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Genetic evaluation of winter wheat genotypes under rainfed conditions

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Abstract
The experimental material of the present study comprised 20 true breeding facultative type winter wheat lines namely (Alfrog, Berserka, Bolal, Mega, Centruck, Jose cambier, Golden valley, Vir 453-47, Saptadhara, WW12 Arkaan, Blue boy, China 84-40022, Drina, Drina NS 720, Norderesprez, WW7, WW21, WW23 and WW25) and were evaluated under rainfed conditions during Rabi 2014-15 and planted on 29th October, 2014 in a randomized block design with three replications. Each entry was planted in four rows in 1m with plant to plant and row to row distance of 5 cm and 25 cm respectively. Of these, the best ten winter wheat lines (Arkaan, Blue boy, China 84-40022, Diana, Diana NS 720, Norderesprez, WW12, WW21, WW23 and WW25) used as females and three spring wheat (PBW175, PBW 644 and WH 1080) were used as males parents to develop the experimental material for line x tester mating design. Analysis of variance for different morphological, yield, root and quality traits revealed that all the 20 winter wheat lines differ significantly for all of the traits with respect to days to 50% flowering (no), days to maturity (no), flag leaf area (cm^2), plant height (cm), no.of effective tillers per plant, no.of grains per spike, grain yield per plant (g), 1000 grain weight (g), Biological yield per plant (g), harvest index (%), root number per plant, root length per plant (cm). root volume per plant (ml), root weight (g), proline content (µmol/g), seed protein content (ppm). Seed iron content (ppm), Manganese content (ppm), zinc content (ppm) under rainfed conditions. Different genetic parameters that were used to explain the variability revealed that most of the characters showed moderate to high values of PCV and GCV. The trait viz no. of effective tillers per plant and grain yield per plant (g) showed high value of PCV and GCV, whereas the traits like flag leaf area (cm^2), spike length (cm), 1000 grain weigh (g), biological yield per plant (g), harvest index (%), root number, root weight (g), proline content (µmol/g), seed protein content (ppm) had moderate values of PCV and GCV. The traits viz days to 50% flowering (no), days to maturity (no), plant height (cm), root volume (ml), root length (cm), iron content (ppm), manganese content (ppm), zinc content (ppm) had low values of PCV and GCV. All morphological, yield, root and quality traits exhibited low values of environmental co-efficient of variance (ECV). Estimate of heritability and genetic advance expressed as percent of mean were high for traits viz: flag leaf area (cm^2), spike length (cm), no.of tillers per plant, no.of grains per plant, 1000 grain weight (g), harvest index (%), root weight (g), proline content (µmol/g) and seed protein content under study. Whereas, the traits as days to 50% flowering (no), plant height (cm), biological yield per plant (g), root number plant, root length per plant (cm), root volume per plant (ml), iron content (ppm) manganese content (ppm), zinc content (ppm) had high PVC and moderate GCV. But the traits like days to maturity has high PCV and low GCV.

Keywords: winter wheat, PCV, GCV, ECV, heritability

Introduction
Wheat (*Triticum aestivum* L.), self-pollinated crop of the Poaceae family and of the genus *Triticum*, is the world's largest cereal crop. It is popularly known as 'Stuff of life or King of the cereals' because of the acreage occupied, high productivity and the prominent position it holds in the international food grain trade. Wheat (*Triticum* spp.), is the most important cereal crop and occupies prominent position in Indian agriculture after rice. India is now the second largest producer of wheat in the world with the production hovering around 75 million tonnes during the last decade.). The area and production of wheat in India during year 2016-17 was recorded 30.97 million ha with 97.44 million tonnes production and with an average productivity of 3172 kg ha-1 (Director's Report, IIWBR, Karnal, 2016- 17). The problem of drought is in the soil with low water holding capacity especially in the rain fed areas of mountainous and sub-mountainous regions. Therefore, there is an urgent need for genetic improvement of wheat in such environments. One of the ways by which this can be achieved is by the incorporation of genes from winter wheat. The importance of winter wheat

for the improvement of spring wheat under rainfed conditions was highlighted as early as in 1949 by Ackerman and Mackey. The success of winter x spring hybridization depends upon the ability of these two physiologically different ecotypes to combine well with each other.

