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Estimation of variability for grain yield, quality and some agronomic traits in bread wheat and triticale

S. DIYALI, BHANUPRIYA, S. MUKHERJEE, K. K. SARKAR AND S. K. MUKHOPADHAYAY

Dept. of Genetics and Plant Breeding, [1]Dept. of Agronomy, AICW&BIP, Bidhan Chandra Krishi Viswavidylaya, Mohanpur-741252, Nadia, West Bengal

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ABSTRACT

The investigation was carried out to study the genetic variability of quantitative traits and their contribution towards seed yield that may be used as criteria for yield improvement in wheat. The experiment was conducted with forty nine genotypes including two triticale in Nadia district of West Bengal during rabi season in two consecutive years 2012-2013 and 2013-2014 following RBD design with two replications. A wide spectrum of variability for all the characters except days to maturity within the genotypes were evident which could provide scope for improvement on the characters following selection and most of the characters like plant height, days to heading, days to flowering, 1000 grain weight, number of grains spike^{-1} and yield plant^{-1} were associated with high heritability along with high genetic advance which suggested that the characters are predominantly controlled by additive gene effect and direct selection on the basis of phenotypic data may response positively to desired direction.

Keywords: Genetic advance, heritability, *Triticale*, wheat

Wheat is the king of all cereals because of its high nutrient content and its suitability to all agro-ecological regions. Wheat crop has wide adaptability as it can be grown in the tropical, sub-tropical and in the temperate zone and the cold tracts of the far north, beyond even 60 degree north latitude. Wheat is 2nd most important cereal in west Bengal as well as in India. The annual production of wheat in West Bengal during 2011-12 was 0.88 mt with 2800 kg/ ha productivity in 0.32 m ha cultivated area. It provides more calories and protein to human diet than any other crop. Protein content is a key quality factor that determines the suitability of wheat for a particular type of product as it affects other factors including mixing tolerance, loaf volume and water absorption capacity (Shah *et al.,* 2008). Both protein quantity and quality are considered important in estimating the potential of flour for its end use quality (Farooq *et al.,* 2001). Wheat proteins (12-16%) are of special important. Hard wheat is high in protein (10-17%) and yields a flour rich in gluten, making it particularly suitable for yeast breads. The low-protein (6 to 10%) softer type yields flour lower in gluten and therefore, better suited for tender baked products, such as biscuits, pastries and cakes. *Triticum durum* wheat, although high in gluten, is not suitable for baking, but suitable for semolina, the basis for excellent pasta, such as spaghetti and macaroni preparation.

The success of a crop improvement program depends upon the amount of genetic variability existing in the germplasm. To bring the heritable improvements in economic characters through selection and breeding, estimation of genetic parameters must be made before starting a program. There are different techniques available to compute the genetic parameters and the index of transmissibility of characters. Heritability estimates provide information about the extent to which a particular character can be transmitted to the successive generations. Knowledge of heritability of a trait thus guides a plant breeder to predict behavior of succeeding generations and helps to predict the response to selection. High genetic advance coupled with high heritability estimates offer a most suitable condition for selection (Larik *et al*., 1989). Therefore, availability of good knowledge of heritability and genetic advance existing in different yield parameters is a pre-requisite for effective plant improvement exercise (Haq *et al*., 2008).

MATERIALS AND METHODS

The wheat germplasm consisted of forty nine genotypes including two triticale were collected from Directorate of Wheat Research, Karnal through All India Coordinated Wheat & Barley Integrated Project of Kalyani centre, BCKV. Field experiments were conducted at two locations, District Farm, AB Block, BCKV, Kalyani, West Bengal and Instructional Farm, BCKV, Jaguli, Nadia, West Bengal during rabi seasons in two consecutive years 2012-2013 and 2013-2014 following RBD design with two replications. The important characters considered in the present investigation were days to heading, days to flowering,

Email: bpriya1011@gmail.com

days to maturity, plant height, number of tillers plant^{-1}, number of spikes plant^{-1}, spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grain spike^{-1}, flag leaf area, chlorophyll-a content, chlorophyll-b content, total chlorophyll content, 1000 grain weight, amylose content, grain protein content and yield plant^{-1}. Genotypic and phenotypic variances, genotypic and phenotypic coefficient of variability, broad sense heritability and genotypic and phenotypic correlation were computed according to the method suggested by Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

