February 15th, the effect of growth regulators except CCC alternated with DAP one per cent did not have any considerable effect on seed cotton yield.

Analysis of economic data revealed that application of ccc at 40 ppm alternated with DAP and per cent fetched Rs.2.81, Rs.2.76 and Rs.2.47 during winter 1989, summer, 1990 and summer 1991 respectively for every rupee invested on cost of cultivation, whereas the corresponding values in water spray (control) are Rs.2.15, 2.01 and 2.04 respectively (Table 2).

It can be concluded that optimum dates of sowing for increased seed cotton yield were 15th August during winter and 15th February during summer seasons and application of ccc alternated with DAP one per cent spray for normal and delayed sowings.

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ESTIMATION OF VARIABILITY PARAMETERS AND PATH COEFFICIENTS FOR SOME QUANTITATIVE CHARACTERS IN HILL WHEATS

JAGSHORANI
Directorate of Wheat Research
Karnal 132 001

ABSTRACT

Fifty hill wheats along with three checks (Kalyansona, Sonalika and VL 421) were evaluated to work out phenotypic and genotypic coefficient of variations (PCV, GCV) heritability, genetic advance (GA) and path coefficients for 12 matric traits. High estimates of PCV, GCV, heritability and GA indicated substantial genetic variability and scope for selection for grain weight/spike, 1000 grain weight, grains/spike, grain yield/plant, harvest index, biological yield/plant, spikes/plant and tillers/plant in the experimental material. There was little variability and scope for improvement through selection for days to 50 per cent flowering, days to maturity, spikelets/spike and plant height. Path coefficient analysis revealed importance of harvest index, biological yield/plant, 1000 grain weight and spikes/plant for improving grain yield/plant.

KEY WORDS : Hill Wheat, Variability Parameters, Path Coefficients, Estimation

Indigenous wheats are still under cultivation in eight hill districts of Uttar Pradesh and the adjoining area of Nepal. There is an urgent need to collect and maintain these materials before these are replaced by the improved wheat varieties and lost for ever. Beside their collection and maintenance, it is also equally important to evaluate them properly for utilisation in wheat improvement programme. With this objective, the present study was undertaken to assess the magnitude of variation and relative importance of different characters with the help of certain genetic parameters like coefficients of variability, heritability and genetic advance. Path analysis as suggested by Wright (1921) was performed to quantify the direct and indirect contributions of yield components and developmental attributes to grain yield.

MATERIAL AND METHODS

Fifty hill wheat collections from Kumaon and Garhwal hills of Uttar Pradesh and the adjoining area of Nepal were evaluated along with three checks *viz.*, Kalyansona, Sonalika and VL 421 in randomised complete block design with three

Table 1. Estimates of mean square, range and mean and promising accessions of hill wheats

