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Estimates of genetic variability and correlation studies for some quality traits in cabbage (*Brassica oleracea* var. *capitata*)*

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Among the cole crops, cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most important vegetable being grown and consumed widely around the globe (Singh *et al*. 2010). Cabbage head is a rich source of protein, minerals and antioxidants, which is reported to have anti-carcinogenic properties (Singh *et al*. 2009 and Ghebramlak *et al.* 2004). It is also rich source of ascorbic acid, carotene (pro. Vit. A) and has high fiber content and calcium which reduce the risk of colon cancer. Improvement in any crop depends on the magnitude of genetic variability and the extent of transmission of characters from one generation to the next. The net head weight and its component characters are polygenic in nature, hence, influenced by the environmental factors. In spite of immense economic and medicinal importance, dry matter and total minerals content of the cabbage neglected traits in breeding programmes and practically very little information is available about the genetic variability of minerals in cabbage. Therefore, it is essential to partition the overall variability into its heritable and non-heritable components, which will enhance the precision of selection. Thus, the present study was conceived with objective to examine the magnitude and the direction of variability, inter-relationship and path analysis for minerals content and identify/developing superior genotypes for obtaining higher yield with good quality traits in cabbage.

The experimental materials comprised 30 cabbage genotypes of tropical and sub-tropical origin belonging to white, red and savoy types. Each genotype was planted in a plot having 3.0 × 2.7 m area in randomized block design with three replications. Thus, there were 25 plants in each plot planted at row and plant spacing of 60 cm × 45 cm. All the standard package of practices and plant protection measures were timely adopted to raise the crop successfully. Five randomly selected plants from each replication were utilized for recording observations and drawing sample for estimating quality parameters in the Laboratory of the Department of Applied Plant Science (Horticulture), BBAU, Lucknow during the winter seasons of 2007 and 2008. The ascorbic acid and total carotene were estimated as per method of Ranganna (1986); Sulphur through flame photometer (Chesnin and Yien 1951), potassium through spectrophotometer (Jackson 1967) and calcium, iron and zinc through atomic absorption spectrophotometer. The genotypic and the phenotypic coefficients of variation were calculated by the formulae given by Burton (1951), heritability in broad sense and genetic advance as percent of mean were computed following the methods of Allard (1960) and Johnson *et al.* (1955), respectively. Correlation coefficient analysis was calculated as per formulae suggested by Al-jibouri *et al.* (1958).

The analysis of variance for eight quality traits revealed that mean square were highly significant for all. The extent of variability with respect to various characters in different diverse genotypes of cabbage measured in terms of general mean, range, coefficients of variation along with the amount of heritability in broad sense and expected genetic advance as per cent of mean for eight quality characters (Table 1). A wide range variation was observed for all most all the traits. C 10 recorded the maximum amount of sulphur (75.30), carotenoids (95.84), ascorbic acid (39.95), iron (0.82), potassium (296.65), zinc (0.31), calcium (57.90) and dry matter (9.67). However, absolute variability in different traits does not permit in deciding as to which character is showing the highest degree of variability, the relative values of phenotypic variance, genotypic variance and coefficients of variations (PCV and GCV). Therefore, it gives an idea about

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Table 1 Estimates of genetic constants for different quality characters in some cabbage genotypes

Trait	Range		Mean ± SE (m)	Coefficient of variation		Heritability (%)	Genetic advance	Genetic gain
	Min.	Max.		Phenotypic	Genotypic			(%)
Ascorbic acid (mg/100g)	9.75	39.95	21.40 ± 0.44	29.38	29.16	98.50	12.76	59.65
Carotenoids (ìg/100g)	27.05	95.84	49.37 ± 0.63	25.52	25.42	99.30	25.76	52.18
Sulphur (mg/100g)	22.15	75.30	41.91 ± 0.46	26.30	26.23	99.50	22.59	53.90
Iron (mg/100g)	0.23	0.82	0.48 ± 0.03	26.86	24.29	81.80	0.22	45.83
Potassium (mg/100g)	196.25	296.65	234.35 ± 1.39	8.39	8.33	98.50	39.89	17.02
Zinc (mg/100g)	0.13	0.31	0.20 ± 0.01	18.08	14.07	60.50	0.05	25.00
Calcium (mg/100g)	41.25	57.90	46.38 ± 0.56	7.54	7.25	92.30	6.65	14.34
Dry matter (mg/100g)	6.80	11.58	9.67 ± 0.30	12.80	11.64	82.80	2.11	21.82

the magnitude of variability present in a population. In the present investigation, the information obtained showed that the estimates of phenotypic coefficient of variation were higher than the genotypic coefficient of variation meaning thereby that the apparent variation was not only due to genotypes but also influenced by environment.