The analysis of variance showed wide spectrum of variability for all the characters except days to maturity within the genotypes which provided sufficient scope for further on these traits through selection. Wide range in mean value was observed in days to heading, days to flowering, plant height, number of tillers plant^{-1}, number of spikelets spike^{-1}, number of grains spike^{-1}, flag leaf area, chlorophyll content, 1000 grain weight, grain protein content, grain yield plant^{-1} which supported the variant nature of the genotypes considered in the present investigation for most of the characters and may provide success in selection on the basis of phenotypic value of component characters. The average performances of the genotypes for all the characters under study are presented in table 1. As revealed by the LSD value, significantly early heading was noticed in genotypes JAUW 616 and UP 2856 (55.50 days) and early flowering was noticed in UP 2856 (61.00 days) followed by HD 3133 and JAUW 616. Early maturing genotype was identified as JAUW 616 (111.25days) alongwith DBW 115, NW 5095, RAJ 4329 and RAJ 4330 and UP2858 (119.25 days) was found to be late in maturity. Maximum plant height was observed in genotype WH 1154 (104.75cm) followed by WH 1155, JAUW 616 and WH 1151. Maximum number of tillers plant^{-1} was noticed in DBW 115 followed by RAJ 4333, PBW 692 and RAJ 4332. Genotype PBW 694 was recorded maximum number of spike plant^{-1} (11.50), it was followed by RAJ 4332, PBW 692 and HD 2733© and found within the critical range of RAJ 4332. Maximum spike length in HUW 670 (11.79cm) followed by HD 3130 and DBW 17© and fall within critical difference of HUW 670. The same genotype HUW 670 showed maximum number of spikelets spike^{-1} (20.25) and it was followed by NW 6002, K 0307©, DBW 17©, WH 1151 and UP 2858 and showed no significance difference from HUW 670. Highest number of grains spike^{-1} was recorded in genotype HD 3129 (40.25) and was being followed by NW 5095, UP 2857 and DBW 113. Genotype HD 3128 (1.27g) exhibited least weight of grain spike^{-1} and its highest value was shown by DBW 116 (2.27g) alongwith WH 1151 and DBW 114. The highest chlorophyll-a content was observed in genotype HD 3129 (0.278 mg^{-1} g) closely followed by HD 3130 and DBW 115, while highest amount of chlorophyll-b content was recorded on genotype UP 2856 (0.378mg^{-1} g) noticed no significance different from UP 2856. Thousand grain weight was least in genotype UP 2856 (24.70g) and highest in genotype NW 6002 (43.40g) it was followed by WH 1154, RAJ 4329, TL 2995, HD 3130 and JAUW 611. Maximum protein percentage was recorded in genotype HD 3133 (15.70%) followed by PBW 696, RAJ 4330, RAJ 4329 and WH 1152 and showed no significant difference from HD 3133. Highest amylose percentage was recorded in HD 3127 (27.60 %) followed by TL 2995, HD 3131 and HD 3126. Lowest grain yield plant^{-1} was noticed in genotype HD 3128 (12.70g) followed by HD 3133, UP 2854 and WH 1154. The highest grain yield plant^{-1} was recorded by PBW 692 (24.60g) followed by DBW 115, HD 2967©, NW 6002 and RAJ 4332 and the following genotype either from minimum or maximum yielder showed no significant variations.

The range, mean values, variances due to phenotype, genotype and environment, coefficient of variation (CV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2), genetic advance (GA) and genetic advance as percentage mean are presented in table 2. The phenotypic and genotypic variances were found to be high for days to flowering, plant height and days to heading and it was substantial high for 1000 grain weight, number of grains spike^{-1} and yield plant^{-1} and other characters showed small variances due to genotype and phenotype. The characters with high variances due to genotype and phenotype also showed high environmental variance and similarly small environmental variances was noticed in character with small variance with respect to these parameters. Characters with high variances also highlighted high environmental variances which suggested that selection on the basis of phenotypic characters may not produce desirable result for which progeny selection may constitute desirable component for effective selection. On the other hand the characters like number of tillers plant^{-1}, number of spikes plant^{-1}, spike length, flag leaf area, chlorophyll content with