Character	Crop season	Mean square	Range	Mean ± SE	Promising accessions with best checks
Days to 50% flowering	I	39.5**	119.0-135.3	128.1±0.8	VHC 6139 (128.5), VHC 6202 (130.5), check Sonalika (127.2)
	II	33.5**	135.3-152.7	143.6±1.4	
Days to maturity	I	4.6**	169.7-175.7	171.8±0.7	VHC 6139 (175.0), VHC 6202 (175.7), Check Sonalika (175.3)
	II	20.9**	180.0-192.7	184.8±0.9	
Plant height (cm)	I	548.7**	68.3-133.3	115.5±1.7	VHC 6215 (88.5), L1 (90.7), Check Sonalika (98.9)
	II	497.9**	78.3-145.0	124.3±2.8	
Tillers/plant	I	5.0**	5.7-10.7	8.5±0.5	VHC 6205 (15.4), L14 (14.5), N0079A (13.1), N0047A (12.5), VHC
	II	25.6**	6.3-19.0	12.2±0.8	6191 (12.2), N0031B (11.8), L23 (11.5), check Sonalika (7.5)
Spikes/plant	I	4.2**	4.7-9.7	6.9±0.5	VHC 6205 (12.9), L15 (12.9), VHC 6264 (10.3), VHC 6281 (10.1),
	II	18.6**	5.3-17.5	10.3±0.8	N0031B (9.7), check VL 421 (7.2)
Spikelets/spike	I	4.1**	17.9-23.0	19.8±0.6	L1 (23.5), L31 (22.9), VHC 6215 (22.9), Check VL 421 (22.0)
	II	5.2**	18.7-24.9	21.2±0.8	
Grain/spike	I	148.2**	31.4-67.1	41.7±1.5	L1 (66.7), VHC 6215 (50.4), Check Kalyansona (58.0)
	II	99.1**	32.6-66.2	42.6±1.8	
Grain weight/ spike (g)	I	0.4**	0.7-2.4	1.2±0.1	L1 (2.3), VHC 6090 (1.9), Check Sonalika (2.3)
	II	0.6**	0.5-2.3	1.1±0.1	
Biological yield/plant (g)	I	31.1**	11.8-27.8	17.0±0.9	VHC 6090 (33.9), N0045A (33.5), L14 (31.9), VHC 6272 (30.9),
	II	112.4**	20.3-49.3	34.7±2.6	N0072A (30.8), VHC 6215 (30.0), Check Sonalika (28.0)
Harvest index	I	0.004**	0.15-0.32	0.22±0.01	VHC 6090 (0.32), VHC 6215 (0.29), Check Kalyansona (0.32)
	II	0.01**	0.16-0.37	0.24±0.01	
1000 grain weight (g)	I	112.9**	15.3-47.0	26.6±1.2	VHC 6090 (43.1), N0072A (39.0), Check Sonalika (48.5)
	II	218.4**	18.3-50.1	26.1±0.8	
Grain yield/ plant (g)	I	4.5**	2.2-7.6	3.8±0.3	VHC 6090 (11.0), VHC 6272 (9.2), Check Sonalika (9.1)
	II	14.8**	4.3-14.3	8.4±0.8	

** Significant at 1% level. Figures within prentheses are average over two crop seasons.

replications in two consecutive crop seasons at the experimental fields of V.P.K.A.S., Hawalbagh situated at 1250 m above mean sea level. Each treatment was allotted a plot size of 2.5 x 0.90 m having 3 rows 30 cm apart. Plants within rows were spaced at 10 cm distance. Five randomly selected plants were tagged in middle row of each treatment to record observations on plant height (cm), tillers/plant, spikes/plant, spikelets/spike, grains/spike, grain weight/spike (g), biological yield/plant (g), harvest index, 1000 grain weight (g) and grain yield/plant (g). Days to 50 per cent flowering and days to maturity were recorded on plot basis. Mean values of five plants were used for statistical analysis. The phenotypic and genotypic coefficients of variability (PCV, GCV), (Burton, 1952), heritability (broad sense) and genetic advance (GA) (Johnson *et al.*, 1955) were computed. The formula devised by Robinson *et al.* (1949) was adopted for the calculation of correlations. Direct and indirect effects were worked out using genotypic correlation coefficients (Dewey and Lu, 1959).

RESULTS AND DISCUSSION

Analysis of variance (Table 1) showed consistently significant differences among genotypes for all the characters. The estimates of mean and range varied considerably in case of days to 50 per cent flowering, days to maturity, plant height, tillers/plant, spikes/plant, biological yield/plant and grain yield/plant, while these estimates remained comparatively stable for spikelets/spike, grain/spike, grain weight/spike, harvest index and 1000 grain weight in two crop seasons. This shows that the characters in the first group were highly sensitive to environmental variations than those in the second group. A comparison of mean values with best check led to the identification of a number of superior accessions for tillers/plant, spikes/plant and biological yield/plant, while a few accessions showed promise for the remaining traits (Table 1). Based on the magnitude of mean and range, the hill wheats have been observed, in general, to possess small grains, tall stature, late maturity and more biological yield.

