (95%). The mean value of the vigour index-I with a range of 1008 to 2440 was 1389.45 and the coefficient of variation was 6.4 per cent. The vigour index-II ranged from 12.14 to 19.36 with a mean of 15.44 and a 12.97 percent coefficient of variance. The coefficient of variation was determined to be 26.42 and the average seed density was found to be 3.61 with a range of 1.00 to 9.0. The findings of the study are in agreement with the reports of Tomer and Maguire (1990), Farahani *et al.* (2011), Moshatati and Gharineh (2012), Wani *et al.* (2013), Zarein *et al.* (2013), Rani *et al.* (2018), Kumar *et al.* (2019), Sarojini *et al.* (2020) and Kiran *et al.* (2021).

Table 2. Descriptive statistics for seed quality traits of emmer wheat

Variable name → Parameter name ↓	Test weight (g)	Seed length (mm)	Seed breadth (mm)	Seed density (g/cm^3)	Electrical conductivity (µS. cm. g)	Germination percentage (%)	Vigour Index- I	Vigour Index-II
Mean	69.05	8.15	2.87	3.61	115.29	92.16	1389.45	15.44
Minimum	45	3.35	1.56	1	49	72	1008	12.14
Maximum	87.8	9.97	4.20	9	210	100	2440	19.36
C. V	1.9	7.58	14.96	26.42	9.30	6.05	6.4	12.97
C. D	4.922	2.320	1.613	3.584	40.302	20.966	333.953	2.004

The study depicted presence of significant variability among the genotypes for seed traits. The values of means, range and CV (Table 2) revealed that there was significant variation among the genotypes for seed quality traits. The highest CV was observed for seed density (26.42) and lowest for test weight (1.9). The genotypes EW- 56, EW-57, EW-84, EW-85, EW-89, EW-93, EW-94, EW-112, EW-114, EW- 128, EW- 156, EW-157, were significantly different in all the quality parameters. The table-2 shows their performance in various quality parameters and vigour tests viz. 1000 grain weight (g.), standard germination test (%), electrical conductivity, seed density, seed vigour index-I, seed vigour index-II. The frequency distribution for various seed quality traits are presented in Figure 3, which showed more or less normal distribution for all the traits under study.

