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RESEARCH ARTICLE

GENETIC DIVERSITY FOR YIELD AND SOME QUALITY TRAITS IN A LARGE COLLECTION OF WHEAT GERMPLASM

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ABSTRACT

The present investigation was conducted to estimate the extent of genetic divergence among wheat accessions through hierarchical cluster analysis to formulate genetically diverse groups to facilitate choice of parents for hybridization. Based on adjusted mean of the accessions for yield *per se* the two hundred ninety five germplasm accessions surpassing lowest check yield were selected and analyzed for genetic diversity in an augmented block design under timely sown and late sown irrigated conditions. Divergence analysis was carried out using hierarchical cluster analysis method based on Euclidean distance. The 400 germplasm accessions were screened for cluster analysis on the basis of lowest check yield. The selected 299 germplasm accessions (including checks) were grouped into 4, 3, 5 and 6 clusters. The pattern of distribution of these accessions in various clusters showed that there was considerable genetic diversity in the germplasm. Based on genetic diversity, IC397955, IC416050, IC416010, IC393124, IC416005, IC372646, IC396579, IC279320, IC321906 and IC396579 accessions were screened as donors for more tillers per meter. Further, with respect to high grain yield per plot IC415945, IC416055, IC415979, IC397821, IC416129, IC416062, IC415995 IC398144, IC416197 and IC415979 accessions were identified as donor parent for future breeding programme.

INTRODUCTION

Wheat is an important cereal crop. The central Asia is said to be the place of origin of bread wheat. It is a staple food of 36 per cent of global population in as many as 43 countries of the world providing about 20 per cent of the total calories. India is one of the major producers of wheat and ranks second after China in area and production. Wheat cultivation extends from about below Palani Hills, Tamil Nadu to about Srinagar, J & K. Hybridization followed by selection is the most preferred method during this period because selection of transgressive segregants played an important role in crop improvement especially in self–pollinated crops. Now we are self sufficient in wheat production but the increasing population of the country necessitates further increase in the production. The demand for wheat by 2020 has been projected to be between 105 to 109 m. tones (Shoran *et al*., 2005). Increase in land area is not possible beyond the limit. Therefore, improvement in productivity is a big challenge to the breeder. Therefore, a need of resorting new premises of research felt. In this context, emphasis is, now days, shifted towards choice of parents with high *per se* performance from diverse groups. Because the level of heterosis as well as selection advance in segregating generations depends upon the genetic diversity among the parents rather than geographical diversity.

To break the yield *plateau* the breeding strategies should be modified such a way to increase the efficiency of creation and identification of desirable recombinants. Selective mating between improved lines based on *per se* performance and genetic diversity to obtain better recombinants can provide a great opportunity to the breeder. Critical evaluation of the germplasm generated so far for yield components and simultaneous clustering into diverse group seems desirable for recombinant breeding to break the existing yield *plateau*. In view of above the present study was designed to estimate the extent of genetic divergence through and to formulate genetically diverse groups to facilitate choice of parents for hybridization.

MATERIALS AND METHODS

The present study was conducted at Kisan P.G. College, Simbhaoli during *rabi* 2007-08 and *rabi* 2008-09. The experimental material comprised of 400 bread wheat accessions (listed below) with eight blocks and four checks (PBW 343, Lok 1, GH 322 and Sonalika) under timely sown and late sown irrigated conditions. Experiment was conducted using augmented design as described by Petersen (1985). The plot size consists of 2 rows of 3 m length at 23 cm apart. The seed was drilled in each row at the rate of 100 kg per hectare. The N: P: K was applied at the ratio of 120: 60: 40 kg / hectare.

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Table. List of Wheat accessions used for divergence analysis through HCA

