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Research Note

Evaluation of Wheat Recombinant Inbred Lines for heat tolerance and variability

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Abstract
Twenty two heat tolerant recombinant inbred lines (RILs) of wheat derived from crosses *viz:* AAI12 x K9162 and AAI12 x K8962 were developed through disruptive seasonal selection. These heat tolerant lines along with two check varieties (NW 1017 and HD 2733) were raised during *Rabi*-2013-14 in RBD design. The data obtained in the present investigation were analysed to compute the coefficient of variation, heritability, genetic advance, correlation between grain yield and sixteen component traits and physiological traits of wheat. Analysis of variance revealed significant difference among genotypes. On the basis of *per se* performance for grain yield per plant, genotypes RLW 3, 7, 13, 5 and 15 were found promising. High estimates of genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were obtained for canopy temperature depression, chlorophyll content and membrane stability. High estimates of heritability were recorded for all characters studied. High heritability along with moderate genetic advance was registered for plant height, grain filling period, grains per spike and test weight. Suggesting sufficient variability and thus scope for genetic improvement through selection for these traits. Estimates of correlation co-efficient exhibited highly significant positive correlation with number of grains per spike, spike weight, spike length, canopy temperature depression, tillers per plant, grain filling period and chlorophyll content. Therefore this character may be used as an index for selection to higher yield in wheat genotype. However it was found to be negatively significant correlation of yield with plant height was observed.

Keywords
Wheat, Recombinant inbred line, variability, correlation

Wheat occupies a prominent place in the cereal economy of the world. The total area of wheat in the world is around 215.26 million ha, with a production of 584.76 million tonnes. The average world productivity is 2717 Kg/ha (http:// Directorate of wheat research 2013-14). The major wheat producing countries are China, India, USA, France, Russia, Canada, Australia, Pakistan, Turkey, UK, Argentina, Iran and Italy. These countries contribute about 76% of the total world wheat production. India stands 2nd position on both in area and production next to China. The India's share in world wheat area is about 12.5%, whereas it occupies 12 % share in the total world wheat production. It constitutes the staple food of the people (http:// Directorate of wheat research 2013-14)

Grain yield is a sum total of the several component characters that together will give the overall yield in a crop. Grafius (1964) suggested that the selection for yield *per se* may not be effective as it is a function of the various component plant characters. Moreover, genes for yield *per se* may be absent but genes may be present for its components. Also, since all the characters are correlated, the change in one character brings about a series of changes in the other characters also. Therefore direct selection of characters correlated to yield may enable an indirect selection for higher yield. Thus to bring about a desirable change in yield or other character a proper understanding of the associations among the yield and yield contributing character is a must. This will help in selection of traits associated with highest expression of yield and simultaneously improvement of one character without sacrificing much on the other character. If the association is positive it will accelerate the rate of genetic progress, while if the correlation is negative it will retard the genetic progress. The observed correlation is a function of linkage of genes determining the two characters. However it may also arise as a result of plieotropy and therefore it is the multiplicative interaction of yield and yield contributing characters that result in the ultimate yield. Hence, it becomes mandatory to have information on the association between different characters, and their relative contribution to the yield for developing a high yielding variety. Large spectrum genetic variability in segregating populations depends on the level of genetic diversity among genotypes offer better scope for selection, (Burton, 1952). Heritability estimates can anticipate improvement by selection of useful characters (Lush, 1949**).**

Correlation coefficient analysis measures the mutual relationship between various plant characters. It helps to determine the component character on which selection can be made for genetic improvement. Correlation studies would provide reliable information on nature, extent and the direction of the selection. Correlation studies permit only a measure of relationship between two traits in order to improve the yield potential without sacrificing the special quality features, (Snedecor and Cochran, 1967). The main objective of this study is to investigate genetic variability, heritability, genetic gain and correlation co-efficient of recombinant inbred lines (RILs) under drought condition.

Three heat tolerant lines of wheat *viz*., K 9162, K 8962 and K9533 were taken as male parent and crossed with AAI-12 female. The experiment was laid out at center of the Department of Genetics and Plant Breeding, Sam Higginnbottom Institute of Agriculture Technology and Sciences, Allahabad. F_1's and F_2's were raised and evaluated but due to lack of desirable plant types in the F_2 progenies of cross AAI-12 x K 9533 were discarded. Selection were made among the F_2 progenies of AAI-12 x K-9162 and AAI-12 x K-8962. Selection for cross derivatives was carried out mainly on earliness, grain yield, number of tillers, spike length, spike weight, grains per spike and heat tolerant characters like canopy temperature depression, membrane stability and days to maturity. From the F_3 generation and onwards, disruptive seasonal selection was practiced up to F_6 generation among the early selected lines of the said cross derivatives.

