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CHOICE OF ADVANCE HETEROGENEOUS POPULATION FOR WHEAT (*TRITICUM AESTIVUM* L.) IMPROVEMENT

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ABSTRACT
The present study was aimed to estimate the extent of genetic variability for grain yield & its components, genetic association, path coefficient analysis and selection index in 60 genotypes of wheat. High values of GCV and PCV were observed for disease reaction to leaf blight, number of effective tillers per plant, flag leaf area and grain yield per plant, respectively. High heritability coupled with high genetic advance were recorded for flag leaf area and disease reaction to leaf blight indicating that these characters are governed by additive gene effects and directional selection for these traits would be more effective. Correlation and path analysis studies revealed that number of effective tillers per plant exhibited positive and strong association and maximum positive direct effect on grain yield. Therefore, while imparting the selection in wheat the character number of effective tillers per plant must be given preference. Selection of heterogeneous population in wheat based on visual observation for different quantitative traits is less rewarding. In this context, selection of superior genotypes by assigning ranks to each genotypes for various quantitative traits followed by rank correlation was estimated and on the basis of yield and its component characters, PBW466-97, K8706-59, RW3501-53, RW3604-39 and RW3502-98 were found to be top ranking genotypes respectively.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the world's most important crop that excel all other, cereal crops both in area and production, thereby providing about 20.0 percent of total food calories for the people of the world. India is the second largest producer of wheat in the world, with production of 95.91 million tonnes in 2013-14 (as per the 4th advance estimate of the Directorate of Economics and Statistics, Govt. of India). Since 2013, India has struggled to match the record production figure and thus faces a critical challenges in maintaining food security in the face of its growing population. The current major challenges facing future wheat production are wide gap between the potential and harvested yield (around 2.5t/ha), increasing heat stress, a growing threat of new virulence of diseases, dwindling water supplies for irrigation and demand for better quality wheat (Joshi *et al.*, 2007). Therefore, the breeding programme of wheat under such situation would lead to increased productivity at national level. According to Dudley and Moll (1969) a plant breeding programme can be divided into three stages viz. (i) building up a pool of variable germplasm, (ii) selection of individual from the pool, and (iii) utilization of selected individuals to evolve a superior variety.

A knowledge of genetic variability associated with each yield components, the interrelationship and effect (direct and indirect) among yield components is essential pre-requisite for a successful hybridization aimed at producing superior high yielding progenies. The selection of parents become more difficult if the improvement is made for a polygenetically controlled complex trait like grain yield. Since, efficient selection of genetically superior individuals requires adequate phenotypic variance in the base population and sufficient high heritability (Nukasani, *et al*, 2013). Correlation studies along with path analysis provide a better understanding of the association of different characters with grain yield. Correlation is useful in disclosing the magnitude and direction of the relationship between various yield contributing traits and yield (Kumar *et al.*, 2013). While, path coefficient (or) standardized partial regression coefficient their measures the direct effect of a predictor variable upon its response variable and the second component being the indirect effects of a predictor variable (Dewey and Lu, 1959).

Therefore, efforts were made on eight different segregating populations each with seven progenies and four standard checks of wheat to study the extent of variability, heritability and possible amount of genetic gain expected to occur during the selection for yield improvement. Similarly, an attempt was made to analyze grain yield and its contributing traits of wheat by correlation and path coefficient analyse.

MATERIALS AND METHODS

The experimental material comprised of eight different F_6 populations each with seven progenies and four standard check of common bread wheat grown in a compact family block design with three replications at the field experimentation centre of Pusa Farm, Department of Plant Breeding and Genetics, Rajendra Agricultural University, Pusa, Samastipur (Bihar). Each treatment consisted of a single row