Materials and Methods

The experimental material of the present study comprised 20 true breeding facultative type winter wheat lines received from Indian Agriculture Research Institute, Regional Station, Tutikardi, Shimla, CSK, Himachal Pradesh Krishi Vishvidyalaya, Palampur, H.P and three spring wheat received from Indian Institute of wheat and Barley Research (IIWBR), Karnal. These lines were maintained in the Division of Plant Breeding & Genetics, SKUAST –Jammu, Chatha (Table1). Above 20 winter wheat lines were evaluated under rainfed conditions during Rabi 2014-15 and planted on 29th October in a randomized block design with three replications. Each entry was planted in four rows in 1m, each with plant to plant and row to row distance of 5 cm and 25 cm respectively. Of these, the best ten winter wheat lines (Arkaan, Blueboy, China, Diana, Diana NS 720, Nordersprez, WW12, WW21, WW23 and WW25) and three spring wheat (PBW175, PBW 644 and WH 1080) were used as males parents to develop the experimental material for line x tester mating design.

Parameters of variability

To test the significance of differences among different genotypes used in the study, the data on mean values for different characters was analysed as per standard statistical procedure for augemented design. Different biometrical measures that were used to explain dispersion of variability includes:

1. Mean

The mean was calculated by dividing the sum of the observation with the number of observations.

Mean of trait = ΣX /n

Where,
ΣX = Sum of x character
n = Number of seed sources/progenies

2. Range

It was expressed as the difference between the lowest value and the highest value present in the observation for each trait.

3. Variance

Expressed as the average of squared deviation of all the individual observation from the mean. Mathematically,

$$\text{Variance (var.) or } \sigma^2 = \frac{\sum (x-\bar{x})^2}{N-1}$$

N = Total number of observations

4. Standard deviation (σ)

Expressed in terms of square root of variance.

$$\text{SD} = \sqrt{Var} = \sqrt{\sigma^2} = \sigma$$

5. Standard error(SE)

Expressed as the mean difference between sample estimates of mean and the population parameter μ i.e. it is the measure of uncontrolled variation present in a sample. The Standard error of a variable mean was calculated by dividing the estimate of Standard deviation by the root of the number of the observations in the sample. Mathematically

$$\text{Standard error} = \frac{\text{Standard deviation}}{\sqrt{N}}$$

where,
N = Total number of observations

6. Critical Difference (CD)

Critical difference was calculated with the help of SE for testing the difference of two means.

CD = SE(d) ×'t' tab. at error d.f.

Where,
SE (d) = Standard error (difference of two means).

7. Coefficient of variation (CV)

CV (%) = Standard deviation /Mean x100

8. Genotypic and Phenotypic Variances

The genotypic and phenotypic variances were estimated as suggested by Lush (1940).

1. Genotypic variance: $V_g \text{ or } V = \frac{M_g - M_e}{r}$
2. Phenotypic variance: V_P or $\sigma^2_p = M_g + M_e$
3. Environmental coefficient of variance $V_e$or $\sigma^2_e = M_e$.

The phenotypic and genotypic variance was further used to compute coefficient of variation as suggested by Burton (1952).

1. Phenotypic coefficient of variation (PCV)

$$\text{PCV (\%)} = \frac{\sqrt{\text{Phenotypic Variance}}}{\text{Mean}} \times 100$$

$$= \frac{\sqrt{V_p}}{\bar{X}} \text{ or } \frac{\sigma_p}{\bar{X}} \times 100$$

2. Genotypic coefficient of variation (GCV)

$$\text{GCV (\%)} = \frac{\sqrt{\text{Genotypic Variance}}}{\text{Mean}} \times 100$$

$$= \frac{\sqrt{V_g}}{\bar{X}} \text{ or } \frac{\sigma_g}{\bar{X}} \times 100$$

3. Environmental coefficient of variation (ECV)

$$\text{ECV (\%)} = \frac{\sqrt{\text{Environment Variance}}}{\text{Mean}} \times 100$$

$$= \frac{\sqrt{V_e}}{\bar{X}} \text{ or } \frac{\sigma_e}{\bar{X}} \times 100$$

Where,

$\sigma_{p,}$ andσ_g are phenotypic and genotypic standard deviation respectively.

The PCV and GCV were classified as follows as suggested by Sivasubramaniam and Madhavamanon (1973).

Low	:	less than 10%
Moderate	:	10-20%
High	:	More than 20%

9. Heritability (broad sense) h^2_{bs}

It was calculated by the method adopted by Lush (1940) and expressed as percentage.