S. No.	Acc. No.	S. No.	Acc. No.	S. No.	Acc. No.	S. No.	Acc. No.
1	IC-66531	77	IC-398067	153	IC-416020	229	IC-416152
2	IC-260877	78	IC-398084	154	IC-416021	230	IC-416153
3	IC-262042	79	IC-398091	155	IC-416023	231	IC-416154
4	IC-274004	80	IC-398111	156	IC-416024	232	IC-516155
5	IC-279318	81	IC-398115	157	IC-416025	233	IC-516156
6	IC-279320	82	IC-398133	158	IC-416026	234	IC-416157
7	IC-279321	83	IC-398144	159	IC-416027	235	IC-416158
8	IC-279642	84	IC-413429	160	IC-416028	236	IC-416159
9	IC-279688	85	IC-415836	161	IC-416031	237	IC-416160
10	IC-279707	86	IC-415837	162	IC-416032	238	IC-416161
11	IC-281566	87	IC-415838	163	IC-416033	239	IC-416162
12	IC-313156	88	IC-415841	164	IC-416034	240	IC-416163
13	IC-321154	89	IC-415842	165	IC-416035	241	IC-416164
14	IC-321862	90	IC-415844	166	IC-416036	242	IC-416165
15	IC-321906	91	IC-415846	167	IC-416040	243	IC-416166
16	IC-321943	92	IC-415847	168	IC-416041	244	IC-416168
17	IC-321985	93	IC-415848	169	IC-416042	245	IC-416170
18	IC-321993	94	IC-415938	170	IC-416043	246	IC-416171
19	IC-322001	95	IC-415943	171	IC-416045	247	IC-416173
20	IC-322012	96	IC-415945	172	IC-416046	248	IC-416174
21	IC-322020	97	IC-415946	173	IC-416048	249	IC-416175
22	IC-322024	98	IC-415948	174	IC-416049	250	IC-416176
23	IC-322026	99	IC-415949	175	IC-416050	251	IC-416178
24	IC-322030	100	IC-415950	176	IC-416052	252	IC-416179
25	IC-356468	101	IC-415952	177	IC-416053	253	IC-416181
26	IC-356469	102	IC-415953	178	IC-416054	254	IC-416182
27	IC-361690	103	IC-415954	179	IC-416055	255	IC-416183
28	IC-372643	104	IC-415956	180	IC-416056	256	IC-416184
29	IC-372646	105	IC-415957	181	IC-416057	257	IC-416185
30	IC-372654	106	IC-415958	182	IC-416058	258	IC-416187
31	IC-372656	107	IC-415959	183	IC-416059	259	IC-416188
32	IC-372657	108	IC-415960	184	IC-416060	260	IC-416189
33	IC-372660	109	IC-415961	185	IC-416061	261	IC-416190
34	IC-372661	110	IC-415962	186	IC-416062	262	IC-416191
35	IC-372666	111	IC-415965	187	IC-416064	263	IC-416192
36	IC-372670	112	IC-415966	188	IC-416065	264	IC-416193
37	IC-372686	113	IC-415967	189	IC-416067	265	IC-416194
38	IC-372745	114	IC-415968	190	IC-416073	266	IC-416195
39	IC-381085	115	IC-415969	191	IC-416074	267	IC-416197
40	IC-381144	116	IC-415970	192	IC-416076	268	IC-416198
41	IC-381542	117	IC-415972	193	IC-416077	269	IC-416201
42	IC-382649	118	IC-415973	194	IC-416078	270	IC-416202
43	IC-382658	119	IC-415974	195	IC-416079	271	IC-416203
44	IC-382723	120	IC-415975	196	IC-416105	272	IC-416204
45	IC-382726	121	IC-415979	197	IC-416106	273	IC-416205
46	IC-384525	122	IC-415980	198	IC-416108	274	IC-416206
47	IC-393114	123	IC-415982	199	IC-416110	275	IC-416207
48	IC-393124	124	IC-415984	200	IC-416112	276	IC-416208
49	IC-395828	125	IC-415985	201	IC-416113	277	IC-416209
50	IC-396579	126	IC-415986	202	IC-416115	278	IC-416210
51	IC-396586	127	IC-415987	203	IC-416116	279	IC-416211
52	IC-396596	128	IC-415989	204	IC-416117	280	IC-416212
53	IC-397215	129	IC-415990	205	IC-416118	281	IC-416213
54	IC-397222	130	IC-415991	206	IC-416120	282	C-416215
55	IC-397317	131	IC-415992	207	IC-416121	283	IC-416229
56	IC-397323	132	IC-415993	208	IC-416122	284	IC-416230
57	IC-397515	133	IC-415995	209	IC-416123	285	IC-416232
58	IC-397815	134	IC-415996	210	IC-416124	286	IC-416233
59	IC-397821	135	IC-415997	211	IC-416127	287	IC-416235
60	IC-397827	136	IC-415998	212	IC-416128	288	IC-416236
61	IC-397830	137	IC-415999	213	IC-416129	289	IC-416237
62	IC-397831	138	IC-416000	214	IC-416130	290	IC-416238
63	IC-397839	139	IC-416001	215	IC-416131	291	IC-416239
64	IC-397845	140	IC-416002	216	IC-416132	292	IC-416240
65	IC-397868	141	IC-416003	217	IC-416133	293	IC-416241
66	IC-397874	142	IC-416004	218	IC-416139	294	IC-416243
67	IC-397893	143	IC-416005	219	IC-416140	295	IC-416258
68	IC-397922	144	IC-416006	220	IC-416141	296	Sonalika
69	IC-397955	145	IC-416007	221	IC-416142	297	PBW343
70	IC-397959	146	IC-416008	222	IC-416143	298	GW 322
71	IC-397983	147	IC-416009	223	IC-416144	299	LOK 1
72	IC-397989	148	IC-416010	224	IC-416145		
73	IC-397998	149	IC-416011	225	IC-416148		
74	IC-397999	150	IC-416013	226	IC-416149		
75	IC-398010	151	IC-416017	227	IC-416150		
76	IC-398060	152	IC-416019	228	IC-416151		