Table 2. Estimates of phenotypic coefficient of variability (PCV), genotypic coefficient of variability (GCV), heritability and genetic advance (GA) for 12 characters in hill wheats

Parameter	Crop season	Days to 50% flowering	Days to maturity	Plant height	Tillers/ plant	Spikes/ plant	Spikelets /spike	Grains/ spike	Grain weight/ spike	Biological yield/ plant	Harvest index	1000 grain weight	Grain yield/ plant
PCV (%)	I	2.9	0.9	11.9	17.8	20.0	7.4	17.5	35.2	20.0	18.9	23.8	34.6
	II	2.7	1.5	10.8	25.6	26.6	8.1	14.7	40.0	20.6	22.0	32.9	29.7
GCV (%)	I	2.7	0.5	11.6	13.7	15.7	4.9	16.5	33.4	18.1	15.8	22.5	31.4
	II	2.1	1.3	10.1	22.8	22.8	5.1	12.0	37.6	15.9	20.1	32.5	24.5
Heritability	I	87.6	57.1	95.1	58.9	61.2	42.9	88.0	90.1	80.1	70.1	89.5	82.5
(Broadsense) %	II	59.7	71.8	87.1	79.2	73.4	39.6	75.6	88.6	59.7	83.4	97.6	67.9
GA	I	5.3	0.7	23.3	21.6	25.3	6.6	31.9	65.4	33.5	27.5	44.0	58.9
(% of mean)	II	3.3	2.3	19.4	41.9	40.2	6.6	22.9	73.0	25.3	37.7	66.2	41.6

The estimates of PCV, GCV, heritability and GA have been provided in Table 2. Consistently high values of PCV and GCV were recorded for tillers/plant, spikes/plant, grain weight/spike, grains/spike, biological yield/plant, harvest index, 1000 grain weight and grain yield/plant; moderate for plant height and low for the remaining characters. There was a close resemblance between corresponding estimates of PCV and GCV, however the slight edge of former over the latter indicated a good scope for making selection for these characters. These results also suggest that there is considerable genetic variability and scope for selection in the experimental materials with respect to grain yield and its component characters. However, on the basis of genetic coefficient of variation alone, it is not possible to determine the amount of variation that is heritable. For this purpose the estimate of heritability is considered as an important measure of effectiveness of selection for the particular character.

Comparatively high estimates of heritability varying between 57.1 to 95.1 per cent in the first crop season and 59.7 to 97.6 percent in the second crop season were observed for different characters excluding spikelets/spike which exhibited the lowest estimates (39.6% to 42.9%).Similarly, the estimates of GA were observed to be high for all the characters except days to 50 percent flowering, days to maturity and spikelets/spike. Heritability alone may also mislead during selection, therefore, genetic advance and heritability should be taken into consideration during selection. In the present study, high heritability (more than 55%) accompanied by high GA was recorded for grain weight /spike, 1000 grain weight, grain/spike, grain yield/plant, harvest index, biological yield/plant, plant height, spikes/plant and tillers/plant (Table 2). High estimates of heritability and genetic advance for ears/plant, 1000 grain weight and grain yield/plant and low for grains/spike, plant height, spikelets/spike and days to flowering have been reported by Gandhi *et al.* (1964) in Indian wheats.

It is noted (Table 3) that the estimates of correlation coefficients as well as direct and indirect effect varied considerably in two crop seasons revealing the influence of environmental factors on these estimates. Jatasra and Paroda (1978) have also reported the correlation coefficients to vary across the environments in wheat. The inconsistency in results suggest that the correlation and path coefficient analyses based on single environment can be misleading, hence such studies should be conducted across the environments.

Significance of path coefficient analysis in determining the nature of character association has been highlighted in wheat by Bhatt (1973). In the present investigation, grain yield/plant exhibited consistently significant and positive association with grain weight/spike, biological yield/plant, harvest index and 1000 grain weight and significantly negative association with days to 50 percent flowering. The association of grain yield with the remaining characters was either inconsistent of non-significant. However, the path coefficient analysis revealed the importance of only biological yield/plant, harvest index, 1000 grain weight, as these characters showed consistently positive and high direct effects on grain yield (Table 3) The indirect effects of grain weight/spike

Table 3. Correlation coefficients alongwith direct effects (in parentheses) and indirect effects of different characters on grain yield in hill wheats

