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Variance components and correlation of economic traits in tropical cabbage (*Brassica oleracea* var. *capitata*)

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ABSTRACT

Variance components and character association of economic traits were analyzed in 31 genetically diverse genotypes of tropical cabbage (*Brassica oleracea* var *capitata*) during 2012-14. Wide range of variability was observed for important economic traits like net head weight, gross plant weight and number of non-wrapping leaves. High heritability coupled with high genetic advance was observed for days to harvest. Net head weight showed significant positive correlation with days to harvest, plant spread, gross plant weight, leaf width, leaf length, head width, stalk length and number of wrapping and non-wrapping leaves. The significant positive inter relationships point to the need for simultaneous selection among these characters for improvement of yield. Path analysis showed that gross plant weight, leaf length and head width are the characters to be considered in direct selection for genetic improvement in tropical cabbage.

Key words: Cabbage , Correlation, Path analysis, Variability

Cabbage (*Brassica oleracea* var. *capitata* L.) is an important cole crop grown in temperate to tropical climates for its leaves which are the edible part commonly called as the 'head'. India is one of the leading producers of cabbage in the world with a cultivated area of 4.00 lakh ha and total production 90.39 lakh tonnes (NHB 2014). Cabbage is a rich source of minerals like calcium (52 mg/100 g), phosphorus (44 mg/100 g), and vitamin C (55 mg/100 g). (Hanif *et al.* 2006). With the development of tropical cultivars that are early and can form marketable heads under high temperatures (average day temperature 32° - 35°C and night 19° – 23°C), cultivation of cabbage is being extended even to warm humid plains of Kerala (Narayanan Kutty *et al*. 2012). Improvement in any crop depends on extend of genetic variability and the magnitude of transmission of characters from parents to the offspring. The knowledge of inter relationships among variance components and their direct and indirect effects on yield is an important prerequisite for a successful breeding programme. According to Antonova (2009), studies on inter relationships among cabbage genotypes of a particular maturity group is applicable to that group only. Hence, the present studies were undertaken with 31 diverse genotypes of tropical cabbage to examine the magnitude of variance components and their inter relationships with yield.

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MATERIALS AND METHODS

The present investigations were carried out at the Agricultural Research Station, Mannuthy during the rabi season of 2012-13 and 2013-14. Thirty one tropical genotypes of cabbage collected from various public and private sector agencies were utilized for the study (Table 1). Sowing in nursery was carried out in pro-trays during the last week of October in a naturally ventilated polyhouse in soilless medium comprising sterilized coco peat, vermiculite and perlite (3:1:1) by volume. The field experiment was laid out in a randomized block design with two replications during the third week of November. Each genotype was planted in two rows (9m length) per replication at a spacing of 60 × 60cm. Thus there were 30 plants per genotype per replication. All the recommended package of practices was timely followed to raise a successful crop during both the years. Observations were recorded on five plants per genotype per replication on 12 important quantitative characters, viz. days to harvest, plant spread (cm), number of non-wrapping leaves, number of wrapping leaves, stalk length (cm), head polar length (cm), head equatorial width (cm), core length (cm), leaf length (cm), leaf width (cm), gross plant weight (kg) and net head weight (kg) as per the standard descriptor. Pooled analysis of the data collected for two years were carried out. Correlation and path analysis were worked out employing the formula of Al-Jibouri *et al.* (1958), Miller *et al.* (1958) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

The range of variability observed among the 31

Table 1 Tropical cabbage and their sources

Name	Source
NS 43	Namdhari seeds, Bengaluru
NS 183	"
NS 22	"
NS 35	"
NS 154	"
Saurabh	"
Sathyawan	Century seeds , New Delhi
Gayathri	"
Super Gayathri	"
CH 21 plus	"
CH 2200	"
163 A	"
164 A	"
165 A	"
166 A	"
167 A	"
Green Voyager	Seminis seeds, Mumbai
Green Challenger	"
Zennith	"
Saint	"
Tropic Sun Plus	"
Dolares	"
Shaurya	"
Royal Cross	"
Disha	"
Rare Ball	"
Indam Radha	Indo American Hybrid seeds, Bangaluru
Indam 296	"
Acc: 6093	Sungro seeds , New Delhi
Acc: 5005	"
Acc: 5024	"

genotypes of tropical cabbages for the 12 morphological and economic traits along with the genetic parameters of variability, viz. phenotypic and genotypic coefficient of variation (PCV and GCV), heritability in a broad sense and genetic advance are given in Table 2. Significant differences were observed among the 31 genotypes for all the 12 traits studied. Highest range of variability was observed for net head weight (0.49 - 1.57 kg), gross plant weight (0.96 - 2.53 kg), head width (9.75 – 18.58 cm) and number of non-wrapping leaves (8.50 – 17.13). In general the phenotypic coefficient of variation was higher than the genotypic coefficient of variation, indicating the predominant role of environment in the expression of these traits. Similar results have been reported by Meena *et al.* (2014). The estimate of PCV and GCV was maximum for gross plant weight (29.976 and 28.158) followed by net head weight (27.778 and 26.089), number of non-wrapping leaves (20.068 and 18.224) and head width (19.399 and 18.877). Lowest coefficient of variation, both phenotypic (8.26) as well as genotypic (7.02) was observed for head length. The above results are in accordance with that of Antonova (2009) and Kibar *et al.* (2014). The wide range of variability for important economic traits like yield, head width and number of non-wrapping leaves showed ample scope for the improvement of these characters through selection. Narrow differences between values of PCV and GCV gave the evidence that variability among genotypes is mainly due to their genetic makeup.