Crop was raised in two contrasting seasons that is in the normal season during *Rabi* (November-December to April-May) as winter crop and during off season (June-July to October) as summer wheat. Finally, 20 uniform RILs were developed. *viz.* ,RLW-1, RLW-2, RLW-3, RLW-4, RLW-5, RLW-6, RLW-7, RLW-8, RLW-9, RLW-10, RLW-11, RLW-12, RLW-13, RLW-14, RLW-15, RLW-16, RLW-17, RLW-18, RLW-19, RLW-20, respectively. The experiment was laid out in randomized block design (RBD) with three replications. Standard agronomic practices and plant protection measures were adopted as per schedule. Observations were recorded on five randomly selected plants per replication for days to 50% heading, measured by the number of days taken from the time of sowing to the time of 50% head emergence for each treatment in each replication, flag leaf length was measured in centimeter from the collar junction of the blade and leaf sheath to the tip of blade, flag leaf width was measured in centimeter in middle part of the leaf from one margin in each of the randomly selected flag leaf, plant height was measured in centimetre from the base of the plant to the top of the largest spike bearing tiller at the time of physiological maturity, total number of tillers in each of the five randomly selected plants were counted and averaged. The estimation of chlorophyll was done by using dimethyl sulphoxide (DMSO) extraction procedure, flag leaves were collected at random from each plot during grain filling period and chopped into fine pieces, 50 mg samples from these chopped leaves were added in replicated tubes each containing 10 ml DMSO, tubes containing leaf pieces and DMSO incubated at 65^0 C for 3 hr. in an oven, after complete extraction a clear supernatants were used for measuring the absorbance with the help of a spectrophotometer against DMSO blank. The chlorophyll a, chlorophyll b and total chlorophyll content were calculated according to the formula given below on mg g^{-1} fresh weight of leaf tissue basis (Hiscox and Israelstam, 1979).

Canopy temperature (^{0}C) of plant was recorded using infrared thermometer, membrane thermo stability (%) test was carried out to screen for high temperature tolerant genotypes of wheat based on the percentage electrolyte leakage in flag leaves during anthesis stage, spike length was measured in centimeter, days to maturity was recorded by counting number of days required from the date of sowing to the date of physiological maturity, grain filling period were recorded by number of days taken from the 50% flowering to the date of physiological maturity, weight per spike (g), grains per spike (g), test weight(g) and grain yield/plant (g) were recorded. The data were subjected to Burton statistics to measure the phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). Heritability (h^2) was worked out by using formula suggested by Lush (1949) and Burton and Devane (1953). The genetic advance in terms of the expected genetic gains was worked out by using the formula suggested by (Johnson *et al.* 1955). Simple correlation co-efficient computed to determine the association among all the yield contributing characters. The significance of correlation co-efficient (r) was tested by comparing with't' value at (n-2) degree of freedom (Snedecor and Cochran, 1967), using windowstat version 8.5 software.

The mean sum of squares values for sixteen quantitative characters are given in Table 1. The mean sum of squares due to genotypes was significant for all the sixteen characters. The significant difference among the genotypes for all the characters under study suggested that there was ample scope for selection of promising recombinant inbred lines (RIL) for yield improvement. Similar finding was observed by Narjesi *et al.* (2010).

On the basis of *per se* performance for grain yield per plant genotype RLW3, 7, 13, 5 and 15 were found promising as they showed high value for grain yield and its components of wheat. Estimates of genetic parameters for different quantitative and physiological traits in RILs of wheat are presented in Table 2. The higher magnitude of Genotypic coefficient of variation (GCV) and Phenotypic coefficient of variation (PCV) were recorded for canopy of temperature depressions, chlorophyll content, membrane stability suggesting sufficient variability and thus scope for genetic improvement through selecting for these traits. Relatively low magnitudinal difference was observed between GCV and PCV for all the traits studied. This indicated less environmental influence on the expression of all the attributes. Mukherjee *et al.* (2008) observed the PCV values higher than GCV values for different quantitative character in wheat.