The observations were recorded on a sample of five plants from each plot on every accession in all the environments for plant height (cm), days to heading, number of tillers per meter row length, spike length (cm), number of spikelets per spike, number of grains per spike, thousand grain weight (g), grain yield per plot (g), hactoliter weight (hl), protein content (%), sédimentation value, gluten content. The data recorded was subjected to the analysis of variance following the procedure described by Petersen (1985) and mean performance of the accessions was adjusted for block effect accordingly.

The adjusted mean of the test entries along with the checks were subjected to genetic divergence analysis through hierarchical cluster analysis procedure described by Anderberg (1973).

RESULTS AND DISCUSSION

The knowledge of genetic divergence has been successfully utilized in different crop species for the selection of parents. In past Mahalanobis D^2 statistic has been used as a statistical tool for estimating genetic divergence for use in plant breeding programme.

Table 1. Cluster formation through HCA for 299 wheat genotypes under FYTS

Cluster	No. of Genotypes	Genotype Numbers													
I	7	54	55	57	58	194	195	197							
II	11	59	66	96	121	213	222	227	228	235	240	266			
III	192	2	3	5	6	7	8	9	10	11	14	15	16	17	18
		22	23	24	26	28	30	31	32	33	36	37	38	40	41
		42	43	45	46	47	49	60	64	65	67	68	69	71	73
		74	76	82	83	85	87	88	92	94	95	97	98	99	100
		101	103	105	107	109	110	112	113	114	115	116	117	118	119
		120	122	127	129	130	131	132	133	135	137	139	140	141	143
		146	147	148	149	151	152	154	155	156	157	158	159	161	162
		163	164	165	166	168	169	170	171	172	173	174	175	176	177
		181	182	183	184	186	188	192	193	198	199	201	204	205	207
		209	211	214	215	216	218	219	220	221	223	224	225	226	229
		230	231	232	233	234	236	237	239	241	242	243	244	245	246
		247	248	250	251	252	253	254	255	256	260	261	262	263	264
		265	266	268	272	273	274	276	277	279	280	281	282	283	285
		286	287	288	290	291	292	294	295	297	298				
IV	89	1	4	12	13	14	19	20	21	23	25	27	28	29	33
		34	35	39	44	48	50	51	52	53	56	61	62	63	70
		72	75	77	78	79	80	81	84	86	89	90	91	93	102
		104	106	108	111	125	126	134	136	138	144	145	150	153	160
		167	178	179	180	185	187	189	190	191	196	200	202	203	206
		207	208	210	212	217	238	249	257	258	259	269	270	271	275
		278	289	293	296	299									

Table 2. Cluster formation through HCA for 299 wheat genotypes under FYLS.