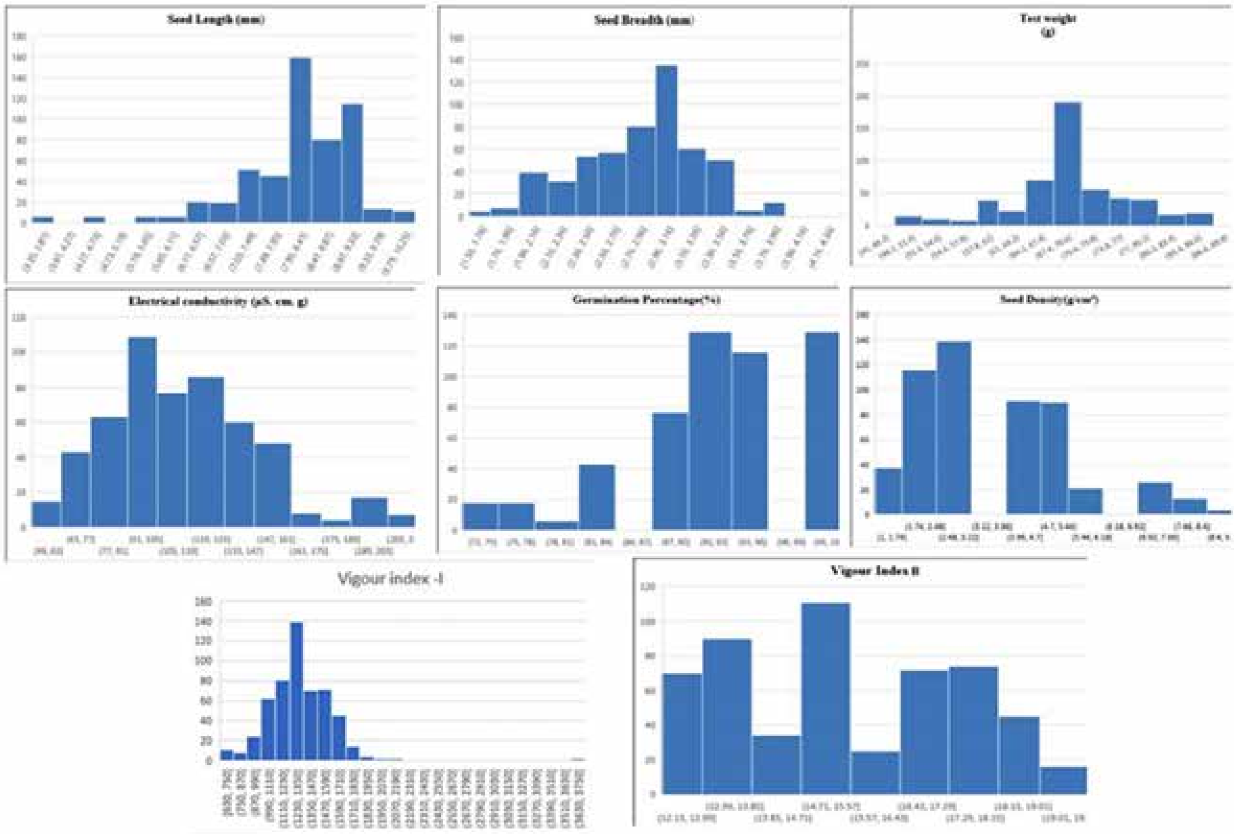

Figure 3 Frequency distribution of seed quality traits in emmer wheat germplasm

The significant diversity was observed for seed length (Table2 and Figure 4). The measure of seed length ranged from 3.35 to 9.97 mm with an average length of 8.15 mm, and the coefficient of variance was 7.58 per cent. The mean performance of seed breadth was recorded as 2.87 mm and the coefficient of variance was observed as 14.96 per cent and it ranged from 1.56 to 4.20 mm. The coefficient of variance for test weights was 1.9 per cent which ranged from 45 to 87.8 g and had an average value of 69.05 g. Electrical conductivity had a mean value of 115.29 and a coefficient of variance observed was 9.30 per cent with a range of 49 to 210. A mean germination percentage of 92.16% was recorded with a coefficient of variance of 6.05 per cent that ranged from 72 to 100%. The vigour index I had a mean value of 1389.45 and a coefficient of variance was 6.4 per cent with a range of 1008 to 2440. The vigour index II had a mean of 15.44, a coefficient of variation was 12.97 per cent, and it ranged from 12.14 to 19.36. The mean performance of seed density was recorded as 3.61 and it ranged from 1.00 to 9.0, and the coefficient of variation was found as 26. 42.

Figure 4 .Variability of emmer wheat germplasm for a) Germination b) Seedling length c) Dry weight

3.3 Analysis of variance for morphological, yield related and seed quality traits

The analysis of variance (ANOVA) for morphological and yield related traits (Table 3) under study depicted that the mean square for blocks were significant for all the traits except days to flowering and number of spikes per plant. The mean square of treatments was found significant for all traits except spike length and days to maturity. The mean square was non-significant among checks for all traits except days to flowering and grain yield. The mean square for test entries versus checks were significant for variation for all traits except, days to maturity and spike length. The mean sum of square (MSS) values for seed traits was partitioned in the form of ANOVA (Table 4). The MSS values for seed traits were found highly significant for all the seed traits studied, depicting the satisfactory variability among all the genotypes for the traits under study. The findings of the study are in agreement with the reports of Zarein *et al.,* (2013), Kalimullah *et al.* (2012), Bode *et al.*, (2017) and Safi *et al.,* (2017), Rani *et al.,* (2018) and Kumar *et al.,* (2019) who could find that the number of grains per spike, number of tillers per plant, grain yield per plant and various seed traits showed significant differences among genotypes. The high yielding wheat genotypes possessed better agronomic performance for all yield related attributes such as spike length, number of tillers per plant and 1000 grain weight. The emmer wheat genotypes reported to have better performance for different yield and yield attributing traits could be used in hybridization programmes in transfer of economically important traits and utilized in future wheat breeding programmes of the country.