1.5m row spaced 23cm apart. The total area of the plot including path was 89.7m^2. All the recommended package of practices for wheat was followed to raise a healthy crop. Data were recorded on five randomly and competitive plants of each genotype from each replications for nine quantitative characters viz, days to 50% flowering, plant height (cm), numbers of effective tillers per plant, flag leaf area(cm^2), ear length(cm), numbers of spikelet per spikes, harvest index(%), 1000 grain weight(gm) and grain yield per plant(gm). Disease reaction to leaf blight was recorded visually on percentage of flag leaf area covered with blight symptom at matured stage. The data was transformed by the arc Sin root square percentage transformation (Bliss, 1937). Heritability (broadsense) was estimated according to Hanson *et al* (1956). Phenotypic and genotypic coefficients of variation were estimated as per Burton (1952). Genetic advance as percent of mean was estimated according to Johnson *et al* (1955). Correlations were worked out according to the procedure of Weber and Moorthy (1952). The partioning of genotypic correlation coefficient of traits into direct and indirect effects was carried out using the procedure suggested by Dewey and Lu (1959). Formulation of selection indices were carried out in ordered to identified superior genotypes as per Spearman's coefficient of rank correlation.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the ten characters under study (Table 1), suggested that the genotypes were genetically divergent. This indicates that there is ample scope for selection of promising lines from the present gene pool for yields and its components. Thus, it indicates ample scope for selection for different quantitative characters for wheat improvement. Asif *et al*. (2004) and Kumar *et al* (2009) also reported considerable genetic variability for grain yield and its component characters in wheat. Genotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, heritability (broadsense), genetic advance and genetic advance as percent of mean for ten characters are presented in Table 2. The estimates of phenotypic coefficient of variation (PCV) were higher than those of genotypic coefficient of variation (GCV) for all the traits indicating environmental factors influencing the characters. The estimates of GCV and PCV were moderate for all the characters and highest PCV and GCV were recorded for disease reaction to leaf blight followed by number of effective tillers per plant, flag leaf area and grain yield per plant, indicating the presence of ample variation for these traits in the present material. In the present investigation high heritability were recorded for the traits viz., flag leaf area followed by disease reaction to leaf blight, 1000-grain weight, plant height, harvest index , days to 50% flowering, number of spikelets per spike, ear length & number of effective tillers per plant. Sachan and Singh (2003), Chandra *et al* (2010), Kumar *et al* (2013), Arya *et al* (2013) and Yadawad *et al* (2015) also reported high heritability estimates for grain yield per plant, number of seeds per spike, plant height, 1000 seed weight and number of tillers per plant. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone (Johnson *et al*.,1955). High heritability accompanied with high genetic advance as percent of mean for traits, flag leaf area and disease reaction to leaf blight. It indicates that most likely the heritability is due to additive gene effect and

Table 1: Analysis of variance for ten quantitative characters of wheat genotypes

SI. NO.	Characters	Mean Sum of Squares Replication(d. f. = 2)	Treatment (d .f. = 59)	Error (d. f. = 118)
1.	Days to 50% flowering	30.68	49.83**	3.02
2.	Plant height (cm)	35.37	110.31**	5.24
3.	No. of effective tillers per plant	0.62	3.65**	0.51
4.	Flag leaf area(cm^2)	2.31	79.17**	1.39
5.	Ear length(cm)	2.10	1.89**	0.23
6.	No. of spikelets/ spike	7.06	6.16**	0.63
7.	Harvest index	2.90	32.87**	1.79
8.	1000-grain weight(g)	2.84	28.17**	1.31
9.	Grain yield per plant(g)	0.56	7.85**	1.18
10.	Disease reaction to leaf blight	45.91	299.12**	11.62

Table 2: Estimates of genetic parameters for ten quantitative characters in wheat genotypes

SI. NO.	Characters	G. V.	P. V.	G.C.V.	P.C.V.	H (%)	G.A.	GA as of % of mean
1.	Days to 50% flowering	15.60	18.62	4.96	5.42	83.78	7.45	9.35
2.	Plant height (cm)	35.02	40.26	6.35	6.81	86.98	11.37	12.20
3.	No. of effective tillers per plant	1.04	1.55	13.91	16.98	67.10	1.72	23.47
4.	Flag leaf area(cm^2)	25.92	27.32	16.22	16.65	94.88	10.22	32.56
5.	Ear length(cm)	0.55	0.78	6.73	8.01	70.52	1.29	11.65
6.	No. of spike lets/ spike	1.84	2.47	6.60	7.65	74.49	2.41	11.73
7.	Harvest index	10.36	12.15	7.33	7.94	85.27	6.12	13.93
8.	1000-grain weight(g)	8.95	10.26	8.21	8.79	87.23	5.76	15.82
9.	Grain yield per plant(g)	2.22	3.41	8.65	10.72	65.10	2.48	14.39
10.	Disease reaction to leaf blight	95.83	107.45	55.78	59.06	89.19	19.04	108.49