Cluster	No. of Genotypes	Genotype Numbers													
I	11	66	142	198	218	221	228	229	240	263	280	285			
II	17	6	96	98	99	116	121	134	148	152	155	168	174	179	180
		182	202	213											
III	271	1	2	3	4	5	7	8	9	10	11	12	13	14	15
		16	17	18	19	20	21	22	23	24	25	26	27	28	29
		30	31	32	33	34	35	36	37	38	39	40	41	42	43
		44	45	46	47	48	49	50	51	52	53	54	55	56	57
		58	59	60	61	62	63	64	65	67	68	69	70	71	72
		73	74	75	76	77	78	79	80	81	82	83	84	85	86
		87	88	89	90	91	92	93	94	95	97	100	101	102	103
		104	105	106	107	108	109	110	111	112	113	114	115	117	118
		119	120	122	123	124	125	126	127	128	129	130	131	132	133
		135	136	137	138	139	140	141	143	144	145	146	147	149	150
		151	153	154	156	157	158	159	160	161	162	163	164	165	166
		167	169	170	171	172	173	175	176	177	178	181	183	184	185
		186	187	188	189	190	191	192	193	194	195	196	197	199	200
		201	203	204	205	206	207	208	209	210	211	212	214	215	216
		217	219	220	222	223	224	225	226	227	230	231	232	233	234
		235	236	237	238	239	241	242	243	244	245	246	247	248	249
		250	251	252	253	254	255	256	257	258	259	260	261	262	264
		265	266	267	268	269	270	271	272	273	274	275	276	277	278
		279	281	282	283	284	286	287	288	289	290	291	292	293	294
		295	296	297	298	299									

Table 3. Cluster formation through HCA for 299 wheat genotypes under SYTS

z	No. of Genotypes	Genotype Numbers													
I	17	33	35	59	60	61	83	182	186	197	201	203	209	210	215
		231	262	288											
II	68	14	29	30	31	36	42	49	52	54	55	57	64	72	74
		75	80	87	91	97	99	100	105	106	113	135	138	141	153
		159	160	164	166	174	175	176	178	179	181	184	188	189	190
		194	195	200	202	204	205	211	212	213	221	222	224	235	237
		244	260	264	266	267	268	271	272	280	281	282	297		
III	3	88	94	116											
IV	55	2	6	9	10	11	17	18	24	34	37	38	41	45	48
		66	69	70	71	73	77	81	82	85	93	98	101	103	109
		111	117	127	129	131	146	157	165	171	172	216	225	226	232
		236	247	251	254	255	257	261	274	279	285	287	289	290	
V	156	1	3	4	5	7	8	12	13	15	16	19	20	21	22
		23	25	26	27	28	32	39	40	43	44	46	47	50	51
		53	56	58	62	63	65	67	68	76	78	79	84	86	89
		90	92	95	96	102	104	107	108	110	112	114	115	118	119
		120	121	122	123	124	125	126	128	130	132	133	134	136	137
		139	140	142	143	144	145	147	148	149	150	151	152	154	155
		156	158	161	162	163	167	168	169	170	173	177	180	183	185
		187	191	192	193	196	198	199	206	207	208	214	217	218	219
		220	223	227	228	229	230	233	234	238	239	240	241	242	243
		245	246	248	249	250	252	253	256	258	259	263	265	269	270
		273	275	276	277	278	283	284	286	291	292	293	294	295	296
		298	299												

Table 4. Cluster formation through HCA for 299 wheat genotypes under SYLS.

Cluster	No. of Genotypes	Genotype Numbers													
I	1	79													
II	45	18	24	48	55	58	59	63	65	69	71	76	77	81	82
		84	90	94	96	120	121	129	139	142	143	150	156	157	164
		174	175	177	179	184	203	212	221	248	249	266	267	270	272
		273	275	278											
III	159	2	6	9	12	16	20	23	25	29	30	31	32	33	34
		36	39	40	41	45	46	47	51	52	53	54	56	57	60
		61	62	64	66	70	72	73	74	75	80	83	85	86	87
		88	89	91	92	93	94	97	98	99	101	103	104	105	106
		107	108	109	111	116	117	119	122	125	126	130	132	133	134
		135	137	138	141	144	145	146	147	148	151	152	153	154	155
		158	159	160	161	163	165	166	166	168	169	170	171	172	173
		176	181	182	183	185	187	188	189	190	191	192	193	196	197
		199	200	201	202	208	211	213	214	216	217	218	220	222	223
		224	226	228	231	232	235	236	238	239	241	242	243	246	250
		254	257	259	260	262	263	264	271	276	280	281	282	285	287
		289	290	291	295	298									
IV	2	209	237												
V	62	4	5	7	11	13	14	15	17	19	22	26	27	28	35
		37	38	44	67	68	95	102	110	112	113	123	127	128	131
		136	140	149	162	195	198	204	205	206	207	210	215	219	225
		227	230	233	240	245	255	261	265	268	269	274	279	283	284
		288	292	293	296	297	299								
VI	30	1	3	8	10	21	42	43	49	50	78	100	114	115	118
		124	178	180	186	229	234	244	247	251	252	253	256	258	277
		286	294												