Heritability (broad sense) (%) = $\frac{\text{Genotypic variance}}{\text{Phenotypic variance}} \times 100$

= $\frac{\sigma^2_g}{\sigma^2_p}$

As suggested by Johnson *et al.* (1955) heritability values were categorized as follows.

Low	:	less than 30%
Moderate	:	30-60%
High	:	More than 60%

10. Genetic advance (GA)

The expected genetic gain or advance under selection was estimated by following method as suggested by Johnson *et al.* (1955).

Genetic advance (GA) = $\sigma_p x\ h^2 x\ k$

Where,

σ_p = Phenotypic standard deviation of the original population for the character

h^2 = Heritability coefficient

k = Selection differential at particular level of selection intensity, which is 2.06 for 5 per cent selection intensity.

Genetic advance as per cent of means = $\frac{\text{Genetic advance}}{\text{Mean}}$

Genetic advance as per cent of mean was calculated as suggested by Johnson *et al.* (1955)

Low	:	Less than 10%
Moderate	:	10-20%
High	:	More than 20%

Results and Discussion

Analysis of variance and components of variation

Twenty winter wheat lines were analysed to estimate the magnitude of genetic variability for different morphological, yield, root and quality traits related drought tolerance under rainfed conditions during 2014-15. Analysis of variance, estimate of different genetic parameters and genetic advance have been in Table (3) and Table (4).The analysis of variance revealed that all the lines/genotypes showed highly significant difference for all the morphological, yield, root and quality traits under rainfed conditions.

Morphological traits

Days to 50% flowering

Winter wheat lines showed significant differences as for this trait with overall mean of 126.93 ± 1.98 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were low under rainfed condition i.e. 8.49, 8.04 and 2.75 respectively for this trait. Estimate of heritability (h^2bs) was high i.e. 90.Genetic advance as percent of mean was moderate i.e. 15.67 percent.

Days to Maturity

Winter wheat lines showed significant differences as for this trait with overall mean of 164.95 ± 2.20 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were low under rainfed condition i.e. 5.42, 4.89 and 2.34 respectively for this trait. Estimate of heritability (h^2bs) was high i.e. 81.00 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was low i.e. 9.09 percent.

Flag leaf area

Winter wheat lines showed significant differences as for this trait with overall mean of 58.06± 1.90 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 15.40 and 15.34 respectively for this trait. Estimate of heritability (h^2bs) was high i.e. 87 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 29.53 percent.

Plant height

Winter wheat lines showed significant differences as for this trait with overall mean of 115.93 ± 1.57 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were low under rainfed condition i.e. 6.76, 6.32 and 2.39 respectively for this trait. Estimate of heritability (h^2bs) was high i.e. 88.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was low i.e. 12.19 percent.

Yield contributing traits

Effective tillers per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 24.83 ± 1.11 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were high under rainfed condition i.e. 21.03, 19.54 respectively for this trait. The ECV was observed low value i.e. 7.79 percent. Estimate of heritability (h^2bs) was high i.e. 88.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 37.38 percent.

Spike length

Winter wheat lines showed significant differences as for this trait with overall mean of 9.80 ± 0.21 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 13.16, 12.56 respectively for this trait. The ECV was observed low value i.e. 3.39 percent. Estimate of heritability (h^2bs) was high i.e. 88.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 24.69 percent

Grains per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 42.86 ± 0.99 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 11.77, 11.05 respectively for this trait. The ECV was observed low value i.e. 4.06 percent. Estimate

of heritability (h^2bs) was high i.e. 88.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 21.37 percent.

Grains yield per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 55.10 ± 1.95 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 20.09, 19.10 respectively for this trait. The ECV was observed low value i.e. 6.23 percent. Estimate of heritability (h^2bs) was high i.e. 88.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 37.41 percent.

1000 grain weight

Winter wheat lines showed significant differences as for this trait with overall mean of 43.08 ±1.00 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 16.23, 15.70 respectively for this trait. The ECV was observed low value i.e. 4.09 percent. Estimate of heritability (h^2bs) was high i.e. 94.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 31.30 percent

Biological yield per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 120.95 ± 4.07 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 11.91, 10.35 respectively for this trait. The ECV was observed low value i.e. 5.90 percent. Estimate of heritability (h^2bs) was high i.e. 75.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was moderate i.e. 18.51 percent.

Table 3.1: Analysis of variance and estimates of ECV, GCV, PCV, heribility and genetic advance in winter wheat genotypes for morphological and yield traits.

