Genetic Variability for Morphological and Qualitative Traits in Cabbage *(Brassica oleracea* var. *capitata* L.)

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(Received: 25 September 2010; Revised: 15 March 2012; Accepted: 18 March 2012)

An experiment was conducted during the winter season of 2006-2008 to investigate the genetic variability for morphology and quality traits in 30 diverse cabbage genotypes. Wide range of variation was observed for all most all morphological and qualitative traits. The study showed high rang for yield, days to maturity and leaf length. The highest estimates of PCV and GCV were for stalk length and low for leaf width. High estimates of heritability were noticed for yield while gross weight showed low heritability. Positive and significant association of yield was observed with all the characters except days to maturity ant stalk length at both genotypic and phenotypic level. C-10 recorded the maximum amount of sulphur, carotenoids, ascorbic acid, iron, potassium, zinc, calcium and dry matter. Estimate of phenotypic coefficient of variation were higher than the genotypic coefficient of variation indicating that the apparent variation was not only due to genotypes but also due to environment. The genotypic correlation coefficient is higher than the corresponding phenotypic correlation coefficient for all the parameters. The dry matter had significant and positive correlation with all quality traits. Positive direct effect on the dry matter was the highest for sulphur followed by iron. Total carotenoids and potassium exhibited a negative direct effect on dry matter content but this negative direct effect was neutralized due high positive indirect effect through sulphur content on dry matter. Thus, these traits may be effectively be used as a selection criterion for screening potential genotypes in a breeding programme.

Key Words: Quality, Germplasm, Chapatti quality, Bread loaf volume, Bread quality

Introduction

Among the Cole crops, cabbage (*Brassica oleracea* var. *capitata* L. 2n = 2x = 18) is one of the most important vegetable being grown in more than ninety countries throughout the world and consumed widely around the globe (Chiang *et al*., 1993; Singh *et al*., 2010). It belongs to the family Brassicaceae, which includes Brussels sprouts, broccoli, collards, cauliflower, knol-khol and kale. The cabbage head is best described as a single, large terminal bud comprising of tightly overlapping leaves attached to and enclosing most of the un-branched short stem. The different cultivated type of cabbage show great variation in respect of shape, size and colour of leaves as well as texture of the head (Singh *et al.,* 2006). The head shape ranges from pointed ellipsoidal to flattened drum heads. Spherical or nearly spherical heads are preferred. Foliage is either with or without waxy surface. Leaf texture may be smooth or savoy types. It is a rich source of protein comprising all essential amino acids, especially sulphur containing amino acids, minerals such as calcium, iron, magnesium, sodium, potassium, phosphorus and antioxidants, which is reported to have anti-carcinogenic properties (Singh *et al*., 2009, Ghebramlak *et al.,* 2004; Kopsell *et al.,* 2004). It is also rich source of ascorbic acid, carotene (pro. Vitamin 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

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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.

Materials and Methods

The experimental materials comprised of 30 cabbage genotypes (Table 1). Each genotype was planted in a plot having 3.0 × 2.7 m area in a randomized block design with three replications. Thus, there were 25 plants in each plot planted at row and plant spacing of 60 × 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 season of 2006 to 2008. The ascorbic aid 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 mean values obtained from 2 years data were used for estimating the analysis of variance (Panse and Sukhatme, 1978). 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.

Table 1. Diverse genotypes of cabbage and their sources under study.

Genotypes	Sources
1923	IARI, New Delhi
C – 1	IARI, Katrain
C – 2	IARI, Katrain
C – 3	IARI, Katrain
C – 4	IARI, Katrain
C – 5	IARI, Katrain
C – 6	IARI, Katrain
C – 7	IARI, Katrain
C – 8	IARI, Katrain
C – 9	IARI, Katrain
C – 10	IARI, Katrain
C – 11	IARI, Katrain
C – 12	IARI, Katrain
C – 13	IARI, Katrain
C – 14	IARI, Katrain
C – 15	IARI, Katrain
C – 16	IARI, Katrain
C – 17	IARI, Katrain
EDH	IARI, New Delhi
Golden Acre	IARI, New Delhi
KK – 3	IARI, New Delhi
KK - 2	IARI, New Delhi
MR - 1	IARI, Katrain
Prem Nath	IARI, Katrain
Pride of India	IARI, Katrain
Pusa Agetti	IARI, New Delhi
Pusa Mukta	IARI, Katrain
Pusa Synthetic	IARI, Katrain
Red Cabbage - 2	IARI, Katrain
RRM	IARI, Katrain