The use of Mahalanobis D^2 statistic becomes limited in application when a large number of entries are to be objectively evaluated in a breeding programme. Under these conditions the hierarchical Euclidean cluster analysis (Ward, 1963), a method of numerical taxonomy has been found successful as a tool for estimation of genetic divergence. Therefore, in the present study Hierarchical cluster analysis based on Euclidean distances was employed for characterizing the genetic divergence among wheat germplasm. The 400 germplasm accessions were screened for cluster analysis on the basis of lowest check yield.

The selected 299 germplasm accessions (including checks) were grouped into 4 clusters in first year timely sown (FYTS), into 3 clusters in first year late sown (FYLS), into 5 clusters in second year timely sown (SYTS) and into 6 clusters in second year late sown (SYLS). The pattern of distribution of these accessions in various clusters (Table 1-4) showed that there was considerable genetic diversity in the germplasm. In general, major clusters in the above mentioned divergence analysis contained accessions of heterogeneous parentage.

The movement of accession from one cluster to other was observed in different year and sowing conditions. This indicates the environmental effect on the expression of the accessions. Some of the accessions express better in timely sown conditions, while others in late sown conditions. Based on the movement of accession from one cluster to other due to change in time of sowing reflect the suitability of those accessions for that particular environmental conditions. This information is of immense help in identifying the probable donors of different characters in order to breed the varieties for timely or late sown conditions.

Table 5. Cluster mean for different characters of wheat genotypes under FYTS

Character	Cluster			
	I	II	III	IV
Days to heading	91.59	97.42	95.65	95.24
Plant height (cm)	98.04	95.16	95.29	95.31
Tillers per meter	97.66	110.72	104.70	96.00
Spike length (cm)	10.99	11.56	10.70	10.85
Spikelets per spike	17.53	20.11	19.43	18.68
Grains per spike	53.70	56.50	54.37	52.92
Plot yield (g)	332.92	1026.76	781.13	575.48
1000 grain weight (g)	36.82	41.66	38.80	37.43
Protein per cent	10.62	11.33	11.25	11.16
Gluten content (g)	26.87	28.63	28.28	27.80
Sedimentation value (ml)	29.63	36.28	35.77	34.55
Hectoliter weight (g)	77.47	80.06	79.42	78.54

Table 6. Cluster mean for different characters of wheat genotypes under FYLS

Character	Cluster		
	I	II	III
Days to heading	84.71	84.05	83.44
Plant height (cm)	80.96	88.24	88.58
Tillers per meter	100.19	106.97	93.52
Spike length (cm)	9.62	10.10	10.16
Spikelets per spike	17.77	18.90	18.41
Grains per spike	52.16	56.89	54.21
Plot yield (g)	218.61	551.56	509.29
1000 grain weight (g)	40.57	37.12	38.11
Protein per cent	10.99	11.09	10.97
Gluten content (g)	29.90	29.01	29.10
Sedimentation value (ml)	33.78	33.83	33.70
Hectoliter weight (g)	79.35	79.19	78.08

Table 7. Cluster mean for different characters of wheat genotypes under SYTS

Character	Cluster				
	I	II	III	IV	V
Days to heading	87.65	85.57	91.06	87.61	86.85
Plant height (cm)	85.93	87.89	97.33	90.55	89.22
Tillers per meter	85.91	87.80	96.95	90.64	89.18
Spike length (cm)	10.96	10.50	11.03	10.73	11.42
Spikelets per spike	20.23	19.87	19.77	19.61	19.33
Grains per spike	55.45	53.92	62.26	51.63	51.40
Plot yield (g)	1175.20	980.34	409.15	587.23	776.72
1000 grain weight (g)	43.40	43.38	44.15	40.18	42.25
Protein per cent	10.81	11.27	11.70	11.46	11.09
Gluten content (g)	29.29	28.50	28.53	28.61	29.00
Sedimentation value (ml)	35.17	35.11	34.01	35.27	34.98
Hectoliter weight (g)	77.51	77.99	78.33	77.40	77.92