Genetic parameters	Days to 50% Flowering	Days to Maturity	Flag Leaf Area	Plant Height cm	Tillers Per Plant	Spike Length	Grains Per Plant	Grain Yield	1000 Grain Weight	Biological Yeild Per Plant	Harvest Index (%)
Treatment (19)	76.78**	312.04**	101.14**	189.06**	2.68**	283.89**	54.10*	54.64*	86.94**	28.21*	421.62**
Error (38)	40.51	57.80	30.55	66.75	1.70	112.59	20.88	20.32	50.97	33.34	258.6
CD (0.05)	5.60	6.26	5.40	4.49	3.14	0.62	2.82	5.55	2.80	11.50	3.22
Mean (X ± SE_m)	126.3 ± 1.98	164.2 ± 2.20	55.06 ±1.9	115.73 ± 1.5	24.83 ±1.11	9.8 ± 0.21	42.86 ±.99	55.1 ±1.9	120.955.1 ±1.9	55.1 ±1.9	43.69 ±1.1
ECV	2.39	2.75	2.34	5.82	6.23	3.93	7.79	4.06	4.54	4.09	5.90
GCV	8.04	4.89	15.34	6.32	19.54	12.56	11.05	19.10	15.70	10.35	14.94
PCV	8.49	5.42	16.40	6.76	21.03	13.16	11.77	20.09	16.23	11.91	15.61
h^2 (Broad Sense)	0.90	0.81	0.87	0.88	0.86	0.91	0.88	0.90	0.94	0.75	0.92
Genetic Advancement 5%	19.79	14.99	17.15	14.13	9.28	2.42	9.16	20.62	13.49	22.39	12.87
Gen.Adv as % of Mean 5%	15.67	9.09	29.53	12.19	37.38	24.69	21.37	37.41	31.30	18.51	29.44

*, ** significant at 5% and 1% level, respective

Table 3.2: Analysis of variance and estimates of ECV, GCV, PCV, hertibility and genetic advance in winter wheat genotypes for root and quality traits.

Genetic parameters	Roots Per Plant	Root Length	Root Volume	Root Weight	Proline Content	Seed Protein Content	Iron Content	Manganese Content	Zinc Content
Treatment (19)	64.68**	1.73*	3.99*	0.39*	0.02*	5.81*	17.24**	22.71**	51.69**
Error (38)	56.22	1.08	3.20	0.24	0.13	2.96	13.96	10.38	10.18
CD (0.05)	4.52	0.73	1.20	0.36	0.06	1.32	2.12	1.88	1.77
Mean (X ± SE_m)	59.05±0.25	13.2 ±0.25	20.2±0.25	1.75±09	1.75±0.02	11.07±0.46	34.45±0.74	35.5±0.25	36.15±0.58
ECV	4.72	3.39	3.67	8.67	5.49	7.38	3.69	3.24	3.34
GCV	10.50	6.26	6.15	14.60	12.59	13.45	7.11	7.44	7.28
PCV	11.51	7.11	7.17	16.98	13.74	15.34	8.01	8.12	8.01
h^2 (Broad Sense)	0.83	0.77	0.74	0.74	0.84	0.77	0.79	0.84	0.83
Genetic Advancement 5%	11.65	1.51	2.20	0.66	0.18	2.69	4.61	5.04	4.93
Gen.Adv as % of Mean 5%	19.72	11.33	10.88	25.86	23.79	24.29	12.99	14.06	13.63

*, ** significant at 5% and 1% level, respective

Table 4.1: Mean performance of twenty winter genotypes for yield, morpho-physiological and quality traits for 20 winter wheat lines.

Name of winter wheat lines	Days to 50% Flowering	Days to Maturity (No.)	Flag Leaf Area (cm^2)	Plant Height (cm)	No. of Effective Tillers/ Plant	Spike Length (cm)	No. of Grains/ Spike	Grains Yield/ Plant (g)	1000 Grain Weight (g)	Biological Yield/ Plant (g)	Harvest Index (%)
	1	2	3	4	5	6	7	8	9	10	11
Alfrog	116.00	159.00	43.55	124.30	19.66	8.00	40.00	42.45	33.70	108.50	34.00
Arkan	139.33	168.33	67.86	108.00	28.33	9.40	43.00	71.00	38.20	121.33	37.33
Berserka	121.33	156.00	54.10	111.33	20.66	8.20	38.33	35.50	32.00	102.33	34.20
Blue Boy	121.33	161.33	54.82	122.46	31.33	10.40	41.33	55.50	39.40	122.66	37.33
Golden Valley	141.00	172.33	63.80	110.00	17.66	8.70	33.60	44.50	30.5	108.90	36.00
Bolal	131.66	160.33	54.43	114.33	18.66	7.60	38.00	40.50	30.20	106.33	34.33
Centruck	128.66	158.00	48.16	124.33	21.66	8.40	41.00	48.00	31.85	88.10	32.70
China 84-	141.33	171.00	66.70	110.93	30.00	10.70	47.33	66.25	40.40	135.33	48.33