Table 3: Phenotypic and Genotypic correlation coefficients between yield and its component characters in wheat genotypes

SI. n.	Characters	Plant height (cm)	No. of effective tillers/ Plant	Disease reaction to leaf blight	Flag leaf area (cm^2)	Ear Length (cm)	No. of spiklets per spike	1000-grain weight (g)	Harvest Index (%)	Grain yield / plant (g)
1.	Days to 50% flowering	-0.05(-0.02)	-0.12(-0.12)	-0.65**(-0.71)	0.50** (0.55)	-0.10(-0.11)	-0.38**(-0.44)	-0.22(-0.27)	-0.29*(-0.35)	0.03(-0.008)
2.	Plant height(cm)		-0.10 (-0.16)	-0.14(-0.18)	0.03 (0.03)	0.41**(0.53)	-0.007(-0.023)	-0.05(-0.06)	-0.17(-0.20)	-0.04(-0.03)
3.	No. of effective tillers per plant			0.12(0.15)	-0.16(-0.23)	-0.09(-0.28)	0.08(0.01)	0.27*(0.29)	-0.12(-0.10)	0.38**(0.48)
4.	Disease reaction to leaf blight				-0.49**(-0.52)	0.11(0.13)	0.25*(0.31)	0.28*(0.30)	0.30*(0.37)	-0.18(-0.20)
5.	Flag leaf area(cm^2)					0.32**(0.38)	0.15(0.15)	0.01(-0.0002)	-0.39**(-0.44)	0.06(0.07)
6.	Ear length(cm)						0.58**(0.58)	-0.10(-0.15)	0.02(0.04)	0.08(0.10)
7.	No. of spiklets / spike							-0.07(-0.11)	0.15(0.20)	0.05(0.11)
8.	1000-grain weight(g)								-0.21(-0.27)	0.02(0.06)
9.	Harvest index									0.03(0.07)

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

Table 4: Direct and indirect phenotypic effect of different characters towards grain yield in wheat

SI.n.	Characters	No. of effective tillers/ Plant	Disease reaction to leaf blight	Ear Length (cm)	No. of spiklets / spike	1000-grain weight(g)	Harvest Index	Correlation with grain yield / Plant
1.	No. of effective tillers per plant	0.450	-0.039	-0.016	-0.003	0.014	-0.024	0.382**
2.	Disease reaction to leaf blight	0.056	-0.318	0.020	-0.009	0.015	0.059	-0.179
3.	Ear length(cm)	-0.041	-0.036	0.179	-0.020	-0.006	0.004	0.079
4.	No. of spiklets / spike	0.036	-0.080	0.103	-0.036	-0.004	0.029	0.049
5.	1000-grain weight (g)	0.123	-0.088	-0.019	-0.003	0.053	-0.041	0.025
6.	Harvest Index	-0.055	-0.096	0.004	-0.006	-0.011	0.192	0.028

The residual effect = 0.867; *, ** Significant at 5% and 1% levels of significance, respectively

selection may be effective in early segregating generation for these traits. Similar results have been reported by Sharma and Gray (2002). High heritability coupled with moderate genetic advance were observed for 1000-grain weight, harvest index, plant height, days to 50% flowering. The selection for these characters may also be effective owing to considerable presence of additive gene action. Number of effective tillers per plant, ear length, number of spikelets per spike and grain yield per plant had low heritability coupled with low genetic advance indicates non-additive gene effects. Therefore, these seem a limited scope for improvement in these traits.

The phenotypic and genotypic phenotypic correlations between grain yield and its component characters are presented in Table 3. Grain yield per plant showed highly significant and positive genotypic correlation with number of effective tillers per plant. Similar result was reported by Paroda *et al.* (1974), Singh *et al.* (1989) and Nirala (1995). Days to 50% flowering showed highly significant and positive correlation with flag leaf area and positive correlation with flag leaf area and highly significant and negative correlation with disease reaction to leaf blight and number of spikelets per spike with significant negative correlation with harvest index. Plant height was highly significant positive correlation with ear length while, number of effective tillers per plant was significantly and positively correlated with 1000-grain weight. Disease reaction to leaf blight had significant positive correlation with number of spikelets per spike, 1000-grain weight and harvest index while, highly significant negative correlation with flag leaf area. Flag leaf area showed highly significant positive association with ear length and highly significant negative correlation with harvest index. Ear length showed highly significant positive interrelationship with number of spikelets per spike.