Table 8. Cluster mean for different characters of wheat genotypes under SYLS

Character	Cluster					
	I	II	III	IV	V	VI
Days to heading	82.19	84.40	84.25	89.44	84.76	84.29
Plant height (cm)	90.94	94.48	92.01	95.31	93.24	92.38
Tillers per meter	60.00	138.97	125.29	146.13	109.10	94.89
Spike length (cm)	9.77	9.80	9.59	10.03	9.49	9.21
Spikelets per spike	14.28	18.13	17.63	17.16	17.64	17.60
Grains per spike	40.50	47.63	48.98	56.38	48.59	50.58
Plot yield (g)	779.06	777.45	611.95	211.56	459.05	329.40
1000 grain weight (g)	50.27	42.78	41.19	37.30	41.60	40.03
Protein per cent	10.28	10.69	10.99	11.11	10.76	10.62
Gluten content (g)	25.08	28.46	29.03	30.13	29.37	28.64
Sedimentation value (ml)	37.15	32.30	33.05	38.80	32.55	31.97
Hectoliter weight (g)	78.10	78.30	77.83	79.48	77.97	77.02

Table 9. Donors for different yield and quality characters of wheat

S.No.	Characters	Accessions / genotypes
1.	Early heading	IC416020 IC416074 IC379815 IC379983 IC415987 IC416002 IC361690 IC416105 IC397323 IC416011
2.	Short plant height	IC415965 IC416243 IC416187 IC416073 IC416117 IC415985 IC415986 IC416112 IC416151 IC415987
3	Tillers/meter	IC397955 IC416050 IC416010 IC393124 IC416005 IC372646 IC396579 IC279320 IC321906 I
4	Spike length	IC279688 IC415990 IC279321 IC415959 IC416163 IC372643 IC382726 IC416061 IC415958 IC415841
5	Spikelets/spike	IC372654 IC279688 IC416128 IC321154 IC416131 IC415938 IC416009 IC416036 IC416061 IC416035
6	Grains/spike	IC 66531 IC415938 IC416076 IC415995 IC415980 IC416160 IC416132 IC415992 IC416131 IC415991
7	Plot yield	IC415945 IC416055 IC415979 IC397821 IC416129 IC416062 IC415995 IC398144 IC416197
8	1000 Grain weight	IC416046 IC416163 IC416118 IC416041 IC416189 IC416164 IC416205 IC416204
9	Protein (%) High Medium Low	IC416011 IC416148 IC415985 IC415952 IC416036 IC415968 IC416131 IC416258 IC416120 IC416171 IC66531 IC397317 IC321906 IC395828 IC321154
10	Gluten content	IC416148 IC415837 IC416110 IC416149 IC416211 IC416206 IC416115 IC416042 IC416152
11	Sedimentation value <30 30-60	IC416165 IC397317 IC416168 IC395828 IC398115 IC416003 IC416122 IC416176 IC416052 IC397839
12	Hectoliter weight	IC416176 IC416182 IC416153 IC416105 IC415945 IC416201 IC416194 IC415967 IC416191 IC415968

Table 10. Donors for different yield and quality characters of wheat and their respective cluster indicating genetic diversity under different environmental conditions