40022											
Drina	127.66	160.00	46.00	115.20	32.33	11.10	50.40	73.00	46.00	136.00	51.00
Nordisprez	119.66	161.33	65.13	127.16	31.66	11.60	41.13	72.00	49.10	121.66	47.33
Josecambier	138.00	167.33	41.06	114.03	19.33	7.40	38.50	47.00	47.70	97.20	34.70
WW7	121.33	159.00	48.10	115.00	24.66	10.60	44.00	53.20	37.45	140.66	47.80
WW12	122.33	164.00	46.60	128.73	19.00	8.40	36.10	48.10	30.80	110.00	33.00
WW21	139.66	178.66	43.66	117.66	34.33	12.30	52.00	75.00	49.50	141.66	51.33
WW23	122.66	160.66	65.95	110.00	28.66	10.50	47.10	65.00	39.10	123.33	40.70
WW25	109.33	170.66	66.36	130.66	26.00	9.10	48.66	54.75	36.50	133.70	39.00
Drina NS720	134.33	174.00	44.60	115.33	26.00	11.50	50.00	67.65	47.70	141.33	51.00
Saptadhara	105.33	146.33	58.63	107.33	24.00	9.00	34.66	52.00	36.15	120.33	37.00
Vir 453-47	117.33	162.33	69.86	131.00	20.00	8.30	38.00	45.70	29.50	118.66	37.33
Mega	133.66	169.33	43.50	117.96	18.00	8.00	34.70	44.80	36.20	118.20	31.33

Table 4.2: Mean performance of twenty winter genotypes for yield, morpho-physiological and quality traits for 20 winter wheat lines.

Name of winter wheat lines	Root Number per Plant	Root Length/ Plant (cm)	Root Volume/ Plant (ml)	Root Weight/ Plant (g)	Proline Content (µ mol/g)	Seed Protein Content (ppm)	Seed Iron Content (ppm)	Seed Manganese Content (ppm)	Seed Zinc Content (ppm)
	12	13	14	15	16	17	18	19	20
Alfrog	44.33	9.20	19.33	1.95	0.686	9.78	29.66	30.00	31.63
Arkan	56.33	10.85	21.33	2.60	0.710	10.20	31.33	37.66	34.10
Berserka	47.00	9.45	20.00	1.95	0.683	9.40	25.66	29.66	33.53
Blue Boy	58.33	11.20	21.75	2.10	0.770	12.83	29.77	36.93	35.60
Golden Valley	51.00	10.40	20.00	2.00	0.621	9.15	26.00	28.33	32.00
Bolal	50.00	10.4	20.80	2.00	0.702	9.50	26.66	32.95	34.10
Centruck	41.66	8.90	18.00	1.85	0.655	9.66	27.33	27.56	30.66
China 84-40022	66.66	11.40	22.33	3.30	0.797	13.14	30.33	38.50	36.93
Drina	71.66	14.20	25.00	3.20	0.863	13.90	37.66	39.33	39.26
Nordisprez	64.66	12.85	22.40	3.20	0.765	10.16	32.70	38.33	37.73
Josecambier	50.33	9.80	20.50	2.10	0.760	10.2	29.66	30.00	32.40
WW7	71.33	14.10	26.10	3.00	0.820	13.14	36.33	37.86	38.96
WW12	40.01	9.40	20.00	1.90	0.585	9.96	28.33	32.77	34.26
WW21	72.33	15.10	26.33	3.33	0.835	12.78	39.33	39.33	41.33
WW23	69.00	13.50	22.90	2.45	0.770	10.34	34.66	38.00	38.53
WW25	68.66	12.60	21.70	2.30	0.763	10.26	37.66	39.80	37.10
Drina NS720	69.66	13.90	22.40	2.80	0.862	14.30	36.00	39.80	40.00
Saptadhara	50.33	9.70	20.20	2.10	0.647	9.58	28.33	35.60	32.13
Vir 453-47	50.00	9.40	20.00	1.95	0.634	9.52	26.00	33.95	31.40
Mega	50.00	9.20	19.33	1.80	0.565	9.51	25.66	31.23	30.66

Harvest Index

Winter wheat lines showed significant differences as for this trait with overall mean of 43.69± 1.13 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 14.94, 15.61 respectively for this trait. The ECV was observed low value i.e. 4.72 percent. Estimate of heritability (h^2bs) was high i.e. 92.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 29.44 percent.

