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Stability analysis for economic traits in kale (*Brassica oleracea* var. *acephala* L.)

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Abstract

Stability analysis was carried out in sixteen kale genotypes including three commercial checks over six environments (three locations for two years) to identify phenotypically stable genotypes that could perform more or less uniformly under different environmental conditions for various economic traits. Pooled analysis of variance for stability in the performance of different genotypes of kale were highly significant for all the characters viz. plant height, plant spread, leaf thickness, stem thickness, leaf number, leaf weight, leaf yield, leaf length, lamina length, leaf breadth, leaf size, average stalk weight, average midrib weight, leaf: stalk ratio, blade: midrib ratio, days to first leaf picking and duration of picking indicating that the material selected possessed significant variation for all the characters under study confirming that the environments selected were variable and random and influenced the expression of most of the traits selected for stability studies. Mean squares arising due to G x E interaction were significant for most of the traits except plant spread, leaf thickness, leaf weight, average stalk weight, average midrib weight, blade: midrib ratio and leaf: stalk ratio revealing that most of the characters under study were having significant differential response to the changing environments and the characters showing non significant mean squares revealed, by and large, less effects of the changing environments. In the present study no genotype was found stable for leaf yield across environments. However, genotypes SH-K-28, SH-K-33, *Khanyari* and SH-K-21 could be recommended for cultivation across environments on the basis of stability performance for various economic characters.

Key words: Kale, environments, stability, economic traits

Introduction

Kales/borecoles (*Brassica oleracea* var. *acephala* L.) are group of non-heading plants of cabbage family and are hardiest of Cole crops. They are biennials or perennials, usually grown as annuals for their edible leaves. They can withstand drought and temperatures of –10 to –15^{o} C and, therefore, when supply of most of the vegetables is scarce kales are still conveniently available as greens. In India, kale has not been grown as a vegetable crop for commercial use. However, it is commercially grown in Kashmir and to a limited extent in Jammu, Assam and Himachal Pradesh. In Jammu and Kashmir, it is a popular vegetable both among rich and poor and grown in almost all kitchen gardens and also as a commercial crop around cities and towns. In Kashmir, kale is grown round the year but it shines most as a cold weather crop and is at its most flavourful and tender condition in winter months. Genotype-environment interactions are of major importance to a breeder in the process of developing new varieties. As such the interaction of genotype with the environment has an important bearing in breeding improved varieties. Genotype x environment interaction has a masking effect on the performance of a genotype and hence the relative ranking of the genotypes do not remain the same over number of environments. Adaptability of genotypes to environmental fluctuations is important for the stabilization of crop production both over regions and years. Estimation of phenotypic stability, which involves regression analysis, has proven to be a valuable tool in the assessment of varietal adaptability. Stability analysis is useful in the identification of adaptable genotypes and in predicting the response of various genotypes over changing environments. It is generally agreed that, the more stable genotypes can somehow adjust their phenotypic responses to provide some measures of uniformity in spite of environmental fluctuations.

In kale breeding programme it is, therefore, important to screen and identify the phenotypically stable genotypes which could perform more or less uniformly under different environmental conditions. In view of

scanty information with respect to adaptability of kale genotypes, the present investigation was undertaken to determine genotype x environment interaction and stability parameters for various economic traits and to identify stable genotype(s).

Materials and methods

The experimental material for the present investigation comprised of sixteen kale genotypes/lines including three commercial checks. These genotypes were grown over six environments (three locations for two years) during *rabi* 2003-04 and 2004-05 in a randomized block design at three locations, namely Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology Shalimar, Srinagar; Faculty of Agriculture, Wadura, Sopore and High Altitude Rice Research Sub station, Larnoo, Anantnag. There were three rows of each genotype in a plot at a spacing of 20 x 30 cm. Observations were recorded on five competitive plants in respect of twenty traits namely plant height (cm), plant spread (cm), leaf thickness (mm), stem thickness (cm), number of leaves plant^{-1}, average leaf weight (g), number of pickings plant^{-1}, leaf yield plant^{-1}(g), leaf length (cm), lamina length (cm), leaf breadth (cm), leaf size (cm^2), average stalk weight (g), average midrib weight (g), blade: midrib ratio, leaf: stalk ratio, days to first leaf picking and duration of picking.