Character / Environment	Genotype Number									
Early maturity	153	191	58	71	127	140	27	196	56	149
timely sown condition FYTS	IV	IV	I	III	III	III	IV	IV	IV	III
late sown condition FYLS	III	III	III	III	III	III	III	III	III	III
timely sown condition SYTS	II	V	V	IV	IV	V	V	V	V	V
late sown condition SYLS	III	III	II	II	V	V	V	III	III	V
Short plant height	111	294	258	190	204	125	126	200	228	127
timely sown condition FYTS	IV	III	IV	IV	III	IV	IV	IV	II	III
late sown condition FYLS	III	III	III	III	III	III	III	III	I	III
timely sown condition SYTS	IV	V	V	II	II	V	V	II	V	IV
late sown condition SYLS	III	VI	VI	III	V	III	III	III	III	V
Tillers/meter	69	175	148	48	143	29	50	6	15	
timely sown condition FYTS	III	III	III	IV	III	IV	IV	III	III	
late sown condition FYLS	III	III	II	III	III	III	III	II	III	
timely sown condition SYTS	IV	II	V	IV	IV	II	V	IV	V	
late sown condition SYLS	II	II	III	II	II	III	VI	III	V	
Spike length	9	129	7	107	240	28	45	185	106	88
timely sown condition FYTS	III	III	III	III	II	III	III	IV	IV	III
late sown condition FYLS	III	III	III	III	I	III	III	III	III	III
timely sown condition SYTS	IV	IV	V	V	V	V	IV	V	II	III
late sown condition SYLS	III	II	V	III	V	V	III	III	III	III
Spikelets/spike	30	9	212	13	215	94	147	166	185	94
timely sown condition FYTS	III	III	IV	IV	III	III	III	III	IV	III
late sown condition FYLS	III	III	III	III	III	III	III	III	III	III
timely sown condition SYTS	II	IV	II	V	I	III	V	II	V	III
late sown condition SYLS	III	III	II	V	V	III	III	III	III	III
Grains/spike	1	94	192	133	122	131	215	237	216	130
timely sown condition FYTS	IV	III	III	III	III	III	III	III	III	III
late sown condition FYLS	III	III	III	III	III	III	III	III	III	III
timely sown condition SYTS	V	III	V	V	V	IV	I	II	IV	V
late sown condition SYLS	I	III	III	III	III	V	V	IV	III	III
Plot yield	96	179	121	59	213	186	133	83	267	
timely sown condition FYTS	II	I	II	II	II	III	III	III	II	
late sown condition FYLS	II	II	II	III	II	III	III	III	III	
timely sown condition SYTS	V	II	V	I	II	I	V	I	II	
late sown condition SYLS	II	II	II	II	III	VI	III	III	II	
1000 Grain weight	172	240	205	168	273	260	241	272		
timely sown condition FYTS	III	II	III	III	III	III	III	III		
late sown condition FYLS	III	I	III	II	III	III	III	III		
timely sown condition SYTS	IV	V	II	V	V	II	V	II		
late sown condition SYLS	III	V	V	III	II	III	III	II		

Continue………………………..

1000 Grain weight		172	240	205	168	273	260	241	272	
timely sown condition	FYTS	III	II	III	III	III	III	III	III	
late sown condition	FYLS	III	I	III	II	III	III	III	III	
timely sown condition	SYTS	IV	V	II	V	V	II	V	II	
late sown condition	SYLS	III	V	V	III	II	III	III	II	
Protein (%) High		149	225	125	101	166				
timely sown condition	FYTS	III	III	IV	III	III				
late sown condition	FYLS	III	III	III	III	III				
timely sown condition	SYTS	V	IV	V	IV	II				
late sown condition	SYLS	V	V	III	III	III				
Medium			215	295	206	246				
timely sown condition	FYTS		III	III	IV	III				
late sown condition	FYLS		III	III	III	III				
timely sown condition	SYTS		I	V	V	V				
late sown condition	SYLS		V	III	V	III				
Low		55	1	15	49	13				
timely sown condition	FYTS	I	IV	III	III	IV				
late sown condition	FYLS	III	III	III	III	III				
timely sown condition	SYTS	II	V	V	II	V				
late sown condition	SYLS	II	I	V	VI	V				
Gluten content		86		225	226	229	279	274		169
timely sown condition	FYTS	IV		III	III	III	III	III		III
late sown condition	FYLS	III		III	III	I	III	III		III
timely sown condition	SYTS	V		IV	IV	V	IV	IV		V
late sown condition	SYLS	III		V	III	VI	V	V		III
Sedimentation value	<30	242	55	244	49	81				
timely sown condition	FYTS	III	III	III	III	IV				
late sown condition	FYLS	III	III	III	III	III				
timely sown condition	SYTS	V	II	II	II	IV				
late sown condition	SYLS	III	II	VI	VI	II				
Sedimentation value	30-60	141	208	250	176	63				
timely sown condition	FYTS	III	IV	III	III	IV				
late sown condition	FYLS	III	III	III	III	III				
timely sown condition	SYTS	II	V	V	II	V				
late sown condition	SYLS	III	III	III	III	II				
Hectoliter weight		250	254	230	196	96	269	265	262	113
timely sown condition	FYTS	III	III	III	IV	II	IV	III	III	III
late sown condition	FYLS	III	III	III	III	II	III	III	III	III
timely sown condition	SYTS	V	IV	V	V	V	V	V	I	II
late sown condition	SYLS	III	III	V	III	II	V	V	III	V