The path coefficient analysis (Table 4) provides an effective way of finding out of direct and indirect source of correlation. The path analysis reveals that the number of effective tillers per plant exhibited the highest positive direct effect on grain yield per plant, whereas, disease reaction to leaf blight had maximum negative direct effect. Similar results were reported by Nirala and Jha (1997). Direct positive effect of number of spikelets per spike, harvest index and 1000-grain weight was observed for grain yield per plant. These findings are in accordance with the result of Mandal *et al* (1991) and Nirala and Jha (1997). Path analysis suggested that number of effective tillers per plant and disease reaction to leaf blight were the important characters which may be given due importance in formulating selection index.

Yield being a complex quantitative character, is highly influenced by the environmental fluctuations. Hence, it may not be effective to select the grain yield directly. Martynov and Krupnov (1982) indicated that selection based on index was more efficient than direct selection. Therefore, selection criteria based on yield as well as its components would be more helpful in selecting desirable genotypes. The knowledge of relationship between yield components and relative weightage that should be given to different components to obtain maximum gain, therefore important in selection programme.

In multiple regression analysis, the effect of more than one independent variables upon the dependent variables is worked out, so that the relationship of the dependent variable with other variables, which are independent may be used to estimate the dependent variable for given values of the independent variables. The efficiency of multiple regression equation in the present study were observed to be $r^2(1) = 42.40$ and $r^2(2) = 30.90$ in case of nine characters (days to 50% flowering, plant height, numbers of effective tillers per

Table 5: Relative ranking and selection score of different genotypes for yield in wheat based on selection index of all component characters

Sl. No.	Genotypes	Selection Score	Ranking
1.	K9705-99	17.855	17
2.	K9705-51	18.074	10
3.	K9705-53	16.746	46
4.	K9705-54	17.729	20
5.	K9705-65	14.966	59
6.	K9705-82	16.708	47
7.	K9705-50	16.123	53
8.	NW1073-31	17.870	15
9.	NW1073-51	17.359	26
10.	NW1073-59	15.778	55
11.	NW1073-80	17.095	34
12.	NW1073-82	16.844	43
13.	NW1073-60	17.122	33
14.	NW1073-81	17.163	30
15.	RW3501-3	16.876	41
16.	RW3501-95	17.620	21
17.	RW3501-66	16.498	49
18.	RW3501-53	19.036	3
19.	RW3501-57	15.478	58
20.	RW3501-61	16.961	39
21.	RW3501-78	18.288	7
22.	PBW466-26	17.009	37
23.	PBW466-41	17.819	18
24.	PBW466-88	16.212	52
25.	PBW466-97	19.309	1
26.	PBW466-27	16.934	40
27.	PBW466-61	16.818	45
28	PBW466-2	16.838	44
29.	RW3502- 54	17.187	29
30.	RW3502-69	17.926	13
31	RW3502-75	16.426	50
32.	RW3502-81	17.741	19
33.	RW3502- 82	17.232	28
34.	RW3502-87	18.631	6
35.	RW3502-98	18.762	5
36.	RW3603-7	17.941	12
37.	RW3603-1	17.458	23
38.	RW3603-99	17.608	22
39.	RW3603-24	16.651	48
40.	RW3603-29	17.139	31
41.	RW3603-33	15.485	57
42.	RW3603- 40	15.987	54
43.	RW3604-23	17.271	27
44.	RW3604-21	17.017	35
45.	RW3604-4	17.120	32
46.	RW3604-61	17.016	36
47.	RW3604-63	18.255	9
48.	RW3604-39	18.771	4
49.	RW3604- 90	16.969	38
50.	K9706-56	17.867	16
51.	K9706-58	18.051	11
52.	K9706-29	17.877	14
53.	K9706-41	15.667	56
54.	K9706-28	17.432	24
55.	K9706-59	19.113	2
56.	K9706-15	17.363	25
57.	HP1731(C)	18.267	8
58.	HP1761(C)	16.295	51
59.	HP1744(C)	13.366	60
60.	K9107(C)	16.874	42

Characters involved: Days to 50% flowering, Plant height, Number of effective tillers per; Plant, Disease reaction to leaf blight, Flag leaf area, Ear length, Number; of spikelets/spike, 1000-grain weight & harvest index.