The stability parameters estimated were mean of the trait (X), linear regression (b_i) and the mean square deviation from the regression (Sd^2_i), while X provides a measure of the performance of a genotype as compared to other entries. The b_i and Sd^2_i values are the measure of the G x E interaction. In general if G x E is non-significant or where it is either or predominantly linear as compared to its non-linear component, the prediction of stability of a genotype over environments becomes more precise and accurate. As per the Eberhart and Russel model of stability, components Sd^2_i measures the predictability where as b_i measures the stability. Stability of a genotype can be predicted more precisely if G x E interaction and Sd^2_i value is non-significant. They defined an ideal genotype as the one having high mean with a regression co-efficient equal to unity and deviation from regression close to zero. They further suggested that genotypes could be classified as, below average stable performing well only in favourable environments ($b_i > 1$), above average stable adapted specifically to poor environments ($b_i < 1$) and average stable performing well in most of the environments ($b_i = 1$). Genotype x environment interaction and stability analysis of different genotypes across the six environments were worked out as per the model given by Eberhart and Russel [1].

Results and discussion

The analysis of variances for the individual environments revealed significant differences for all the characters in all the six environments indicating existence of genetic differences among the kale genotypes studied. Pooled analysis of variance for stability performance of different genotypes showed highly significant differences for all the traits thus, indicating that the material selected possessed significant variation for all the characters studied confirming random and variable nature of environments selected, which influenced the expression of most of the traits studied (Table 1).

Mean squares arising due to genotype and environment (G x E interaction) revealed that except for plant spread, leaf thickness, leaf weight, average stalk weight, average midrib weight, blade: midrib ratio and leaf: stalk ratio the variance ratio was significant for most of the traits viz. plant height, number of leaves, stem thickness, number of pickings, leaf yield, leaf length, lamina length, leaf breadth and leaf size, revealing that most of the characters of the genotypes under study were having significant differential response to the changing environments.

Component analysis of environment + (genotype x environment) were significant for all the traits except for average stalk weight, average midrib weight and leaf: stalk ratio. Partitioning of this variation into linear and non-linear components revealed that the mean squares due to environments (linear) were significant for all the characters. The significant mean squares confirm that the environments were random and different and they exercised influence on the expression of the trait and this variation could have arisen due to the linear response of the regression of the cultivar to the environment. The mean squares due to G x E (L) were significant for most of the characters viz. plant height, leaf thickness, stem thickness, number of leaves, leaf weight, number of pickings, leaf yield, leaf length, lamina length, leaf breadth, leaf size, average stalk weight, blade: midrib ratio, leaf: stalk ratio, days to first leaf picking and duration of picking revealing that the behavior of the genotypes could be predicted over the environments more precisely and accurately as the G x E interaction was the out come of the linear function of the environmental components. However, mean squares due to G x E (linear) were non significant for plant spread and average midrib weight indicating possible absence

