Indian Journal of Agricultural Sciences **80** (2): 116–18, February 2010

Character association and path analysis of morphological and economic traits in cabbage (*Brassica oleracea* var. *capitata*)

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Received: 3 September 2008; Accepted: 11 December 2009

ABSTRACT

The character association and path co-efficient analysis was carried out during 2005–07 after field evaluation of 36 genetically diverse exotic and indigenous genotypes of cabbage (*Brassica oleracea* L. *capitata* L.). The positive association between days to 50% maturity and number of non-wrapper leaves suggested the selection of plants having less number of non-wrapper leaves so as to evolve early-maturing genotypes. Negative association of head compactness with polar diameter, equatorial diameter, frame spread, plant height, gross plant weight and core length, on the other hand, implied to select plants with smaller measurements for the latter morphological and economic traits which will not only help in improved compactness of head but also in marketability, shelf-life and consumers' preference. Gross plant weight proved to be the most effective direct selection index for genetic improvement of cabbage.

Key words: Cabbage, Correlation, Horticultural trait, Interrelationship, Path analysis, Vegetable breeding

Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most important cole crops grown under temperate to tropical climatic conditions for its head in more than 90 countries throughout the world (Singh *et al.* 2009). It is a rich source of sulphur containing amino acids, minerals, carotenes, ascorbic acid and antioxidants, and is reported to have anti-carcinogenic property (Singh *et al.* 2009 and Kopsell *et al.* 2004). The increasing popularity due to adaptability, cheaper and round-the-year availability, and as an integral and inseparable component of the fast food industry has made it necessary to initiate breeding efforts targeted towards genetic improvement of cabbage. Net head weight and other yield-contributing traits are quantitative in nature and influenced by environment. The knowledge of interrelationships among various components and their direct and indirect effects on net head weight are the important pre-requisites to bring genetic improvement in cabbage.

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MATERIALS AND METHODS

Thirty-six diverse exotic and indigenous genotypes of cabbage, viz 'CMS-GA', 'Golden Acre', '83-1', '83-2', 'Pride of Asia', 'AC 204', 'EC 490174', 'Pusa Mukta', 'C 4', 'Red Cabbage', C 2, 'AC 1019', 'EC 490192', 'MR 1', 'AC 208', 'AC 1021', 'CMS 3', 'Pusa Drum Head', 'EC 490189', 'C 6', 'C 8', 'Red Rock Mammoth', 'Sel 6', '83-5', 'KIRC 1A', 'KIRC 8', 'KIRC1 1', 'KIRC 2', 'KIRC 10', 'KIRC 9', 'EC 490162', 'ARU Glory', 'Fieldman K', 'C 3', 'Kinner Red' and 'Pride of India' were evaluated at Naggar Farm of IARI Regional Station, Katrain, Kullu, Himachal Pradesh in a randomized block design with 3 replications during 2005–07. The Farm is located at 32.12°N latitude and 77.13°E longitude at an altitude of 1 690 m above mean sea level. The farm receives 1 000–1 100 cm rainfall and 1 100–1 300 mm snowfall annually. The plot size was 2.7 m × 2.7 m and inter- and intra- row spacing was kept 45 cm each. The nursery was raised in first week of August and 30-days-old seedlings were transplanted in experimental plots. All the recommended package of practices was followed to raise the crop. The observations were recorded on 10 randomly marked plants of each genotype in each of the 3 replicates for the traits like frame spread (cm), plant height (cm), gross plant weight (kg), net head weight (kg), number of non-wrapper leaves, stalk length (cm), polar diameter (cm), equatorial diameter (cm) and core length (cm). Data on days to 50% maturity, however, were taken on whole plot basis.

Harvest index (%), head shape index and head compactness were computed from original measured data. The compactness of head was determined as per formula given by Pearson (1931). The correlation and path co-efficient at phenotypic level was worked out from pooled data employing the formula of Searle (1961), and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSIONS

Correlation co-efficients of net head weight and other contributing economic traits were analyzed to observe the direction and magnitude of associations at phenotypic level (Table 1). The association of characters and the magnitude of their relationship with other characters at phenotypic level revealed that net head weight had significant positive correlation with gross plant weight, equatorial diameter, polar diameter, frame spread, plant height, core length and harvest index (0.794*, 0.745*, 0.639*, 0.599*, 0.587*, 0.420* and 0.370*, respectively). Thus, it may be inferred that the selection based on these traits either in combination or alone would be beneficial to identify the genotypes having better yield potential. Similar views have been reported by Ghebramlak (2002) and Prakash (2004). Non-significant positive correlation of number of non-wrapper leaves with net head weight is in line with Ghebramlak (2002). The negative correlation of head shape index with net head weight (–0.387*) implied that flat or drum head type plants or genotypes would produce cabbage heads with higher net head weight which otherwise was not desirable from the viewpoint of consumers and marketing. Days to 50% maturity showed positive correlation with number of non-wrapper leaves (0.341*) which suggested the selection of early genotypes of cabbage based on less number of non-wrapper leaves. Frame spread had significant positive correlation with gross plant weight, equatorial diameter, plant height, polar diameter, net head weight and core length; whereas significant negative correlation with head compactness and head shape index. Significant positive correlation of frame spread with net head weight is not desirable as increased frame spread will result in accommodating a lesser number of plants/unit area. Stalk length showed a significant positive correlation with core length (0.347*) which can be used for selecting the plants with smaller stalk along with shorter core. The negative association of head compactness with polar diameter, equatorial diameter, frame spread, plant height, gross weight and core length (–0.732*, –0.677*, –0.461*, –0.437*, –0.397* and –0.357* respectively) suggested to select the genotypes producing plant with relatively less measurements for the latter morphological and economic traits. This will prove fruitful not only in increasing the compactness of head but also marketability, shelf-life and consumers' preference.

