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Short Communication

Stability analysis for marketable head yield and its component horticultural traits in cabbage (*Brassica oleracea* var. *capitata* L.) under dry temperate conditions of north-western Himalayas

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In tribal belt of Lahaul and Spiti district of Himachal Pradesh, cabbage (*Brassica oleracea* var. *capitata* L.) is grown as an important off-season vegetable crop during summer from April to early October. The climatic conditions of high hills dry temperate zone are quite conducive for growth and development of the crop. Though, occasionally sharp fluctuation in temperature results in loose heads, thereby lowering the marketable quality and yield. Therefore, it is very essential to know the effect of fluctuating environment on the performance of genotypes with least genotype × environment interaction. Phenotypically stable genotypes are of great importance because environmental conditions vary from season to season and over the years. Hence, wide adaptability in the particular environment alongwith consistent performance of the genotypes is very important for successful cultivation of cabbage. Therefore, the present investigation was aimed to evaluate the hybrids of cabbage over the years and to select the superior hybrids on the basis of stability parameters for marketable head yield and related horticultural traits.

The experimental material for the investigation consisted of 14 hybrids of cabbage from private sector companies which were evaluated during the summer season of 2001 to 2003 at Experimental Farm of Highland Agricultural Research and Extension Centre Kukumseri (32° 44 15" N and 76° 41' 23"E at an elevation of 2672m above mean sea level) district Lahaul and Spiti, Himachal Pradesh, a dry temperate high hill zone in north-western Himalayas. The experiment was laid out in randomized block design with three replications. The seedlings were transplanted at a spacing of 45 cm × 45 cm in a plot size of 2.25m × 2.70m in the last week of May in each year. The recommended package of practices was followed for crop raising. Observations were recorded on five randomly taken plants of each hybrid in each replication for stalk length (cm), non-wrapper leaves, polar diameter (cm), equatorial diameter (cm), gross head weight (kg), net head weight (kg) and head compactness. Marketable head yield was recorded on plot basis and was converted to quintals/ha. The three seasons i.e., summer 2001, summer 2002 and summer 2003 were considered as three environments in stability analysis. The data were analyzed for stability parameters according to the method suggested by Eberhart and Russell [1].

The analysis of variance (Table 1) indicated highly significant differences among genotypes and diversity in environments for all the traits except for net weight of head among genotypes and polar diameter and equatorial diameter among environments. The mean squares due to Genotype × Environment interaction were significant for majority of the traits indicating differential response of genotypes to different environments except stalk length and equatorial diameter. These results further corroborate the findings of Chaubey *et al.*, [2, 3]. High and significant mean squares of environment (linear) showed considerable differences among environments prevailed over three years due to variation in environmental conditions. Genotype × Environment interaction (linear) component against pooled deviation was significant for marketable head yield and non-wrapper leaves which revealed that linear regression was the major component responsible for differences in stability whereby the performance can be predicted for these traits with some reliance under different environments. However, prediction for the unpredictable traits can be made by considering the stability parameters of individual genotypes [4].

Stability parameters (Table 2) for marketable head yield revealed that genotypes Hybrid 601 and Madhavi possessed higher mean values and non-significant regression coefficients greater than unity (bi > 1) and non significant deviation from regression showing their stablity and suitability to favourable environments. The genotypes Bahar, Unnati, Equitoria and T-621 possessed higher mean values and non significant regression coefficient less than unity (bi < 1) and deviation from regression and hence, were stable and suitable to unfavourable environments. Though the genotype Summer Queen gave the highest marketable head yield but was unpredictable on account of significant deviation from regression. Lesser number of non-wrapper leaves

Table 1. Pooled analysis of variance (mean squares) for different horticultural traits in cabbage hybrids

Source of variation	df	Marketable head yield (q/ha)	Stalk length (cm)	Non-wrapper leaves	Polar diameter (cm)	Equatorial diameter (cm)	Gross head weight (kg)	Net head weight (kg)	Head compactness
Genotypes	13	23779.32**	0.37*	17.17**	2.30**	6.11**	0.28**	0.07	95.56**
Environments	2	33950.56**	0.63*	33.29**	0.68	1.13	1.14**	0.29**	239.39**
Genotype × environment	26	2660.51**	0.11	2.10**	0.52**	0.38	0.04*	0.03**	23.74**
Environment + (G × E)	28	4895.51	0.15	4.33**	0.53	0.44	0.11	0.05	39.14
Environment (linear)	1	67901.95**	1.26**	66.58**	1.35*	2.26*	2.27**	0.58**	478.78**
Genotype × environment (linear)	13	2104.29**	0.10	2.95*	0.50	0.33	0.02	0.01	22.07
Pooled deviation	14	2986.90**	0.11	1.16**	0.51**	0.40	0.05**	0.04**	23.58**
Pooled error	78	384.95	0.07	0.52	0.19	0.24	0.007	0.005	7.61