Table 1. Mean squares of stability analysis for economic traits of kale

Source of variance	Mean squares							
	Genotypes	Env.+ (genotype x env.)	Environ.	Genotypes x env.	Environ. (L)	Genotype x env. (L)	Pooled deviation	Pooled error
D.F.	15	80	5	75	1	15	64	192
Plant height (cm)	1076.69**	15.48**	137.823**	7.33*	689.12**	18.05**	4.36**	1.26
Plant spread (cm)	251.25**	17.71**	170.29**	7.53	851.46**	10.37	6.39**	2.30
Leaf thickness (mm)	0.068**	0.0002**	0.0014**	0.0001	0.0070**	0.0002*	0.0001**	0.00006
Stem thickness (cm)	9.0449**	0.084**	0.356**	0.066**	1.781**	0.200**	0.303**	0.007
No. of leaves plant^{-1}	3698.38**	80.913**	497.928**	53.112**	2489.641**	243.779**	5.105**	0.804
Av. leaf weight (g)	139.530**	0.550**	4.692**	0.247	23.459**	0.497**	0.205**	0.834
No. of pickings plant^{-1}	86.089**	2.017**	21.115**	0.745**	105.573**	2.849**	0.204**	0.057
Leaf yield plant^{-1} (g)	179746.9**	7999.9**	73266.1**	3648.8**	366330.5**	15168.5**	720.79**	125.45
Leaf length (cm)	124.51**	4.17**	30.09**	2.45**	150.47**	6.59**	1.32**	0.52
Lamina length (cm	19.19**	0.95**	2.01	0.88**	10.06**	2.79**	0.38**	0.10
Leaf breadth (cm	23.94**	1.04**	7.20**	0.624*	35.99**	1.47**	0.39**	0.40
Leaf size (cm^2)	9990.47**	523.00**	3498.25**	324.65**	17491.25**	869.43**	176.68**	21.72
Av. stalk weight (g)	12.7914**	0.1021	0.1024	0.01021	0.5119*	0.1971**	0.0735**	0.0108
Av .midrib weight (g)	4.159**	0.017	0.018	0.017	0.094*	0.011	0.017	0.003
Blade: mid rib ratio	129.75**	1.33*	3.02*	1.22	15.09**	2.53**	0.84**	0.202
Leaf: stalk ratio	13.03**	0.51	0.47	0.51	2.33**	1.08**	0.34**	0.043
Days to first leaf picking	145.99**	3.76**	34.30**	1.72**	171.48**	5.06**	0.83**	0.26
Duration of picking	145.99**	3.76**	34.30**	1.72**	171.48**	5.06**	0.83**	0.26

, * Significant at 5 and 1 percent, respectively

of genetic differences among the genotypes for their regression on environment index making difficult the prediction for the performance of these traits.

The non-linear component arising due to the heterogeneity measured as mean square due to pooled deviation was significant for all the characters revealing presence of non-linear response of the genotypes to the changing environments. The significance of pooled deviation for all the characters confirms contribution of non-linear component to the total G x E interaction. The genotypes / varieties differed with respect to the stability of these traits making its prediction more difficult. However, the magnitude of linear component i.e., environment (L) and genotype x environment (L) was many times higher than the non linear component (pooled deviation) for most of the characters revealing that the prediction of stability could be reliable though it may get affected to some extent.

Comparison of G x E interaction with non-linear component revealed that it was significant for most of the traits except plant spread, leaf thickness, leaf weight, blade: ratio and leaf: stalk ratio. In traits where the non-linear component was non-significant, the G x E interaction for these traits was greatly influenced by environmental factors and there exist either no relationship or complex relationship between genotype and environment effect making its prediction more difficult for that trait.

In the present study (Table 2) the genotypes showing average stability and high to moderate mean performance than the population mean were SH-K-13, SH-K-8, SH-K-10 and SH-K-12 for plant height; SH-K-1, SH-K-10, SH-K-12, SH-K-21, SH-K-28, SH-K-33 and *Kawdari* for plant spread; SH-K-1, SH-K-5, SH-K-8, SH-K-11, SH-K-13, SH-K-33, *Khanyar*i and *Jumadari* for leaf thickness; SH-K-1, SH-K-2, SH-K-10, SH-K-5, SH-K-12, SH-K-33 and *Kawdari* for stem thickness; SH-K-2, SH-K-10, SH-K-11, SH-K-21, SH-K-24, SH-K-28, *Khanyari* and *Jumadari* for number of leaves; SH-K-14,