Table 6: Relative ranking and selection score of different genotypes for yield in wheat based on selection index of three component characters

Sl. No.	Genotypes	Selection Score	Ranking
1.	K9705-99	17.935	12
2.	K9705-51	18.092	8
3.	K9705-53	16.826	44
4.	K9705-54	17.678	23
5.	K9705-65	15.918	57
6.	K9705-82	16.005	55
7.	K9705-50	15.951	56
8.	NW1073-31	18.010	10
9.	NW1073-51	16.867	42
10.	NW1073-59	16.510	51
11.	NW1073-80	17.521	25
12.	NW1073-82	17.389	30
13.	NW1073-60	17.865	17
14.	NW1073-81	16.936	39
15.	RW3501-3	16.661	49
16.	RW3501-95	17.874	15
17.	RW3501-66	16.933	40
18.	RW3501-53	18.215	5
19.	RW3501-57	15.623	58
20.	RW3501-61	16.965	38
21.	RW3501-78	17.739	20
22.	PBW466-26	17.498	26
23.	PBW466-41	17.824	18
24.	PBW466-88	17.133	33
25.	PBW466-97	19.800	1
26.	PBW466-27	18.090	9
27.	PBW466-61	17.264	31
28	PBW466-2	17.103	35
29.	RW3502- 54	16.345	52
30.	RW3502-69	17.873	16
31	RW3502-75	16.569	50
32.	RW3502-81	17.821	19
33.	RW3502- 82	17.932	13
34.	RW3502-87	18.386	3
35.	RW3502-98	18.481	2
36.	RW3603-7	17.959	11
37.	RW3603-1	17.109	34
38.	RW3603-99	17.614	24
39.	RW3603-24	17.686	22
40.	RW3603-29	17.011	36
41.	RW3603-33	16.052	54
42.	RW3603- 40	16.255	53
43.	RW3604-23	17.435	27
44.	RW3604-21	16.830	43
45.	RW3604-4	16.815	45
46.	RW3604-61	17.393	29
47.	RW3604-63	18.230	4
48.	RW3604-39	18.103	7
49.	RW3604- 90	16.895	41
50.	K9706-56	17.416	28
51.	K9706-58	17.725	21
52.	K9706-29	17.134	32
53.	K9706-41	15.460	59
54.	K9706-28	16.774	47
55.	K9706-59	18.175	6
56.	K9706-15	16.994	37
57.	HP1731(C)	16.775	46
58.	HP1761(C)	16.748	48
59.	HP1744(C)	13.995	60
60.	K9107(C)	17.891	14

$Y = 7.147 + (0.772) X_1 - (0.048) X_2 + (0.476) X_3$; Characters involved: Number of effective tillers per, Disease reaction to leaf blight & ear; length were considered as X_1, X_2, X_3 respectively.

plant, disease reaction to leaf blight, flag leaf area, ear length, number of spikelets per spike, 1000-grain weight and harvest index) and three characters(numbers of effective tillers per plant, disease reaction to leaf blight and ear length), respectively. This indicates that efficiency of selection remained almost unaffected even after deleting six characters in the function. Rank correlation between ranking of genotypes based on both selection indices remained strong indicating selection index based on three characters identified genotypes quite closer to that based on all nine characters. Therefore, selection indices based on number of effective tillers, disease reaction to leaf blight and ear length may be given weightage in selection programme.

On the basis of all nine yield component characters, PBW 466-97, K9706-59, RW 3501-53, RW 3604-39 and RW 3502-98 were found to be top ranking genotypes, respectively. However, on the basis of three yield component characters, PBW 466-97, RW 3502-98, RW 3502-87, RW 3604-63 and RW 3501-53 were found to be top ranking genotypes, respectively.

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