*,** Significant at P = 0.05 and P = 0.01, respectively

Table 2. Stability parameters for different yield and its related traits in cabbage hybrids

S. No.	Hybrid	Marketable head yield			Non-wrapper leaves			Polar diameter			Gross head weight			Net head weight			Head compactness		
		Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di
1.	Bahar	607.53	0.97	325.19	19.61	1.28	55.34	2.68	−7.61	0.50	13.14	−1.93	−0.18	1.88	1.07	0.0	1.16	0.60	0.00
2.	Smriti	449.78	1.01	3953.93*	21.14	0.76	37.41	1.13	−6.55	−0.37	13.18	−0.66	−0.14	1.54	0.64	0.01	0.78	0.37	0.00
3.	Hybrid 601	562.99	1.99	360.50	17.34	0.90	50.14	0.21	−6.01	2.72*	12.95	2.09	0.82*	1.53	0.97	0.0	1.04	1.19	0.00
4.	Madhavi	537.94	2.49	564.31	13.17	0.39	42.26	0.41	−3.47	−0.48	13.91	5.16	0.64**	1.38	1.01	0.04**	1.01	1.40	0.04*
5.	Unnati	560.47	0.77	451.00	20.37	2.84	47.14	1.32	0.11	−0.23	12.73	0.69	0.19	2.16	1.20	0.10*	1.22	1.46	0.08*
6.	BSS-50	308.21	0.54	7524.07*	17.32	0.12	42.36	2.23	−5.50	5.72*	12.03	1.50	1.17*	1.38	0.98	0.04**	0.87	1.46	0.02**
7.	Bajrang	461.07	1.09	163.54	19.20	0.65	45.55	0.35	6.50	0.56	13.16	4.02	−0.11	1.54	1.25	0.00	0.94	1.11	0.00
8.	Green boy	432.86	1.27	4952.75*	19.75	0.59	36.99	1.77	36.69**	1.21	14.11	0.70	1.06*	1.51	1.44	0.16*	0.96	1.66	0.09*
9.	Varun	454.18	1.53	4606.80*	16.87	0.07	45.09	1.05	5.38	−0.52	12.75	0.59	−0.16	1.29	0.72	−0.01	0.86	0.56	0.00
10.	Equitoria	558.46	0.76	−288.86	21.53	1.87	43.20	0.51	57.12*	0.41	12.11	0.30	0.06	2.14	1.62	0.09*	1.17	1.34	0.13*
11.	Green globe	413.49	0.49	9677.28*	15.67	1.50	41.23	1.01	3.23	−0.29	12.31	2.37	0.38	1.32	0.94	0.06*	0.86	1.06	0.05*
12.	Mitra	424.22	0.50	905.59	18.40	1.36	48.44	−0.10	30.33**	0.00	11.93	3.30	−0.17	1.37	0.89	0.00	0.90	0.66	0.00
13.	Summer queen	629.12	0.07	3525.54*	15.26	1.57	41.04	0.30	36.15**	−0.05	12.36	−1.29	1.00**	2.00	0.54	0.14*	1.27	0.28	0.13*
14.	T-621	543.55	0.67	356.09	17.14	0.12	33.92	1.13	77.22*	−0.23	14.99	−2.83	−0.10	1.47	0.72	0.00	1.08	0.86	0.00
Population mean		495.99			18.06			43.50			12.98			1.61			1.01		
S.E. (mean) ±		38.65			0.76			3.43			0.50			0.16			0.15		
S.E. (bi) ±		0.78			0.49			0.83			2.29			0.57			1.03		

bi = non significantly different from unity, S^2di, *,**= significantly different from zero at P = 0.05 and P = 0.01, respectively

is desirable in cabbage. Madhavi, Varun and T-621 were stable and suitable to unfavourable environments whereas Summer Queen and Green Globe for favourable environments. The genotypes Bahar, Smriti, Bajrang and T-621 had higher mean values for polar diameter with non-significant regression coefficient greater than unity for Bajrang, Bahar and T-621 and less than unity for Smriti and accordingly suited to favourable and unfavourable environments, respectively with predictable performance. The genotype Bahar was found to be stable with higher mean value for gross head weight on account of non-significant regression coefficient around unity and non significant deviation from regression.

On the basis of net-head weight, Bahar and T-621 were observed to be stable and suitable to unfavourable environment while Hybrid 601 for favourable environment. The genotypes Bahar, Unnati and Varun had higher mean values for head compactness alongwith stability and suitability to favourable environment. On the other hand, Hybrid 601 and Bajrang were suitable and stable to unfavourable environment. Similar findings for majority of these horticultural traits in some of these hybrids have also been reported in cabbage under different environments (2 and 3).

The genotypes Bahar and T-621 were found stable with predictable performance for majority of the traits studied. Therefore, these two are most suitable and recommended for cultivation under high hill dry temperate conditions of Himachal Pradesh. The present study revealed the fact that hybrids, in general, have an edge not only for increased yield but also exhibit greater stability in production across environments [5].

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