Table 2. Stability parameters for economic traits of kale

Genotype	Plant height (cm)			Plant spread (cm)			No. of pickings /plant			Days to first leaf picking			Duration of picking		
	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i
SH-K-1	9.03	0.148*	-0.979	3.145	0.836	-0.0037	4.200	0.538*	-0.050	23.54	2.257*	0.0110	109.5	2.257*	0.01
SH-K-2	9.32	0.033*	-1.131	3.267	0.738	0.0060	4.211	0.570*	-0.047	23.43	2.266*	0.8788**	109.6	2.266*	0.9*
SH-K-5	31.73	2.308*	0.974	1.406	1.182	0.0046	4.955	0.616	0.092	20.61	1.838*	-0.0169	112.4	1.838*	0.00
SH-K-8	22.19	0.700	-0.553	2.0973	2.238*	0.0095	9.422	1.642*	0.055	17.68	1.221	1.4925**	115.3	1.221	1.5**
SH-K-10	33.78	1.047	0.349	3.133	1.614	0.0003	4.511	0.425*	0.015	22.73	1.693	0.7085**	110.3	1.693	0.7**
SH-K-11	43.78	1.298	7.953**	3.423	1.897	0.1122**	4.656	0.493*	0.028	24.31	0.816	-0.1072	108.7	0.817	-0.1
SH-K-12	33.45	0.635	0.581	0.890	0.410	0.0011	13.589	1.796	0.551**	16.66	-0.024	1.1982**	116.3	-0.024	1.2**
SH-K-13	39.65	1.247	0.826	1.755	3.677*	0.0029	11.278	1.731*	0.071	17.17	0.315	0.6776**	115.8	0.315	0.7**
SH-K-14	38.00	1.515	8.630**	2.538	2.156	0.0671**	9.178	2.030	1.138**	17.02	0.293	1.7431**	116.0	0.293	1.7**
SH-K-21	42.75	0.830*	-1.249	2.661	0.667	0.0859**	4.911	0.495*	-0.004	25.15	0.855	0.1169	107.9	0.855	0.1
SH-K-24	35.68	0.152*	0.774	6.243	-0.363*	0.007	3.689	0.149*	0.037	26.41	0.384*	-0.1791	106.6	0.384*	-0.2
SH-K-28	50.14	1.283	13.421**	2.189	-0.095	0.0310**	9.700	1.342*	-0.023	12.73	0.685	-0.0943	120.3	0.686	0.1
SH-K-33	47.13	0.605	4.501**	2.427	0.458	0.0087	4.633	0.798	0.234**	13.51	0.735	-0.0529	119.5	0.735	-0.1
Khanyari	56.91	2.079*	1.190	1.368	0.492*	-0.0042	14.500	1.792*	0.194**	12.93	0.979	0.1353	120.1	-0.979	0.1
Kawdari	47.38	1.304	11.544**	1.758	2.243	0.0569*	11.678	1.444*	0.069	13.20	0.836	0.7318**	119.8	0.837	0.7**
Jumadari	32.78	0.817	2.767**	2.854	-2.150*	0.0022	3.511	0.139*	-0.014	25.09	0.852	1.8761**	107.9	0.852	1.9**
Population mean	35.87	1.00		2.63	1.00		7.73	1.00		19.51	1.00		113.5	1.00	
S.E(±)	**0.93**	**0.32**		**0.08**	**0.52**		**0.20**	**0.18**		**0.41**	**0.28**		**0.40**	**0.30**	