Root number per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 39.05± 1.50 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 11.51, 10.50 respectively for this trait. The ECV was observed low value i.e. 4.72 percent. Estimate of heritability (h^2bs) was high i.e. 83.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 19.72 percent.

Root length per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 20.05± 0.25 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 7.11, 3.67 respectively for this trait. The ECV was observed low value i.e. 3.67 percent. Estimate of heritability (h^2bs) was high i.e. 77.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was moderate i.e. 11.32 percent.

Root volume per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 3.50± 042 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 7.17, 6.15 respectively for this trait. The ECV was observed low value i.e. 3.67 percent. Estimate of heritability (h^2bs) was high i.e. 74.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was moderate i.e. 10.32 percent.

Root weight per plant

Winter wheat lines showed significant differences as for this trait with overall mean of 6.55± 0.12 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 16.98, 14.60 respectively for this trait. The ECV was observed low value i.e. 8.67 percent. Estimate of heritability (h^2bs) was high i.e. 74.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 25.86 percent

Proline content
Winter wheat lines showed significant differences as for this trait with overall mean of 0.76± 0.02 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 13.74, 12.59 respectively for this trait. The ECV was observed low value i.e. 5.59 percent. Estimate of heritability (h^2bs) was high i.e. 84.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 23.79 percent.

Seed Proline content
Winter wheat lines showed significant differences as for this trait with overall mean of 11.08± 0.46 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were moderate under rainfed condition i.e. 15.34, 13.45 respectively for this trait. The ECV was observed low value i.e. 7.38 percent. Estimate of heritability (h^2bs) was high i.e. 77.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was high i.e. 24.29 percent.

Iron content
Winter wheat lines showed significant differences as for this trait with overall mean of 35.45± 0.74 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were low under rainfed condition i.e. 15.34, 13.45 respectively for this trait. The ECV was observed low value i.e. 3.69 percent. Estimate of heritability (h^2bs) was high i.e. 79.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was moderate i.e. 12.99 percent

Manganese content
Winter wheat lines showed significant differences as for this trait with overall mean of 36.88± 0.58 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were low under rainfed condition i.e. 8.12, 7.44 respectively for this trait. The ECV was observed low value i.e. 3.24 percent. Estimate of heritability (h^2bs) was high i.e. 84.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was moderate i.e. 14.06 percent

Zinc content
Winter wheat lines showed significant differences as for this trait with overall mean of 36.15 ± 0.98 centimetres under rainfed condition. The phenotypic, genotypic and environment coefficient of variation were low under rainfed condition i.e. 8.12, 7.28 respectively for this trait. The ECV was observed low value i.e. 3.24 percent. Estimate of heritability (h^2bs) was high i.e. 83.0 percent of mean was moderate i.e. percent. Genetic advance as percent of mean was moderate i.e. 13.63 percent.

4.1.2 Mean performance
Mean performance for 20 winter wheat lines in respect of morphological, yield, root, biochemical and quality traits under rainfed condition are presented in Table 4(I,II) and described character wise as below :

Days to 50% flowering
Winter lines exhibited significant difference in their mean performance for days to 50% flowering under rainfed condition which ranged from 141-105 days, with an overall mean 126.3 ± 1.98 days under rainfed condition, China 84-440022 with mean days to 50 per cent flowering of days 141 days latest followed by Golden valley (141 days), Arkaan (139 days), WW21 (140 days), Jose Cambier (138 days) and Saptadhara was earliest to flowering (105 days) (Table – 4)

Days to maturity
Winter wheat exhibited significant differences in their mean performance for days to maturity which ranged from 178-146 with an overall mean 164.95 ± 2.20 days under rainfed condition Saptadhara (146 days) with earliest mean days of maturity followed by Alfrog (159 days), WW7 (159), Centruck (158 days), WW23 (160 days), Blue boy (161 days) and WW21 was the latest days to maturity (178 days).