The Heritability estimates coupled with expected genetic advance indicate the mode of gene action in the expression of traits, which helps in choosing an appropriate breeding methodology. High heritability along with moderate genetic advance was registered for plant height, grain filling period, grains per spike, and test weight suggesting predominance of additive gene action in the expression of these traits. Therefore these characters can be improved by mass selection and other breeding methods based on progeny testing. Similar results were reported by Gupta and Verma (2000) for days to 50% flowering and Farzamipour *et al* (2013) for 1000 grain weight, flag leaf length, days to heading and grain yield. Moderate genetic advance was observed for most of traits, suggesting the feasibility of selection among the RILs under investigation. However, character like days to 50% heading, days to 50% flowering and days to maturity, possessed high heritability with low genetic advance, suggesting non-additive gene action of such characters and selection for these traits may not be rewarding. Similar results were reported by Panwar and Singh (2000) for flag leaf area, grain yield, spike length and harvest index in wheat. Whereas, characters like canopy temperature depression, chlorophyll content, membrane stability, flag leaf length and yield per plant, possessed high heritability accompanied by high genetic advance percent mean, indicating additive gene action of these traits.

The correlation co-efficients between different characters obtained in the present study have been summarised in Table 3. It was found that the grain yield per plant showed positive significant correlation with number of grains per spike (0.67), spike weight (0.65), spike length (0.63), canopy temperature depression (0.50), number of tillers per plant (0.46), grain filling period (0.46) and chlorophyll content (0.36) indicating strong association with yield. Therefore, by increasing the value of these components traits, yield may easily pushed up suggesting the selection for these characters will be useful in improving seed yield. These results are in agreement with the work of Ajmal *et al.* (2009), Khan *et al.* (2010), Zafarnaderi *et al.* (2013). The correlation showed negative significant association with plant height (-0.31**), negative and significant association indicates that selection on the basis of these characters will not be beneficial as increase in one character will decrease the other. While the positive but non-significant correlation was observed with membrane stability (0.24) and days to maturity (0.20). Negative non- significant association with yield was observed for days to 50% heading (-0.10), flag leaf length (-0.10), flag leaf width (-0.15) and days to 50% flowering (-0.15). Test weight showed positive significant association with grain yield per plant (0.68), grains per spike (0.62), spike length (0.62), spike weight (0.50), number of tillers per plant (0.45). Days to 50% heading showed positive significant association with days to 50% flowering (0.94), days to maturity (0.74) and the plant height (0.54). Days to 50% flowering showed positive significant correlation with days to maturity (0.72), and plant height (0.52). Tillers per plant showed positive significant correlation with yield per plant (0.46), and test weight (0.45), spike length (0.44), spike weight (0.40), number of grains per spike (0.40), canopy temperature depression (0.35). Spike length showed positive significant association with grain yield per plant (0.63), test weight (0.62), grains per spike (0.59), grain filling period (0.52), spike weight per spike(0.51). Chlorophyll content showed positive significant association with the character like grains per spike (0.50), spike weight (0.43), grain filling period (0.42), test weight (0.37) yield per plant (0.36).

Present investigation highlighted the differential performance of the newly developed RILs. Six RILs viz, RLW-3 RLW-7, RLW-13, RLW-5 and RLW-15 showed promising performance, therefore they may be useful for constitution of new temperature tolerant wheat variety. Spike length, spike weight, number of tillers per plant, grains per spike, grain filling period and test weight were the prime yield contributing characters. These characters are significantly and positively correlated with yield, therefore their direct selection would be effective for yield improvement in wheat.

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Table 1. Analysis of variance for different quantitative and physiological traits in RILs of wheat

Characters	Mean Sum of Squares		
	Replications (df= 2)	Treatments (df= 21)	Error (df= 42)
Days to 50% heading	1.69	25.77**	0.69
Days to 50% flowering	2.86	30.32**	1.10
Flag leaf length (cm)	0.59	46.03**	4.02
Flag leaf width (cm)	0.02	0.12**	0.03
Plant height (cm)	7.46	31.88**	6.17
Tillers/ Plant	4.19	6.17**	1.83
Spike Length (cm)	0.02	1.42**	0.38
Chlorophyll Content (mg/g)	0.01	1.29**	0.08
Membrane Stability	2.49	173.78**	9.87
Canopy Temperature Depression(^{0}C)	0.37	2.40**	0.14
Days to Maturity	0.56	48.04**	2.05
Grain Filling Period	3.31	24.02**	1.17
Spike Weight/spike (g)	0.01	0.39**	0.11
Grains/ Spike	3.46	23.87**	2.89
Yield/ Plant (g)	1.80	7.65**	0.78
Test Weight (g)	0.13	22.75**	2.17

**Significant at p = 0.01

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Table 2.Estimates of genetic parameters for different quantitative and physiological traits in RILs of wheat