Genotypes	Leaf thickness (mm)			No. of leaves plant-1			Av. leaf weight (g)			Leaf length (cm)		
	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i
SH-K-1	0.447	0.627	0.000	22.38	0.374*	1.997*	20.049	0.611*	-0.062	29.641	1.714	1.245*
SH-K-2	0.472	0.084	0.0001*	22.29	0.408*	0824	20.390	0.659	0.459**	29.721	1.727	1.221*
SH-K-5	0.466	1.002	0.0001	22.11	0.157*	1.612*	20.353	2.123	0.179*	21.032	1.081	1.595*
SH-K-8	0.224	0.644	0.000	56.11	2.827*	20.109**	8.932	0.767	0.234**	22.012	1.480	0.144
SH-K-10	0.218	2.799*	0.0001	20.67	0.396*	-0.2764	14.111	1.259	0.164*	25.287	1.214	0.395
SH-K-11	0.221	1.768	0.000	19.52	0.206*	0.359	19.743	1.304	0.252*	25.023	0.924	0.336
SH-K-12	0.132	0.750	0.000	110.88	4.398*	0.845	8.031	0.334*	-0.053	16.545	0.940	2.027**
SH-K-13	0.147	1.154	0.000	61.31	1.656	16.328**	8.276	0.664*	-0.071	22.268	1.415	-0.1199
SH-K-14	0.187	-0.193*	0.000	48.08	2.692*	24.441**	8.989	0.789	0.008	21.293	1.758	0.964*
SH-K-21	0.286	1.565	0.000	20.72	0.428*	-0.310	12.423	0.508	0.023	23.931	2.037	0.815*
SH-K-24	0.345	0.709	0.0002*	14.17	0.039*	0.1401	14.849	1.022	0.122*	32.188	-1.486*	3.173**
SH-K-28	0.297	1.672	0.0003**	24.67	0.786*	-0.0291	8.993	0.491	0.033	23.620	0.287*	-0.316
SH-K-33	0.247	1.400	0.000	23.38	0.259*	1.387**	10.635	1.572	0.553**	25.785	0.460	0.586
Khanyari	0.233	0.435	0.000	32.91	0.745*	-0.6190	8.393	0.631	-0.049	15.611	0.809	-0.175
Kawdari	0.246	0.799	0.0002**	30.54	0.428*	2.582**	9.110	0.937	-0.023	22.729	0.449	0.656
Jumadari	0.237	0.778	0.000	16.12	0.202*	-0.282	14.536	2.331*	0.176*	28.807	1.194	0.257
Population mean	0.28	1.0		34.12	1.00		12.98	1.00		24.09	1.00	
S.E. (±)	0.005	0.50		1.01	0.18		0.20	0.37		0.52	0.38	

Genotypes	Leaf thickness (mm)			No. of leaves plant-1			Av. leaf weight (g)			Leaf length (cm)		
	X	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i
SH-K-1	16.520	1.291	0.293**	13.07	0.149**	0.107**	216.0	0.525	101.1**	449.2	0.758	723.8**
SH-K-2	16.772	3.992*	0.002	13.51	0.748	0.008	227.3	1.832*	51.7*	454.4	0.770	4447.4**
SH-K-5	15.432	0.952	-0.003	13.76	1.635	0.995**	212.7	1.421	287.7*	451.0	0.660	939.1*
SH-K-8	15.495	1.290	0.036	10.00	0.568	0.407**	155.1	0.740	105.0**	504.2	2.254*	1912.2**
SH-K-10	17.408	4.367*	0.137	13.45	2.718*	0.189**	236.5	3.527*	174.8**	292.9	0.651*	16.6
SH-K-11	14.463	2.081	0.599**	14.25	1.216	0.088*	206.7	1.497	255.4**	286.3	0.543	787.5**
SH-K-12	12.363	2.903*	0.171*	8.50	0.551	0.048	105.3	0.865	-16.5	893.8	3.130*	793.1**
SH-K-13	14.725	-0.047	0.635**	11.30	1.367	0.227**	166.3	0.895	106.5**	510.1	1.425	947.1*
SH-K-14	13.485	-1.245*	-0.018	10.98	1.887*	0.008	147.6	0.842	-1.6	435.7	2.153*	2387.6*
SH-K-21	14.626	-0.261	1.764**	13.24	0.066	0.484**	194.2	-0.014	798.7**	257.9	0.527*	-91.1
SH-K-24	12.231	0.931	-0.063	15.60	0.308*	-0.004	190.8	0.516*	-10.6	210.7	0.174*	157.2
SH-K-28	16.465	-0.130	0.159**	15.77	0.985	-0.007	259.7	0.726	96.9**	222.6	0.646*	149.4
SH-K-33	16.353	-2.552*	0.406**	15.31	1.296	0.001	249.5	0.021*	26.2	249.4	0.568*	-54.4
Khanyari	11.627	0.736	-0.044*	14.02	-0.434	2.612**	162.9	0.047	351.4**	277.3	0.675*	-63.8
Kawdari	16.079	-2.277*	0.277**	13.19	1.907*	0.115**	211.2	0.688	25.9	279.5	0.543*	367.4**
Jumadari	16.546	3.966*	0.062	12.59	1.032	0.248**	209.0	1.891	127.0**	235.4	0.522*	106.2
Population mean	**15.04**	**1.00**		**13.03**	**1.00**		**196.9**	**1.00**		**381.9**	**1.00**	
S.E. (±)	0.28	0.78		0.28	0.41		5.90	0.40		12.00	0.20	