Flag leaf Area
Winter wheat lines exhibited significant difference in their mean performance for flag leaf area which ranged from 67-41.06 cm^2 with an overall mean 58.06 ± 1.90cm^2. Vir 453-47 had the longest flag leaf area (69.86 cm^2) followed by Arkaan 67.86 cm^2, China 84-44002 (66.40 cm^2), WW25 (66.36 cm^2). Jose cambier showed the lowest flag leaf area (41.06 cm^2).

Plant Height
Winter wheat lines exhibited significant difference in their mean performance for plant height which ranged from 107-131 cm with an overall mean 115.93 ± 1.57.Under study, Saptadhara was the shortest with mean plant height of 107 cm, followed by Arkaan (108 cm),WW23 (110 cm), China 8444022(111cm),whereas genotype vir 453-47 was the longest (131.00 cm).

No. of tillers per plant
Winter wheat lines exhibited significant difference in their mean performance for no. of tillers per plant which ranged from 34- 18with an overall mean 24.83 ± 1.11. WW21 had the largest effective tillers (34) followed by Blue boy (31).Mega showed the lowest (18).

Spike length
Winter wheat lines exhibited significant difference in their mean performance for spike length which ranged from 12.30-7.40 cm with an overall mean 9.83 ±.21. WW21 had the highest spike length (12.30 cm) followed by Nordresprez (11.60). Jose cambier showed the lowest spike length (7.40 cm).

No. of grains per plant
Winter wheat lines exhibited significant difference in their mean performance for no. of grains per plant which ranged from 55- 33.6with an overall mean 42.86 ±.99. WW21 had the largest grains (52) followed by Drina NS720 (50). Golden valley showed the lowest (33.60).

Grain yield per plant
Winter wheat lines exhibited significant difference in their mean performance for grain yield per plant which ranged from 75- 42.45g with an overall mean 55.1 ± 1.95. WW21 had the largest effective tillers (75.00g) followed by Nordresprez (72.00 g). Bolal showed the lowest (40.50 g).

Biological yield per plant
Winter wheat lines exhibited significant difference in their mean performance for Biological yield per plant which ranged from 141.66- 88.10g with an overall mean 120.45 ± 4.07.

WW21 had the highest biological yield per plant (141.33g) followed by WW7 (140.66 g). Centruck showed the lowest (88.10 g).

Harvest Index (%)
Winter wheat lines exhibited significant difference in their mean performance for harvest index which ranged from 51.33- 31.33% with an overall mean 43.69 ± 1.13. WW21 had the highest harvest index (51.33%) followed by Drina NS 720 (51%). Mega showed the lowest (31.33 %).

Root number per plant
Winter wheat lines exhibited significant difference in their mean performance for spike length which ranged from 72.33-41.66 with an overall mean 59.05 ± 1.50. WW21 had the highest root number (72.33) followed by Drina (71.66). Drina NS 720 showed the lowest root number (40).

Root length per plant
Winter wheat lines exhibited significant difference in their mean performance for root length which ranged from 15.1-9.2 cm with an overall mean 13.2 ±.25. WW21 had the highest root length (15.10 cm) followed by WW 7(14.10). Centruck showed the lowest root length (8.90 cm).

Root length per plant
Winter wheat lines exhibited significant difference in their mean performance for root length which ranged from 15.1-9.2 cm with an overall mean 13.2 ±.25. WW21 had the highest root length (15.10 cm) followed by WW7 (14.10). Centruck showed the lowest root length (8.90 cm).

Root volume per plant
Winter wheat lines exhibited significant difference in their mean performance for root volume which ranged from 26.33-18 ml with an overall mean 20.2 ±.42. WW21 had the highest root volume (26.33 ml) followed by WW7 (26.10 ml). Centruck showed the lowest root volume (18 ml).

Leaf Proline content
Winter wheat lines exhibited significant difference in their mean performance for proline content which ranged from 0.863- 0.565 µmol/g with an overall mean 0.75±.02. Drina had the highest proline content (0.863 µmol/g) followed by WW7 (0.820 µmol/g). Mega showed the lowest proline content (0.565 µmol/g).

Seed protein content
Winter wheat lines exhibited significant difference in their mean performance for protein content which ranged from 14.30- 9.51 ppm with an overall mean 11.07±.46. Drina had the highest protein content (14.30 ppm) followed by WW7 (13.9 ppm). Golden valley showed the lowest protein content (9.15 ppm).

Seed Iron content
Winter wheat lines exhibited significant difference in their mean performance for Iron content which ranged from 39.33-25.66 ppm with an overall mean 34.45±.74. WW21 had the highest protein content (39.3 ppm) followed by WW25 (37.66 ppm). Mega showed the lowest Iron content (25.66 ppm).