An examination of estimate of within and between clusters, genetic diversity revealed that the accessions of the same cluster have little divergence from each other with respect to the aggregate effect of the 12 characters studied. The crossing between the accessions of the same cluster may not provide good segregants. Thus crosses may be attempted between the accessions of different clusters. This can give desirable transgressive segregants. Calculation of genetic distances and heterosis showed that maximum heterosis was displayed by crosses between diverse or moderately diverse parents (Guo and Zhang, 1989).

Therefore, it is essential that sufficient diversity for economic traits must exist in the germplasm. (Jatasara and Paroda, 1983; Sethi *et al*., 1978; Sharma *et al*., 1998; Singh *et al*., 2002; Lilah *et al*., 2005; Mittal *et al*., 2008; Shahryari *et al*., 2011). Cluster mean (Table 5-8) in genetic divergence studies provides indications for selection of probable donors of different yield and quality attributes for their inclusion in crossing programme. Use of such identified donors from diverse group in hybridization increases probability of getting transgressive segregants in subsequent selfed generations and which could be directed for improved accessions through various procedures. Result of cluster means indicated that the clusters are exhibiting differences for various characters specially the yield and some of quality parameters. This indicates that there is option available for identification of donors for different traits to be proposed for inclusion in hybridization programme (Table 9).

Reduced expressions of yield and its contributing characters were also observed in late sown conditions in comparison to timely sown in both the years but formation of more number of clusters during SYLS indicated considerable reflection of similarities and dissimilarities of the accessions and providing better opportunities for identification of probable donors for yield as well as quality parameters for inclusion in hybridization programme. Based on the per se performance and their genetic diversity some of the accession were identified as donor for different characters (Table 10). These accessions could be utilized for creation of de novo variability for yield and quality attributes in wheat. The present investigation revealed that some of the germplasm accessions better than the best check. Early heading leads to early maturity and it has been observed that early maturing varieties as a result of escape mechanism are usually less prone to diseases (Vashnava, 2003).

With respect to early heading IC416020, IC416074, IC379815, IC379983, IC415987, IC416002, IC361690, IC416105, IC397323 and IC416011 accessions were identified. IC415965, IC416243, IC416187, IC416073, IC416117, IC415985, IC415986, IC416112, IC416151and IC415987 accessions were showing short plant height which may be potential donors for lodging resistance. Ear length, spikelets/ear, grains/ear, tillers/meter and 1000 grain weight are main contributors of grain yield/plot. Parents having high value of these characters can be used to increase grain yield/plot. IC415965, IC416243, IC416187, IC416073,

IC416117, IC415985, IC415986, IC416112, IC416151 and IC415987 accessions were observed for higher mean ear length, IC372654, IC279688, IC416128 , IC321154, IC416131, IC415938, IC416009, IC416036, IC416061 and IC416035 accessions for high spikelets/spike, IC 66531, IC415938, IC416076, IC415995, IC415980, IC416160, IC416132, IC415992, IC416131 and IC415991 accessions for more grains/ear, IC397955, IC416050, IC416010, IC393124, IC416005, IC372646, IC396579, IC279320, IC321906 and IC396579 accessions for more tillers per meter and IC416046, IC416163, IC416118, IC416041, IC416205, IC416189, IC416041, IC416164, IC416205 and IC416204 accessions for high 1000 grain weight. With respect to high grain yield per plot IC415945, IC416055, IC415979, IC397821, IC416129, IC416062, IC415995 IC398144, IC416197 and IC415979 accessions were identified as potential donors. The screening of germplasm helped in identifying promising genetic donors for different characters. This view is supported by the Beale, 1969; Garg 1985; Jaradat and Jana 1986; Cui and Ma 1988; Kulshereshtha 1992; Rajaram, 2001, Mittal *et al*., 2008 and Ali *et al* 2010.

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