Genotype	Plant height (cm)			Plant spread (cm)			No. of pickings /plant			Days to first leaf picking			Duration of picking		
	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	$\overline{X}$	b_i	Sd^2_i	X	b_i	Sd^2_i	X	b_i	Sd^2_i
SH-K-1	3.145	0.836	-0.0037	5.19	3.504	0.0841**	2.65	0.001	0.0292**	5.63	-0.541*	-0.1872	3.89	1.164	0.041
SH-K-2	3.267	0.738	0.0060	5.30	3.573	0.2137**	2.74	3.455	0.0162**	5.53	0.067	0.1061	3.89	1.971	0.108**
SH-K-5	1.406	1.182	0.0046	3.48	-1.444	0.1124**	2.50	3.396	0.0094**	6.78	1.420	0.0249	5.92	4.374	0.212**
SH-K-8	20973.000	2.238*	0.0095	2.40	-2.175*	0.011	1.20	-0.316	0.0119**	5.47	-0.395	0.586*	3.74	0.485	0.142**
SH-K-10	3.133	1.614	0.0003	2.69	-0.137	0.046**	1.84	1.915	0.0097**	6.24	0.526	0.1844	5.31	1.138	0.350**
SH-K-11	3.423	1.897	0.1122**	4.32	1.578	0.0129*	2.37	-1.661	0.1067**	6.64	1.967	0.598**	4.58	1.339	-0.029
SH-K-12	0.890	0.410	0.0011	1.11	-0.901*	-0.0062*	0.39	1.413	0.002	18.41	6.025*	2.193**	7.31	0.400	0.271**
SH-K-13	1.755	3.677*	0.0029	1.15	0.299	-0.0080*	0.38	0.509	-0.002	19.01	0.912	1.553**	7.26	0.646	0.0324
SH-K-14	2.538	2.156	0.0671**	1.16	-0.339	-0.004	0.52	0.922	0.002	15.10	0.372	2.459**	7.84	4.300	0.305**
SH-K-21	2.661	0.667	0.0859**	2.99	6.934*	0.038**	1.70	-0.902	0.007*	5.61	0.330	0.114	4.29	0.272	0.876**
SH-K-24	6.243	-0.363*	0.007	4.12	2.239	0.079**	2.07	1.693	0.026*	5.22	-0.640*	-0.143	3.61	-0.590*	-0.002
SH-K-28	2.189	-0.095	0.0310**	1.48	0.112	0.060**	1.06	0.672	-0.001	7.08	1.223	0.1261	6.23	3.510	0.757**
SH-K-33	2.427	0.458	0.0087	1.85	1.547	0.216**	0.73	1.574	0.005	12.35	1.805	1.457**	5.97	-6.319*	0.181**
Khanyari	1.368	0.492*	-0.0042	1.10	-0.581*	-0.002	0.69	2.421	-0.001	10.80	2.491	0.688**	7.72	5.069	0.310**
Kawdari	1.758	2.243	0.0569*	1.49	-1.893	0.047**	0.95	-0.017	0.0001	8.07	-0.371	0.369*	6.24	-1.237	1.125**
Jumadari	2.854	-2.150*	0.0022	2.92	3.685	0.991**	1.28	0.924	0.002	9.11	0.810	0.0933	5.03	-0.523	0.126**
Population mean	2.63	1.00		**2.67**	**1.00**		**1.44**	**1.00**		**9.19**	**1.00**		**5.55**	**1.00**	
S.E. (±)	0.08	0.52		0.12	1.52		0.59	1.71		0.41	0.94		0.66	1.54	