Manganese content
Winter wheat lines exhibited significant difference in their mean performance for Manganese content which ranged from 39.80- 30.00 ppm with an overall mean 34.45±.74. Drina NS 720 had the highest manganese content (39.80 ppm) followed by WW21 (39.33 ppm). Centruck showed the lowest manganese content (27.56 ppm).

Zinc content
Winter wheat lines exhibited significant difference in their mean performance for Zinc content which ranged from 41.33-30.66 ppm with an overall mean 36.15±.98. WW21 had the highest Zinc content (41.33 ppm) followed by Drina (40.00 ppm). Centruck and Mega showed the lowest Zinc content (30.66 ppm).

Analysis of variance for different yield, root, morphological and quality traits revealed that all 20 winter wheat lines differ significantly for most of the traits with respect to 50 % flowering, days to maturity, flag leaf area, plant height, spike length, tillers per plant, 1000 grain weight, spike length, grain yield per plant, Biological yield per plant and harvest index (percent), root weight per plant, proline content and seed protein content. However, in case of plant height, days to 50% flowering, days to maturity, root length, root volume, iron, zinc and manganese content, a low level of GCV and PCV was recorded under study. All the yield, morphological, root and quality traits exhibited low environmental coefficient of variation (ECV) under study. Similar findings have been reported by Ali *et al.* (2008) [1], Shankara rao *et al.* (2010), Kalimullah *et al.* (2012), Talebi and Fayyaz (2012) [12], Degevionce *et al.* (2013) and Maurya *et al.* (2014) [11].

Estimates of heritability and genetic advance expressed as percent of mean were high to moderate for most of the yield morphological and quality traits under rainfed condition. The present study revealed high heritability for all the yield, morphological, root and quality traits and these findings are as in accordance to early reports of different workers in wheat breeding (Majumder *et al.* 2008, Yadav *et al.* 2014, Zeeshan *et al.* 2014) [10].

Screening of drought tolerance is a useful tool to select the most tolerant genotypes. This can be done under laboratory, green house, pots and under field condition, however of all these methods, field condition; however, of all these methods, field condition bioassay is the most successful and effective methods for screening since the evaluation can cover all stage of plant growth and development and thus the data more realistic than using the other method vaezi *et al.* (2010).

The present results revealed that the traits such as 1000 grain weight, spike length, grains per plant, grain yield per plant were decreased under rainfed field condition which is also reported by several investigator (Hraska and Petrovic, Kumar *et al.* 2003, Baric *et al.* 2004). The traits viz, protein content, iron and zinc content were increased under drought by 10.00, 10.61 and 14.00 of control.

Results of the present work exhibited differential response of the winter wheat lines listed to drought stress. This suggests that these difference were due to genetic variation among the test winter wheat lines grown in rainfed conditions since all the treatment were carried out under similar condition. The differential response of genotypes of winter wheat lines grown in rainfed condition since all the treatment were carried out under similar conditions. The differential response of genotypes of winter lines to drought has been reported by several investigation (Grant and Makenzie 1970, Rupert 1971, Kant and Gupta 2002, Baric *et al.* 2004).

The present study demonstrated that winter lines viz: Arkaan, Blue boy, China 84-40022, Drina, Drina NS 720, Norderesprez, WW7, WW21, WW23 and WW25 are the

most tolerant winter wheat lines since they have highest values of grain yield were obtained when grown at rainfed condition. Subsequently data analysis revealed that the drought tolerant winter lines appeared superior in number of effective tillers per plant, grains per plant, grains per plant, 1000 grain weight yield per plant, Biological yield per plant and harvest index, root number, root weight, root length and root volume compared to drought sensitive cultivars viz. Alfrog, Berserka, Bolal, Mega, Centruck, Jose cambier, Golden valley, Vir 453-47, WW12 and Saptathara.

Conclusion

It can be concluded from this study that the mean performance of the 20 winter wheat lines was different under rainfed conditions. The drought tolerance superiority of WW21, WW7, Drina, Drina NS 720, China 84-40022, Nordresprez, WW23, WW 25, Arkaan and blue boy winter lines under rainfed condition could be associated with their higher yielding, number of tillers per plant, spike per plant, 1000 grain weight, biological yield per plant, harvest index, proline content, iron content, manganese content and zinc content compared to other ten winter wheat lines.

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