Table 1: Mean performance estimated on pooled data of the different characters among the genotypes of wheat

Varieties	Days to heading	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers plant^{-1}	No. of spike plant^{-1}	Spike length (cm)	No. of spikelet spike^{-1}	No. of grains spike^{-1}	Wt. of grain spike^{-1} (g)	Flag leaf area (cm^2)	Chl- a (mgg^{-1})	Chl-b (mgg^{-1})	Total chl. (mgg^{-1})	1000 grain wt.(g)	Grain protein (%)	Amy-lose (%)	Yield plant^{-1} (g)
DBW113	73.25	79.25	117.00	93.15	11.00	9.25	10.96	18.75	38.50	1.70	19.74	0.206	0.100	0.337	38.80	12.90	25.10	18.60
DBW114	73.50	79.75	118.00	58.00	10.75	10.25	10.60	17.75	34.75	1.95	22.53	0.199	0.060	0.260	33.50	13.30	23.40	20.90
DBW115	68.50	74.50	114.25	77.69	14.25	10.50	10.71	18.25	37.00	1.74	21.78	0.251	0.097	0.372	38.80	13.10	26.20	24.50
DBW116	71.50	76.00	117.75	92.60	10.00	8.50	9.26	17.25	38.00	2.27	18.92	0.230	0.081	0.309	39.00	13.20	26.40	22.60
DBW117	67.00	71.00	116.75	99.16	12.50	9.75	9.91	16.25	30.50	1.57	21.44	0.163	0.069	0.236	37.90	13.80	24.10	19.50
DBW118	72.50	78.00	116.25	92.82	12.00	9.75	9.12	15.00	34.00	1.70	24.29	0.164	0.069	0.234	41.70	13.70	23.70	20.30
HD3130	68.50	73.75	118.25	92.46	11.50	9.00	11.62	15.25	31.25	1.63	24.15	0.253	0.065	0.301	42.10	14.30	23.50	18.40
HD3133	62.50	66.75	116.25	93.28	10.50	8.25	10.89	16.50	33.75	1.45	18.25	0.193	0.082	0.288	39.40	15.70	24.00	15.20
HD3128	66.75	72.25	115.50	92.75	10.00	8.75	9.14	13.50	30.00	1.27	17.24	0.226	0.065	0.268	36.90	14.00	24.80	12.70
HD3129	68.75	72.50	116.25	98.25	9.50	8.75	11.23	15.75	40.25	1.78	22.26	0.265	0.103	0.402	37.30	13.00	26.50	16.70
HD3132	66.50	71.00	116.25	94.40	12.00	9.75	9.25	15.75	35.00	1.60	21.26	0.187	0.067	0.253	38.40	13.90	24.60	19.20
HD3127	65.50	71.00	117.25	92.85	12.00	10.25	9.44	16.75	37.25	1.66	21.92	0.155	0.063	0.213	36.20	14.30	27.60	19.80
HD3126	70.00	75.25	117.75	98.40	10.50	9.25	10.14	18.50	36.00	1.61	23.07	0.235	0.048	0.278	33.80	13.30	27.00	16.80
HD3131	68.75	72.50	116.75	65.51	11.00	10.50	10.39	17.75	36.25	1.72	20.97	0.192	0.071	0.255	41.60	12.80	27.10	18.80
HUW671	67.25	71.25	115.75	86.97	12.00	10.25	10.99	16.75	34.25	1.70	22.82	0.151	0.066	0.215	39.60	13.10	23.90	20.40
HUW670	72.00	76.75	118.50	63.83	10.25	9.00	11.79	20.25	34.75	1.73	21.78	0.278	0.073	0.376	38.80	12.80	25.20	17.70
JAUW611	72.00	77.00	115.50	87.00	12.00	10.00	10.48	16.25	31.50	1.52	18.09	0.196	0.070	0.285	42.10	14.50	24.50	18.20
JAUW616	55.50	66.00	111.25	102.25	10.75	8.50	8.02	13.25	30.75	1.56	19.75	0.233	0.049	0.264	40.20	13.20	24.70	17.00
K1201	66.50	69.50	116.25	94.10	10.75	9.00	9.13	18.50	29.00	1.59	22.15	0.191	0.072	0.274	33.10	14.20	22.40	17.10
K1202	71.75	75.00	115.25	74.56	11.75	10.25	9.38	16.50	29.00	1.75	20.57	0.183	0.071	0.264	40.60	13.00	24.40	20.60
NW5095	69.50	74.00	114.25	73.60	11.50	9.50	10.64	18.75	39.00	1.73	20.31	0.217	0.080	0.274	32.80	13.40	24.20	19.80
NW6000	65.25	70.00	115.50	90.64	11.50	9.75	10.31	17.25	33.00	1.44	22.47	0.223	0.073	0.311	40.10	14.50	24.20	16.50
PBW692	71.75	76.50	116.25	75.50	13.25	11.00	10.21	17.25	34.25	1.87	22.62	0.224	0.083	0.303	38.10	12.90	25.90	24.60