SH-K-21, SH-K-28 and *Kawdari* for leaf weight; SH-K-8, SH-K-13, SH-K-11, SH-K-10, *Jumadari*, *Khanyari* and *Kawdari*, for leaf length; SH-K-5, SH-K-8 and SH-K-24 for lamina length; SH-K-2, SH-K-28, SH-K-33 and SH-K-12 for leaf breadth, SH-K-14, SH-K-12 and *Kawdari* for leaf size; SH-K-12, SH-K-13, SH-K-14, SH-K-28, SH-K-33, *Khanyari*, *Kawdari* and *Jumadari* for average midrib weight; SH-K-11, SH-K-13 and SH-K-14 for average stalk weight; SH-K-2, SH-K-5, SH-K-10, SH-K-21, SH-K-28 and *Jumadari* for blade midrib ratio; SH-K-1, SH-K-11, SH-K-13 for leaf: stalk ratio; SH-K-11, SH-K-21, SH-K-28, SH-K-33 and *Khanyari* for days to first leaf picking and SH-K-28, SH-K-33, SH-K-11and SH-K-21 for duration of picking.

Genotypes showing below average stability (b_i significant and > 1) and specifically adapted to favourable environments were *Khanyari* for plant height, SH-K-10 for leaf thickness, SH-K-8, SH-K-13 and *Jumadari* for stem thickness; SH-K-12 for number of leaves; SH-K-8, SH-K-13, SH-K-28 and *Kawdari* for number of pickings; SH-K-2, SH-K-10, SH-K-14, SH-K-33 and *Jumadari* for lamina length, SH-K-14 for leaf breadth, SH-K-1 and SH-K-5 for days to first leaf picking and duration of picking.

The genotypes showing above average stability (b_i significant and <1) in respect of most of the traits were SH-K-1, SH-K-2, SH-K-21 and SH-K-24 for plant height; SH-K-5 and *Khanyari* for plant spread; SH-K-14 for leaf thickness; SH-K-24 and *Khanyari* for stem thickness; SH-K-1, SH-K-12 and SH-K-13 for leaf weight; SH-K-1, SH-K-2, SH-K-10, SH-K-11, SH-K-21, SH-K-24 and *Jumadari* for number of pickings; SH-K-10, SH-K-21, SH-K-24, SH-K-28, SH-K-33, *Khanyari* and *Jumadari* for leaf yield; SH-K-28 for leaf length; SH-K-24 for leaf breadth; SH-K-24 and SH-K-33 for leaf size; SH-K-8, SH-K-12 and *Khanyari* for average stalk weight; SH-K-1 and SH-K-24 for blade: midrib ratio. SH-K-24 for days to first leaf picking as well as duration of picking. These genotypes were above average in stability for various traits and would do better under low management / poor environments. In the present study, no genotype was found stable for yield across environments. However, genotypes SH-K-28, SH-K-33, *Khanyari* and SH-K-21 could be considered stable on the basis of higher average response for many characters. Similar findings have also been reported by Chaubey *et al*. [2] in cabbage. Further the compensating mechanism of component characters in imparting homeostasis being important [3], these genotypes would be useful in future breeding programmes as in a homeostatic genotype, the component characters may shift in a compensatory manner in changing environment to give consistent performance of the economic character.

References

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