Table 3. Analysis of variance (ANOVA) of augmented block design for morphological and yield related traits

Source of variation	D. f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of tillers per plant	Spike length (cm)	Number of spikes per plant	Number of grains per spike	Grain yield per plant (g)
Block (ignoring Treatments)	8	51.93	113.84**	750.27**	5.53**	8.45*	5.59	109.68**	13.24 **
Treatment (eliminating Blocks)	182	44.43	11.57	226.4**	2.16**	2.64	2.91	53.66**	17.66 **
Treatment: Check	2	20.58**	16.78	79..58	4.15	0.92	4.15	2.33	12.25 **
Treatment: Test and Test vs. Check	180	44.71	11.51	228.03**	2.14**	2.66	117.35 **	54.25**	17.72 **
Treatment (ignoring Blocks	182	44.47	16.22	257.07**	2.39**	2.9	3.05	57.94**	13.24*
Treatment test	179	42.75	16.07	228.15**	2.34**	2.89	3.01	54.74**	17.72*
Treatment (test vs. check)	1	403.27*	42.44*	5789.89**	6.59**	10.04*	92.93*	743.6**	12.25**
Block (eliminating Treatments)	8	29.64 **	8.08*	91.89**	0.4	2.96**	25.89 *	12.42	12.37**
Error	1	24.74	8.03	23.47	0.69	2.32	2.98	6.33	6.03

(* indicates significance at 5% level of significance, ** indicates significance at 1% level)

Table 4. Analysis of variance (ANOVA) for seed quality traits

Source	Degree of freedom	Test weight (g)	Seed Length (mm)	Seed breadth (mm)	Seed density	Electrical conductivity (µS. cm. g)	Germination percentage (%)	Vigour Index I	Vigour Index II
Genotype	180	164.97*	2.67**	0.27*	6.912*	3108.15*	84.09*	116441.81*	41.04*
Error	360	1.715	0.3813	0.1844	0.90	115.00	31.12	7896.07	36.11
Total	539								

(* indicates significance at 5% level of significance)

3.4 Correlation studies for morphological and yield related traits

The result of the study (Table 5) revealed that days to 50 % flowering was significantly correlated with days to maturity and grain yield per plant and negatively correlated with plant height. The days to maturity was significantly and positively correlated with plant height and spike length whereas, the plant height was significantly and positively correlated to number of spikes per plant and grain yield per plant whereas, spike length was positively correlated to number of grains per spike. Number of spikes was positively correlated with number of grains per spike and grain yield per plant. The correlation co-efficient matrix for the traits under study observed 13 significant positive correlations and one negative significant correlation of total 30 paired combinations of traits. The values for the significant positive correlation ranged from 0.207 (Number of spikes per plant with number of grains per spike) to 0.214 (plant height with number of tillers). Tammam *et al.* (2000) also found positive correlation between grain yield with number of spikes and reported that the number of grains per spike is significantly and positively correlated to grain yield per plant. Singh *et al.* (2015) found significantly positive correlation between days to 50 per cent flowering with days to maturity but negative correlation with plant height. Similarly, Tahmasebi *et al.* (2013) found that plant height and number of spikes have positive and significant correlation with grain yield. Such findings of the experiments are in agreement with the studies of Ivanova and Ilina (2020).

Table 5. Correlation coefficient for morphological and yield related traits under study

Trait	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of tillers per plant	Spike length (cm)	Number of spikes per plant	Number of grains per spike	Grain yield per plant
Days to 50% flowering	1							
Days to maturity	0.140**	1						
Plant height	-0.246**	0.018*	1					
Number of tillers per plant	0.213**	0.022	0.037	1				
Spike length	0.036	0.139*	0.024	-0.078	1			
Number of spikes per plant	-0.006	0.005	0.204**	0.073	0.19	1		
Number of grains per spike	-0.075	0.019	0.033	-0.007	0.195*	0.207**	1	
Grain yield per plant	0.155*	-0.107	0.143	0.173*	0.172*	0.172*	0.676**	1