contd...

Table 1 contd......

PBW693	69.75	74.25	116.50	93.60	11.50	9.25	9.56	16.50	35.75	1.77	20.63	0.253	0.106	0.394	38.20	13.40	24.50	20.00
PBW694	72.75	77.75	117.75	93.78	12.75	11.50	10.78	18.25	34.50	1.61	22.25	0.153	0.091	0.243	38.70	12.70	26.20	20.50
PBW695	62.75	69.00	115.75	92.50	12.00	9.50	10.28	17.50	31.75	1.60	19.77	0.212	0.067	0.278	40.50	13.90	23.80	19.20
PBW696	71.50	75.75	116.25	96.25	10.25	8.50	8.82	15.00	30.50	1.64	20.13	0.216	0.089	0.301	40.00	14.80	23.90	16.70
RAJ4329	70.50	75.00	114.50	72.55	12.25	10.00	10.20	17.00	38.00	1.76	21.30	0.139	0.067	0.510	42.20	14.70	24.30	21.40
RAJ4330	67.00	71.25	114.50	98.61	11.25	9.00	10.42	17.50	30.50	1.78	19.38	0.171	0.073	0.254	39.40	14.70	24.40	19.70
RAJ4331	64.50	70.75	117.00	98.97	10.00	9.75	10.40	17.00	28.25	1.73	21.97	0.201	0.078	0.290	37.30	14.00	26.40	17.00
RAJ4332	67.50	72.50	115.00	71.59	13.00	11.25	10.11	16.50	34.50	1.84	19.62	0.188	0.072	0.272	32.60	14.00	26.00	23.70
RAJ4333	65.25	69.75	115.25	96.25	13.50	10.50	8.12	12.25	30.00	1.48	21.37	0.150	0.051	0.214	34.90	14.70	22.80	20.00
TL2995	63.25	68.25	115.75	97.25	11.50	9.00	9.55	16.25	31.00	1.77	21.90	0.227	0.056	0.271	42.10	14.10	27.30	20.30
UP2854	67.50	72.25	117.50	94.00	11.00	9.00	10.71	15.25	30.50	1.46	18.78	0.200	0.070	0.272	33.90	14.60	23.10	15.80
UP2855	65.75	76.50	117.25	93.75	10.75	8.00	10.19	17.50	37.75	1.64	20.14	0.193	0.075	0.277	32.70	13.10	24.80	17.50
UP2856	55.50	61.00	116.25	79.30	11.00	10.25	9.13	17.75	34.00	1.56	20.04	0.194	0.378	0.280	24.70	12.90	24.80	17.10
UP2857	73.25	77.50	116.50	94.07	10.75	9.50	9.98	17.00	38.75	1.61	21.43	0.167	0.079	0.243	40.80	13.20	24.60	17.40
UP2858	75.00	80.50	119.25	66.71	10.50	9.00	10.07	19.00	37.50	1.66	21.65	0.218	0.080	0.278	33.70	13.20	24.40	17.50
UP2875	64.75	69.25	117.50	66.02	12.00	10.75	10.06	17.25	32.00	1.54	19.70	0.206	0.083	0.282	36.50	12.80	24.50	18.40
WH1151	71.25	77.00	115.75	100.00	11.00	9.75	10.59	19.00	35.75	1.96	22.76	0.139	0.100	0.203	38.70	14.50	24.90	21.50
WH1152	70.75	77.75	115.50	97.00	10.25	8.75	10.23	17.75	33.50	1.74	20.96	0.154	0.059	0.213	38.70	14.70	24.20	17.70
WH1153	72.75	76.25	117.00	93.95	11.00	9.25	9.57	17.25	38.25	1.76	22.32	0.234	0.099	0.346	38.40	13.10	25.30	19.30
WH1154	72.75	79.25	117.00	104.75	9.50	8.25	9.21	17.75	30.50	1.63	16.13	0.158	0.065	0.234	43.10	13.30	25.30	15.50
WH1155	70.00	78.25	118.75	103.16	12.50	10.25	10.82	18.75	37.00	1.50	20.64	0.196	0.060	0.263	38.70	12.90	23.70	18.70
DBW17©	66.25	70.50	116.25	68.19	12.00	9.00	11.17	19.00	34.75	1.72	23.38	0.215	0.092	0.318	40.20	12.70	24.60	20.50
HD2733©	65.00	69.50	117.75	74.42	13.00	11.00	9.91	16.75	28.75	1.57	22.62	0.209	0.088	0.299	39.50	12.70	24.90	20.40
HD2967©	76.25	80.50	118.75	97.92	12.75	9.75	10.72	17.00	34.00	1.88	22.65	0.194	0.073	0.262	41.00	13.40	24.20	24.00
K0307©	65.50	70.75	119.00	90.89	11.75	10.00	10.84	19.00	33.25	1.72	20.93	0.193	0.082	0.283	37.10	13.70	25.70	20.20
Mean	**68.49**	**73.67**	**116.51**	**87.00**	**11.46**	**9.617**	**10.10**	**17.08**	**34.03**	**1.68**	**21.17**	**0.199**	**0.081**	**0.284**	**38.10**	**13.60**	**24.90**	**19.20**
LSD(0.05)	**6.469**	**7.181**	**3.268**	**11.489**	**2.612**	**2.029**	**1.200**	**2.710**	**5.060**	**0.33**	**4.060**	**0.035**	**0.126**	**0.111**	**6.832**	**2.059**	**3.112**	**3.770**