Character	Crop season	Days to 50% flowering	Days to maturity	Plant height	Tillers/ plant	Spikes/ plant	Spikelets/ spike	Grains/ spike	Grain weight/ spike	Biological yield/ plant	Harvest index	1000 grain weight	Correlation coefficients with grain yield	
													Phenotypic	Genotypic
Days to 50% flowering	I	(-0.430)	0.692	0.089	0.087	0.011	0.006	-0.069	-0.249	0.261	-0.750	-0.112	-0.413**	-0.646
	II	(-0.079)	0.011	0.001	0.007	-0.023	0.061	-0.002	0.152	-0.166	-0.251	-0.096	-0.395**	-0.386
Days to maturity	I	-0.266	(1.121)	-0.319	-0.164	-0.026	0.001	0.014	-0.040	-0.055	-0.413	0.025	-0.098	-0.121
	II	-0.068	(0.013)	-0.006	0.059	-0.053	0.074	0.008	0.037	-0.130	-0.130	-0.050	-0.395**	-0.247
Plant height	I	-0.028	-0.260	(1.373)	0.413	0.151	-0.037	-0.664	-0.575	0.235	-0.973	-0.152	0.435**	-0.518
	II	-0.003	-0.001	(0.049)	-0.289	0.169	0.002	-0.020	0.260	-0.177	0.014	-0.136	-0.151	-0.256
Tillers/plant	I	-0.049	-0.240	0.742	(0.764)	0.284	-0.013	-0.479	-0.397	-0.144	-0.517	-0.128	0.046	-0.149
	II	0.001	-0.001	0.027	(-0.525)	0.350	-0.001	-0.020	0.265	0.398	-0.398	-0.137	0.066	-0.042
Spikes/plant	I	-0.015	-0.091	0.643	0.675	(0.322)	-0.020	-0.533	-0.448	-0.090	-0.438	-0.131	0.005	-0.129
	II	0.005	-0.001	0.022	-0.507	(0.363)	-0.003	-0.019	0.022	0.327	-0.345	-0.119	0.186	-0.853
Spikelets /spike	I	-0.029	0.019	-0.568	-0.133	-0.073	(0.091)	0.490	0.341	-0.274	0.261	0.047	0.223	0.291
	II	-0.043	0.008	0.001	0.006	-0.011	(0.113)	0.017	0.043	-0.060	-0.198	-0.090	-0.021	-0.213
Grains/ spike	I	0.032	0.017	-0.996	-0.399	-0.187	-0.048	(0.916)	0.597	-0.343	0.652	0.137	0.433**	0.47
	II	0.004	0.002	-0.022	0.247	-0.160	0.043	(0.044)	-0.254	-0.062	0.250	0.083	0.213	0.17
Grain weight/spike	I	0.140	-0.059	-1.036	-0.398	-0.189	0.040	0.717	(0.762)	-0.565	1.143	0.250	0.741**	0.80
	II	0.026	-0.001	-0.027	0.300	-0.175	-0.010	0.024	(-0.465)	0.120	0.629	0.292	0.586**	0.71
Biological yield/plant	I	0.121	0.066	-0.347	0.094	0.031	0.026	0.338	-0.929	(0.464)	0.798	0.230	0.843**	0.89
	II	0.018	-0.002	0.012	-0.298	0.169	-0.009	-0.003	-0.079	(0.702)	-0.035	0.090	0.661**	0.563
Harvest index	I	0.219	-0.314	-0.907	-0.268	-0.095	-0.022	0.406	0.591	-0.504	(1.473)	0.228	0.811**	0.851
	II	0.023	-0.002	-0.026	0.244	-0.146	-0.026	0.013	-0.342	-0.029	(0.856)	C.229	0.747**	0.793
1000 grain weight	I	0.155	0.092	-0.673	-0.316	-0.136	0.013	0.405	0.616	-0.692	1.085	(0.310)	0.781**	0.862
	II	0.024	-0.002	-0.021	0.229	-0.137	-0.032	0.011	-0.430	0.201	0.623	(0.315)	0.639**	0.781

** Significant at 1% level.

were observed to be high *via* harvest index and 1000 grain weight. Although, spikes/plant did not show significant correlation with grain yield, its direct effect on grain yield was disclosed by the path coefficient analysis to be positively high. Tillers/ plant and plant height also contributed to grain yield *via* spikes/plant. Thus, on the basis of path coefficient analysis, it is concluded that during selection, more emphasis should be placed on harvest index, biological yield/plant, 1000 grain weight, and spikes/plant for bringing improvement in grain yield.

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