Heritability helps to predict the expected progress that could be achieved through selection. In the present study highest heritability (more than 90%) was observed for days to harvest and head width. Moderate heritability values were observed for net head weight, gross plant weight, stalk length, leaf width and number of non-wrapping leaves. Low heritability (less than 80%) was observed for plant spread, head length, core length, leaf length and number of wrapping leaves. High heritability for head width and days to harvest indicated that these characters are highly

Table 2 Estimates of genetic constants for important morphological and economic traits of cabbage

Trait	Range		Mean	Coefficient of variation		Heritability (%)	Genetic advance	Genetic gain
	Min	Max		Phenotypic	Genotypic			
Days to harvest	70.00	94.00	82.444	8.766	8.584	95.897	14.276	17.317
Plant spread (cm)	59.00	78.30	68.080	9.256	8.023	75.137	9.753	14.326
No. of non-wrapping leaves	8.50	17.13	12.355	20.068	18.224	82.465	4.212	34.092
No. of wrapping leaves	4.40	7.50	5.548	14.758	13.138	790257	1.337	24.094
Stalk length (cm)	5.62	9.40	6.876	14.240	13.294	87.148	1.758	25.585
Head length (cm)	11.21	15.28	13.828	8.262	7.021	72.221	1.700	12.291
Head width (cm)	9.75	18.58	12.336	19.399	18.877	94.689	4.668	37.841
Core length (cm)	5.13	7.56	6.132	13.265	11.199	71.276	1.194	19.476
Leaf length (cm)	22.56	30.74	26.031	9.307	8.125	76.211	3.803	14.611
Leaf width (cm)	22.53	33.38	26.512	11.040	10.148	84.498	5.095	19.217
Gross plant weight (cm)	0.960	2.530	1.678	29.976	28.158	88.246	0.914	54.493
Net head weight (cm)	0.490	1.570	0.892	27.778	26.089	88.207	0.450	50.474

Table 3 Correlation matrix of important morphological and economic traits of cabbage

Character		Days to harvest	Plant spread	No. of non-wrapping leaves	No. of wrapping leaves	Stalk length	Head length	Head breadth	Core length	Leaf length	Leaf width	Gross plant wt	Net head wt
Days to harvest	P	- -	0.554**	0.490**	0.100NS	0.278**	0.286**	0.245**	0.046 NS	0.594**	0.268**	0.635**	0.425**
	G	- -	0.601**	0.528**	0.113NS	0.320**	0.313**	0.238**	0.016 NS	0.645**	0.264**	0.649**	0.433**
Plant spread	P		- -	0.493**	0.294**	0.535**	0.048 NS	0.618**	0.237**	0.761**	0.690**	0.764**	0.700**
	G		- -	0.485**	0.419**	0.677**	0.036 NS	0.693**	0.186*	0.847**	0.760**	0.826**	0.775**
No. of non- wrapping leaves	P			- -	0.183**	0.256**	0.280**	0.138 NS	0.266**	0.422**	0.306**	0.632**	0.239**
	G			- -	0.219	0.339**	0.346**	0.143 NS	0.237**	0.477**	0.303**	0.647**	0.246**
No. of wrapping leaves	P				- -	0.367**	- 0.087 NS	0.229*	-0.073 NS	0.174 NS	0.216*	0.272**	0.237**
	G				- -	0.445**	- 0.131 NS	0.260**	-0.105 NS	0.265**	0.290**	0.327**	0.285**
Stalk length	P					- -	-0.344**	0.580**	0.079 NS	0.571**	0.579**	0.602**	0.579**
	G					- -	-0.412**	0.646**	0.104 NS	0.746**	0.681**	0.717**	0.679**
Head length	P						- -	0.311**	0.121 NS	0.025 NS	-0.183*	0.040 NS	-0.146 NS
	G						- -	-0.419**	0.090 NS	-0.021 NS	-0.282**	-0.023 NS	-0.250**
Head width	P							- -	0.125 NS	0.655**	0.862**	0.690**	0.895**
	G							- -	0.100 NS	0.710**	0.933**	0.720**	0.936**
Core length	P								- -	0.283**	0.244**	0.185*	0.131 NS
	G								- -	0.292**	0.217*	0.121 NS	0.067 NS
Leaf length	P									- -	0.740**	0.754**	0.746**
	G									- -	0.792**	0.804**	0.829**
Leaf width	P										- -	0.758**	0.846**
	G										- -	0.798**	0.926**
Gross plant wt	P											- -	0.789**
	G											- -	0.833**
Net head wt	P												- -
	G												- -

* ** Significant at 5 and 1%, respectively.