Correlation co-efficients indicate only the general association between any two traits without tracing any possible causes of such association. In such situation, the path co-efficient analysis at phenotypic level (Table 2) is done to partition the correlation co-efficient into direct and indirect effects. Net head weight was taken as dependent variable while computing the path co-efficient and only directly measured traits (leaving deduced parameters, like harvest index, head shape index and head compactness) were taken into consideration to avoid confusion on further partitioning effects. Positive direct effect on the net head weight was the highest for gross plant weight (0.787), followed by equatorial and polar diameter (0.231 and 0.097), stalk length, core length and number of non-wrapper leaves (0.074, 0.038 and 0.018); while plant height, days to 50% maturity and frame spread reflected a negative direct effect (–0.182, –0.176 and –0.121). The gross plant weight and days to 50% maturity showed positive and negative direct effect,

Table 1 Phenotypic correlation co-efficients for morphological and economic traits of cabbage genotypes

Trait	Days to 50% maturity	Frame spread	Plant height	Gross plant weight	Net head weight	No. of non-wrapper leaves	Stalk length	Polar diameter	Equatorial diameter	Core length	Harvest index	Head shape index	Head compac-tness
Days to 50% maturity		0.175	0.163	0.094	–0.179	0.341*	0.091	–0.017	–0.173	0.098	–0.500*	0.307	0.085
Frame spread (cm)			0.667*	0.797*	0.599*	0.310	–0.022	0.607*	0.712*	0.480*	–0.213	–0.361*	–0.461*
Plant height (cm)				0.801*	0.587*	0.345*	0.202	0.732*	0.574*	0.629*	–0.257	0.013	–0.437*
Gross plant weight (kg)					0.794*	0.387*	–0.035	0.708*	0.755*	0.492*	–0.234	–0.304	–0.394*
Net head weight (kg)						0.226	–0.032	0.639*	0.745*	0.420*	0.370*	–0.387*	–0.205
No. of non-wrapper leaves							0.024	0.208	0.153	0.179	–0.222	0.011	–0.070
Stalk length (cm)								–0.091	–0.144	0.347*	–0.057	0.166	0.207
Polar diameter (cm)									0.739*	0.562*	–0.028	0.050	–0.732*
Equatorial diameter (cm)										0.440*	0.107	–0.618*	–0.677*
Core length (cm)											–0.112	0.047	–0.357*
Harvest index (%)												–0.239	0.220
Head shape index													0.160

*Significant at P=0.05 % level

Table 2 Phenotypic path co-efficient of morphological and economic traits showing the direct and indirect effects on net head weight

Trait	Days to 50% maturity	Frame spread	Plant height	Gross plant weight	No. of non-wrapper leaves	Stalk length	Polar diameter	Equatorial diameter	Core length	'r' value with net head weight
Days to 50% maturity	**–0.176**	–0.021	–0.030	0.074	0.006	0.007	–0.002	–0.040	0.004	–0.179
Frame spread (cm)	–0.031	**–0.121**	–0.121	0.627	0.005	–0.002	0.059	0.164	0.018	0.598*
Plant height (cm)	–0.029	–0.081	**–0.182**	0.631	0.006	0.015	0.071	0.132	0.024	0.587*
Gross plant weight (cm)	–0.017	–0.096	–0.146	**0.787**	0.007	–0.003	0.069	0.174	0.019	0.794*
No. of non–wrapper leaves (cm)	–0.060	–0.038	–0.063	0.305	**0.018**	0.002	0.020	0.035	0.007	0.226
Stalk length (cm)	–0.016	0.003	–0.037	–0.027	0.000	**0.074**	–0.009	–0.033	0.013	–0.032
Polar diameter (cm)	0.003	–0.073	–0.133	0.557	0.004	–0.007	**0.097**	0.170	0.021	0.639*
Equatorial diameter (cm)	0.031	–0.086	–0.104	0.594	0.003	–0.011	0.072	**0.231**	0.017	0.747*
Core length (cm)	–0.017	–0.058	–0.114	0.387	0.003	0.026	0.055	0.101	**0.038**	0.421*

Residual effect = 0.1719
Bold values indicate direct effect, while others indirect effect.
*significant at *P*=0.05 % level.

respectively (0.787 and –0.176) on net head weight which are quite close to its correlation coefficients (0.794 and –0.178), and indicated that a direct selection through these traits would be very effective. High correlation co-efficient along with negative direct effects for frame spread and plant height, and positive but lower values of direct effects for the traits such as polar diameter, equatorial diameter and core length are the result of indirect effect via gross plant weight. Hence, gross plant weight proved to be the most effective selection index while carrying out genetic improvement in cabbage. Lower residual effect (0.1719) revealed that that all the traits under study accounted for 82.81% of variability towards net head weight.

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