Table 2: Mean, range and other genetic parameters estimated on pooled data of the different characters among the genotypes of wheat

Characters	Range	Mean	SED	Variances			CV	GCV	PCV	H^2 broad sense	Genetic advance (GA)	GA as % of mean (at 5%)
				Geno typic	Pheno typic	Environ mental						
Days to heading	55.50-76.25	68.49	0.840	13.745	24.094	10.349	1.227	6.291	6.410	96.337	8.712	12.720
Days to flowering	61.00-80.50	73.668	0.885	11.384	24.139	12.755	1.201	5.657	5.784	95.685	8.398	11.400
Days to maturity	111.25-119.25	116.505	0.765	277.862	280.503	2.641	0.656	1.170	1.341	76.034	2.448	2.101
Plant height (cm)	58.00-104.75	87.767	0.826	133.930	166.575	32.645	0.941	13.95	13.982	99.547	25.165	28.673
No. of tillers plant^{-1}	9.50-14.25	11.459	0.520	0.295	1.983	1.687	4.543	8.742	9.851	78.747	1.831	15.981
No. of spikes plant^{-1}	8.00-11.50	9.617	0.063	0.197	1.215	1.018	6.897	7.249	10.006	52.479	1.040	10.817
Spike length (cm)	8.02-11.79	10.101	0.289	0.481	0.837	0.356	2.869	7.780	8.290	88.073	1.519	15.041
No. of spikelet spike^{-1}	12.25-20.25	17.082	0.716	1.637	3.453	1.816	4.193	8.857	9.799	81.684	2.817	16.489
No. of grains spike^{-1}	28.25-40.25	34.026	0.724	7.178	13.511	6.333	2.129	9.332	9.572	95.052	6.377	18.742
Wt. of grain spike^{-1} (g)	1.27-2.27	1.681	0.054	0.013	0.040	0.027	3.258	9.376	9.918	89.368	0.307	18.259
Flag leaf area (cm^2)	16.13-26.23	21.166	0.561	1.406	5.483	4.077	2.647	8.566	8.966	91.270	3.568	16.858
Chlorophyll a (mg/g)	0.139-0.278	0.199	0.009	0.001	0.001	0.000	0.000	16.353	16.947	93.119	0.065	32.508
Chlorophyll b (mg g^{-1})	0.048-0.378	0.081	0.006	0.000	0.004	0.004	78.081	17.122	77.518	4.879	0.006	7.791
Total chlorophyll(mg g^{-1})	0.203-0.510	0.284	0.053	0.002	0.005	0.003	19.286	14.269	23.564	36.665	0.051	17.798
1000 grain wt. (g)	24.70-43.40	38.123	0.538	6.477	18.021	11.544	1.410	9.126	9.235	97.667	7.083	18.579
Grain protein (%)	12.70-15.70	13.623	0.431	0.025	1.073	1.049	3.166	4.957	5.881	71.062	1.173	8.609
Amylose (%)	22.40-27.60	24.873	0.824	0.232	2.627	2.395	3.313	4.197	5.347	61.621	1.688	6.787
Yield plant^{-1} (g)	12.70-24.60	19.175	0.608	4.578	8.094	3.516	3.168	12.934	13.317	94.335	4.962	25.878