Character	VG	VP	GCV (%)	PCV (%)	h^2 bs (%)	GA	GA as % mean	Range Lowest	Range Highest	Mean
Days to 50% Heading	8.36	9.06	4.11	4.28	92	5.72	8.14	65.67	75.33	70.30
Days to 50% flowering	9.74	10.84	4.16	4.39	90	6.09	8.13	70.00	81.00	74.95
Flag leaf length (cm)	14.00	18.03	12.27	13.93	78	6.79	22.28	23.94	38.43	30.49
Flag leaf width (cm)	0.03	0.06	10.01	14.09	50	0.26	14.63	1.30	2.14	1.75
Plant height (cm)	41.90	48.08	6.76	7.24	87	12.45	13.00	85.73	105.83	95.80
No. Tillers/ Plant	1.45	3.28	12.18	18.33	44	1.65	16.67	5.33	12.62	9.88
Spike length (cm)	0.34	0.73	5.43	7.92	47	0.83	7.67	9.95	12.62	10.82
Chlorophyll Content(mg/g)	0.40	0.49	22.02	24.33	82	1.18	41.08	1.65	4.05	2.88
Membrane Stability	54.64	64.51	18.69	20.31	85	14.01	35.43	25.58	51.05	39.55
Canopy Temperature Depression (^{0}C)	0.75	0.90	27.83	30.47	83	1.63	52.35	2.05	5.18	3.12
Days to Maturity (days)	15.33	17.38	3.55	3.78	88	7.57	6.86	105.00	121.00	110.44
Grain Filling Period	7.62	8.79	7.77	8.35	87	5.29	14.91	31.00	42.00	35.50
Spike Weight/spike (g)	0.09	0.21	13.05	19.78	43	0.41	17.72	1.73	3.03	2.32
Grains/ Spike(g)	6.99	9.89	6.96	8.28	71	4.58	12.06	34.00	44.00	37.97
Grain yield/ Plant (g)	2.29	3.07	11.72	13.57	75	2.69	20.85	10.79	15.96	12.92
Test Weight (g)	6.86	9.03	7.45	8.55	76	4.70	13.38	31.36	40.83	35.14

Legends:- VP= Phenotypic variance VG= Genotypic variance
GCV= Genotypic coefficient of variation h^2 = Heritability
PCV= Phenotypic coefficient of variation GA= Genetic advance

Table 3. Simple correlation coefficient for different quantitative characters with grain yield in RILs of wheat

character	Days to 50% Flowering	Flag Leaf Length (cm)	Flag Leaf Width (cm)	Plant Height (cm)	Tillers/ Plant	Spike Length (cm)	Chlorophyll Content mg/g)	Membrane Stability	CanopyTemperature Depression (^{0}C)	Days to Maturity	Grain Filling Period (days)	Spike Weight (g)	Grains /Spike	Yield/ Plant (g)	Test Weight (g)
Days to 50% Heading	0.94**	-0.34**	0.10	0.54**	-0.004	0.05	0.01	-0.56**	-0.20	0.74**	-0.02	0.19	0.08	-0.10	0.02
Days to 50% flowering	1.00	-0.26*	0.15	0.52**	0.07	0.01	-0.01	-0.64**	0.17	-0.72**	-0.10	0.15	0.05	-0.15	0.05
Flag leaf length (cm)		1.00	-0.47**	-0.14	-0.04	-0.03	0.10	0.33**	0.20	-0.37**	-0.22	-0.17	-0.06	-0.15	0.02
Flag leaf width (cm)			0.10	-0.08	0.04	-0.07	-0.01	-0.17	-0.24**	0.09	-0.03	0.025	0.08	-0.10	0.001
Plant height (cm)				1.00	-0.14	-0.22	0.17	-0.33**	-0.15	0.30*	-0.14	-0.01	-0.09	-0.31*	-0.26
No. Tillers/ Plant					1.00	0.44**	0.20	-0.02	0.35**	0.16	0.15	0.40**	0.40**	0.46**	0.45**
Spike length (cm)						1.00	0.50**	0.14	0.41**	0.37**	0.52**	0.51**	0.59**	0.63**	0.62**
Chlorophyll Content(mg/g)							1.00	0.24	0.28**	0.27*	0.42**	0.43**	0.50**	0.36**	0.37**
Membrane Stability								1.00	0.30**	-0.47**	0.07	-0.05	0.03	0.24	0.16
CanopyTemperature Depression (^{0}C)									1.00	0.01	0.22	0.43**	0.49**	0.50**	0.39**
Days to Maturity (days)										1.00	0.62**	0.44**	0.46**	0.20	0.33**
Grain Filling Period											1.00	0.45**	0.61**	0.46**	0.42**
Spike Weight/spike (g)												1.00	0.56**	0.65**	0.50**
Grains/ Spike(g)													1.00	0.67**	0.62
Grain yield/ Plant (g)														1.00	0.68**

*, ** Significant at 5% and 1% levels respectively