The phenotypic and genotypic coefficient of variation was higher for ascorbic acid (29.38 and 29.16) and lowest for calcium (8.29 and 8.16). These results indicated that higher magnitude of genotypic coefficient of variation for the above traits offer a better opportunity for improvement through selection. The results are in consonance with Singh *et al.* (2009). The genotypic coefficient of variation provides help to measure the genetic variability in a character and accordingly, it is not possible to partition existing heritable variation in population based solely on this estimate. Burton (1953) suggested that genotypic coefficient of variation together with heritability estimates would give the best result of the amount of genetic advance to be expected from selection. High estimates of heritability (broad sense) were obtained for all the characters except zinc and dry matter. The heritability in broad sense ranged from (60.50 to 99.50). Higher values of heritability were obtained for sulphur (99.50) while zinc (60.50) showed the lowest values of heritability which indicate that they were least affected by environment modification and selection based on phenotypic performance would be reliable. Ghebramlak *et al.* (2004) also reported higher heritability for all characters except zinc and dry matter.

The genetic advance as per cent of mean ranged between 14.34 and 59.65%. High genetic advance was recorded for ascorbic acid (59.65%), sulphur (53.90%) and total carotenoids (52.90%). However, the heritability estimates along with genetic advance is more useful than heritability values alone for selecting individual. From this point of view, ascorbic acid and sulphur possessed greater estimates of genetic advance as per cent of mean coupled with high amount of heritability indicating that these traits are governed by additive gene action and continued selection would be helpful in modifying the selection procedure. The characters like zinc and dry matter showed low heritability with moderate to low genetic advance as per cent of mean indicated non-additive gene action and can be improved through multiple crosses. Singh *et al*. (2010) reported low heritability estimates for all the characters except sulphur and total carotenoids. High estimates of heritability along with high genetic advance provide good scope for further improvement in advance generation if characters subject to mass progeny or family selection.

The phenotypic as well as genotypic correlations between different pairs of traits (Table 2) showed higher estimates of correlation coefficient than the corresponding phenotypic. This indicated little role of environment in the expression of genetic relationship on the phenotypes. The dry matter significant and positive correlation coefficients with all quality traits (sulphur, ascorbic acid, carotenoids, iron, potassium, calcium and zinc). Ghebramlak *et al*. (2004) also reported a positive correlation coefficient with all the quality characters. The significant positive associations suggest that selection should be oriented towards higher content of total carotenoids, ascorbic acid, sulphur, calcium, iron, potassium and zinc and thus, ultimately resulting in higher dry matter content. The highly significant and positive association among the various quality traits indicated immense scope for the nutritional quality improvement in cabbage.

SUMMARY

The genetic variability, inter-relationship and path analysis for quality traits were studied in 30 diverse cabbage genotypes. A wide range of variation was observed for all most all traits. C 10 recorded the maximum amount of sulphur, carotenoids, ascorbic acid, iron, potassium, zinc, calcium and dry matter. Phenotypic coefficient of variation and genotypic coefficient of variation were highest for ascorbic acid and lowest for potassium and calcium. High heritability estimates were observed for all the quality

Table 2 Estimates of genotypic (G) and phenotypic (P) correlation coefficients for the biochemical (quality) traits in cabbage genotypes.

Traits		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	G	1.000	0.602**	0.372**	0.496**	0.343*	0.519**	0.298*	0.494**
	P	1.000	0.598**	0.369**	0.448**	0.341*	0.417**	0.276*	0.468**
X_2	G		1.000	0.319*	0.857**	0.600**	0.419**	0.544**	0.675**
	P		1.000	0.317*	0.771**	0.594**	0.327*	0.496**	0.644**
X_3	G			1.000	0.182	0.360**	0.696**	0.285*	0.595**
	P			1.000	0.169	0.356**	0.536**	0.259*	0.570**
X_4	G				1.000	0.479**	0.371**	0.320*	0.696**
	P				1.000	0.431**	0.254*	0.272*	0.601**
X_5	G					1.000	0.297*	0.251	0.403**
	P					1.000	0.236	0.235	0.383**
X_6	G						1.000	0.422**	0.559**
	P						1.000	0.282*	0.413**
X_7	G							1.000	0.358**
	P							1.000	0.313*
X_8	G								1.000
	P								1.000

*Significant at $P = 0.05$ ** significant at $P = 0.01$; X_1, Ascorbic acid (mg/100g) X_2 = Total carotenoids (ìg/100g); X_3 = Sulphur (mg/100g) X_4, Iron (mg/100g); X_5, Potassium (mg/100g) X_6, Zinc (mg/100g); X_7, Calcium (mg/100g) X_8, Dry matter (mg/100g)

characteristics, except for zinc and dry matter percent. Ascorbic acid and sulphur content, high genetic advance as percentage of mean coupled with high heritability and low genetic advance as percentage of mean indicated non additive gene action for expression of calcium and potassium. The genotypic correlation coefficient higher than the corresponding phenotypic correlation coefficient for all the parameters. The dry matter had significant and positive correlation with all quality traits. Thus, these traits may effectively be used as a selection criterion for screening potential genotypes in a breeding programme.

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