GCV=Genotypic coefficient variation; PCV=Phenotypic coefficient variation; H^2=Heritability (broad sense); GA= Genetic advance.

different pigment and protein content showed little environmental influence and the direction selection on the basis of phenotypic value may provide desirable result.

The phenotypic coefficient of variation (PCV) was found to be marginally higher than genotypic coefficient of variation (GCV) for most of the characters except number of spikes plant^{-1}, total chlorophyll content which suggested the presence or little influence on the expression of most of the characters due to environment where phenotypic selection may provide desirable result but for other two character evaluation on the basis of progeny testing considered to be prerequisite to derive success in selection. Ali *et al*. (2008) found high amount of PCV and GCV for grain yield plant^{-1}, whereas remaining traits like number of grains spike^{-1} and 1000 grain weight exhibit moderate to low PCV and GCV estimates.

Heritability of the characters ranged from 4.879 mg/g in chlorophyll -b to 99.547 cm for plant height and genetic advance as percentage of mean 2.101 percent in days to maturity to 32.508 mg/g chlorophyll-a. High heritable characters were found to be days to heading, days to flowering, plant height, spike length, number of spikelet's spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, flag leaf area, chlorophyll a content, 1000 grain weight and grain yield plant^{-1}. Whereas low heritable characters were number of spike plant^{-1}, chlorophyll b content and total chlorophyll content. Other characters showed heritability at intermediate level.

High heritability associated with moderate to low genetic advance were observed for plant height, days to heading, days to flowering, 1000 grain weight, and number of grains spike^{-1}. Similar observations were also recorded by Dhanda and Sheti (2003) and Sarkar *et al.* (2011). Yadav *et al.* (2006) reported that high heritability for days to heading was not associated with high genetic advance. Moderate heritability coupled with high genetic advance was recorded in plant height followed by grain yield plant^{-1}, number of grains spike^{-1} and the characters may be predominantly controlled by additive gene effect and characters may improved by simple breeding methods. Kumar *et al.* (2003) reported high heritability coupled with high genetic advance for number of grains spike^{-1}, the result corroborated to the above finding. The above finding on yield plant^{-1} was supported by Sidharthan *et al.* (2007) and Bhanu Priya *et al.* (2013) which had high heritability along with high genetic advance. Characters bearing high heritability with moderate genetic advance was observed in the character days to heading, days to flowering, number of tillers plant^{-1}, number of spike plant^{-1}, number of grains spike^{-1}, flag leaf area and these characters could be influenced by both additive and non additive gene action for which a complex breeding method like population improvement method suggested to obtain success in breeding. Low to moderate heritability coupled with low genetic advance was noticed in the characters like chlorophyll a and grain protein and the characters may be predominantly controlled by non-allelic gene action and improvement following breeding on these traits could have remote possibility.

According to the present findings it is concluded that the characters plant height, days to heading, days to flowering, 1000 grain weight, number of grains spike^{-1} and yield plant^{-1} were associated with high heritability coupled with high genetic advance which suggested that the characters are predominantly controlled by additive gene effect and direct selection on the basis of phenotypic data may response positively to desired direction.

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