Results and Discussion

Analysis of variance for eleven morphological traits revealed significant differences among the genotypes for all the traits under study. The estimates of genetic parameter of variability viz., phenotypic and genotypic coefficient of variation (PCV and GCV) along with heritability in broad sense (h2) and genetic advance (GA) as percentage of mean for different characters are given in Table 2. The study showed high range for marketable yield (11.10 - 56.60 t/ha), days to maturity (71.28 - 110.53) and leaf length (15.95 - 46.02 cm). The highest estimates of PCV and GCV were for stalk length (PCV = 40.42, GCV = 39.21) followed by core length (PCV = 37.43, GCV = 36.02) and yield (PCV = 37.07, GCV = 36.87) and low for leaf width (PCV = 21.51, GCV = 21.12) followed by polar length (PCV = 16.85, GCV = 16.47) and days to maturity (PCV = 12.91, GCV = 11.50). Narrow differences between PCV and GCV gave evidence to the genotypes that the variability exiting in them was mainly due to their genetic make up. High estimates of heritability was noticed for yield (98.90%) followed by leaf length (97.30%) and equatorial length (97.10%). Number of non-wrapper leaves, head weight, core length and stalk length showed moderate heritability estimates (Atter *et al.,* 2009). Days to maturity (79.40%) and gross weight (78.60%) showed low heritability estimates. High heritability in broad sense indicated that large proportion of phenotypic variance was attributable to the genotypic variance and were less influenced by environment. High percentage of genetic gain was observed for yield (75.54%) whereas it was low for days to maturity (21.10%) and polar length (33.16%). Hence, selection can bring worthwhile improvement in these traits.

The analyses of variance for eight quality traits revealed that mean square were highly significant for all genotypes. The extent of variability with respect to various characters in different diverse genotypes of cabbage

Table 2. Estimates of genetic constants for different morphological and yield characters in some cabbage genotypes

Character	Range		Mean	Coefficient of variation		Heritability (%)	Genetic advance	Genetic gain (%)
	Min.	Max.		Phenotypic	Genotypic			
Days to maturity	71.28	110.53	86.96	12.91	11.50	79.40	18.36	21.10
No. of non – wrapper leaves	5.40	23.70	15.16	25.00	24.25	88.90	7.14	47.09
Core length (cm)	2.31	13.85	7.95	37.43	36.02	92.60	5.62	70.69
Stalk length(cm)	2.36	9.46	4.78	40.42	39.21	94.10	3.75	78.45
Leaf width (cm)	14.35	42.75	26.68	21.51	21.12	96.40	11.40	42.73
Leaf length (cm)	15.95	46.02	25.49	22.78	22.47	97.30	11.64	45.66
Equatorial length (cm)	12.10	31.10	20.05	24.19	23.84	97.10	9.71	48.42
Polar length (cm)	12.43	27.40	19.60	16.85	16.47	95.50	6.50	33.16
Gross weight (kg)	1.20	3.55	2.10	28.28	25.03	78.60	0.96	45.71
Head weight (kg)	0.49	2.33	1.24	32.23	30.13	87.40	0.72	58.06
Yield (t/ha)	11.10	56.60	24.78	37.07	36.87	98.90	18.72	75.54

Table 3. Estimates of genetic constants for different quality characters in some cabbage genotypes

Traits	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
Calcium (mg/100g)	41.25	57.90	46.38 ± 0.56	7.54	7.25	92.30	6.65	14.34
Carotenoids (μg/100g)	27.05	95.84	49.37 ± 0.63	25.52	25.42	99.30	25.76	52.18
Dry matter (mg/100g)	6.80	11.58	9.67 ± 0.36	12.80	11.64	82.80	2.11	21.82
Iron (mg/100g)	0.23	0.82	0.48 ± 0.03	26.86	24.29	81.80	0.22	15.83
Potassium (mg/100g)	196.25	296.65	234.35 ± 1.39	8.39	8.33	98.50	39.89	17.02
Sulphur (mg/100g)	22.15	75.30	41.91 ± 0.46	26.30	26.23	99.50	22.59	53.90
Zinc (mg/100g)	0.13	0.31	0.20 ± 0.01	18.08	14.07	60.50	0.05	25.00

measured in terms of general mean, range, coefficients of variation along with the amount of heritability in broad sense and expected genetic advance as percent of mean for eight quality characters are presented in Table 3. 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). 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 environment also influenced.

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. These results are in consonance with those of Singh *et al.* (2007) and 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 and Devane (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. Panse and Sukhatme (1978) expressed that if a character is governed by additive gene action, heritability and genetic advance both would be high. 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.

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