(* indicates significance at 5% level of significance, ** indicates significance at 1% level)

3.5 Field screening for leaf blight resistance

Leaf blight is considered as both soil borne and seed borne disease. In wheat spikes infected at the pre-anthesis stages, the symptoms appear on the leaf sheath, stem as well as the awns and glumes. Seeds do not develop if the spike becomes infected at this early stage. Glumes, ear and seed infections all originate from infection during the dough stage of seed development. Fields that have been heavily infested seem burned and can be seen from a distance (Singh *et al.,* 1990). The leaf blight incidence on wheat has increased to a significant level in Kashmir valley since last few years, and as such this disease on wheat has received much attention from the wheat breeders. The screening of emmer wheat germplasm was done under natural epiphytotic conditions in field and a significant number of genotypes viz., EW-2, EW-5, EW-10, EW-12, EW-17, EW-18, EW-21, EW-32, EW- 66, EW-68, EW-73, EW-77, EW-78, EW- 79, EW-93, EW-102, EW-113, EW-121, EW-124, EW-131, EW-141, EW-142, EW-143, EW-151, EW-157, EW-172, EW-192, EW-193 and EW-218 were reported to be resistant against leaf blight. The scoring of germplasm was done following Conn *et al.* (1990). The leaf blight resistant genotypes identified from the study could be further tested for their effectiveness of resistance in wheat improvement programmes. Over all, emmer wheat is considered to have more resistance to diseases than modern wheats, because as compared to freely-threshable wheats hulled wheats have more robust glumes that can protect the grain more efficiently against pests (birds and rodents) , against fungal and insect attacks during storage, thus making them comparatively more vigorous (Nesbitt and Samuel 1996). Emmer wheat grains have higher protein content than other wheat types and hence are considered good for diabetic patients compared to modern cultivated wheats under the same conditions (Curna and Lacko-Bartosova, 2017). Emmer wheat is considered as a valuable genetic resource to breed improved bread and durum wheats with higher levels of resistance to biotic and abiotic stresses (Zaharieva *et al.*, 2010; Samiullah *et al.,* 2022). Singh *et al.*, (2003) classified a set on wheat genotypes as resistant, moderately resistant, and susceptible on the basis of their disease reaction. The studies of leaf blight resistance were also accomplished by Sinha *et al.* (2006) and Patel and Patel (2017) to identify sources of resistance.

Conclusion

The study revealed significant variability among genotypes for morphological, yield related and seed quality traits. The emmer wheat genotypes viz., EW-15, EW-20, EW-33, EW-67, EW-97, EW-192, EW-205 possessed better morphological and yield related traits and thus could be used as source lines for improvement of these traits. The genotypes viz., EW- 56, EW-57, EW-84, EW-85, EW-89, EW-93, EW-94, EW-112, EW-114, EW- 128, EW- 156, EW-157 possessed better seed quality traits and as such these genotypes could be recommended for use in plant breeding programmes in improvement of seed quality traits in wheat. The genotypes viz., EW-2, EW-5, EW-10, EW-12, EW-17, EW-18, EW-21, EW-32, EW- 66, EW-68, EW-73, EW-77, EW-78, EW- 79, EW-93, EW-102, EW-113, EW-121, EW-124, EW-131, EW-141, EW-142, EW-143, EW-151, EW-157, EW-172, EW-192, EW-193 and EW-218 were screened as highly resistant types with immune reaction. Such source of resistance to leaf blight could be further tested for their use for deployment of such genes over space and time with ultimate goal of building a long lasting or durable resistance cover against leaf blight in wheat.

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Compliance with ethical standards

This article does not contain any studies involving human or animal participants performed by any of the authors. All authors comply the ethical standards of the journal.

Conflict of interest (Reply in Yes and No.):

The authors declare no conflict of interest.

Author contributions:

Z,MAK,RRM, SK, AKS: conceptualized the methodology for the study; AKS: shared emmer wheat germplasm for the study; FJW, MAB, ABS: contributed in experimental design and statistical analysis while MAK, Z, RRM, HM, TB, SJ, SS: were involved in writing, review and editing of the manuscript.

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