Table 4 Genotypic Path coefficients of morphological and economic traits showing direct and indirect effect on net head weight

Character	Days to harvest	Plant spread	No. of non-wrapping leaves	No. of wrap-ping leaves	Stalk length	Head length	Head width	Core length	Leaf length	Leaf width	Gross plant wt	Genotypic correlation with Net head wt
Days to harvest	**-0.096**	-0.051	-0.104	0.004	-0.061	0.001	0.103	-0.001	0.288	0.013	0.337	0.433**
Plant spread	-0.058	**-0.085**	0.095	0.015	-0.129	0.000	0.298	-0.017	0.379	0.384	0.429	0.755**
No. of non -wrapping leaves	-0.508	-0.041	**-0.197**	0.008	-0.065	0.000	0.061	-0.220	0.200	0.015	0.337	0.246**
No. of wrapping leaves	-0.109	-0.355	-0.043	**0.035**	-0.085	0.000	0.112	0.010	0.118	0.015	0.170	0.285**
Stalk length	-0.031	-0.057	-0.067	0.015	**-0.190**	0.001	0.278	-0.010	0.336	0.034	0.373	0.679**
Head length	-0.030	-0.003	-0.068	-0.005	0.078	**0.002**	-0.180	-0.008	-0.009	-0.014	-0.012	-0.250**
Head width	-0.023	-0.059	-0.028	0.009	-0.123	-0.001	**0.431**	-0.009	0.317	0.047	0.374	0.936**
Core length	-0.002	-0.016	-0.047	-0.004	0.198	0.000	0.043	**-0.093**	0.130	0.011	0.063	0.067 NS
Leaf length	-0.062	-0.071	-0.088	0.009	-0.142	0.000	0.306	-0.027	**0.447**	0.040	0.418	0.829**
Leaf width	-0.025	-0.064	-0.597	0.010	-0.129	-0.001	0.402	-0.020	0.354	**0.051**	0.410	0.926**
Gross head wt	-0.062	-0.070	-0.127	0.011	-0.137	-0.000	0.310	0.011	0.359	0.040	**0.520**	0.835**

Residual 0.0290.

heritable and less influenced by environment. Whatever phenotypic variance observed in these traits was mostly due to genotypic effect and hence, these could be improved through selection. Heritability alone is not sufficient for estimating real effects of selection. Genetic advance along with heritability is more useful. High heritability coupled with high genetic advance was observed for days to maturity. Moderate to high heritability and high genetic advance for days to maturity has been reported by Rai and Asati (2005) and Alter *et al.* (2009) in cabbage. This trait is likely to respond better to selection.

Correlation coefficients both at the phenotypic and genotypic levels were worked out to analyze the magnitude of association of net head weight and other yield contributing economic characters (Table 3). In general the genotypic correlation coefficients were higher than phenotypic correlation coefficients for all the economic traits except core length. The higher genotypic correlation coefficients indicated that the apparent association might be due to genetic reasons. The net head weight showed significant positive correlation with plant spread, gross plant weight, leaf width, leaf length, head width, stalk length, number of wrapping and non-wrapping leaves. These findings are in agreement with Meena *et al.* (2014) and Singh *et al.* (2010). In the present study using tropical cabbage genotypes days to harvest showed significant positive association with net head weight of cabbage. Yadav *et al.* (2003) also reported significant positive association between yield and days to maturity where as in temperate cabbages a significant negative association of yield with days to maturity was reported (Soni *et al.* 2013 and Kibar *et al.* 2014). Core length did not show significant association with net head weight. So selection based on this trait may not be effective for improvement of yield. The results are in consonance with the findings of Yadav *et al*. (2003) and Kibar *et al.* (2014). Head length also showed negative association with net head weight. The results of correlation analysis showed that all yield components except core length and head length showed significant positive association with net head weight. Further, the yield components exhibited significant inter relationships among themselves which points to the need of their simultaneous selection for improvement of yield.

Correlation coefficients indicate only the general association of traits without possible causes of such association. Path coefficient analysis helps in partitioning the genotype correlation coefficients into direct and indirect effects of component characters on yield (Table 4). Net head weight was taken as the dependant variable for computing the path coefficient. Highest positive direct effects were noticed for gross plant weight, leaf length and head width. These characters also showed highly significant positive correlation with yield per plant. Hence, gross head weight, leaf length and head width can be used in direct selection for yield improvement in tropical cabbage. Similar results reported by Soni *et al.* (2013) and Kibar *et al.* (2014). High correlation coefficient along with low direct effect was noticed for leaf width. The low direct effect may be due to the indirect effect via gross plant weight. Number of non-wrapping leaves also exhibited positive direct effect on net head weight of cabbage. Rai and Asati (2005) and Meena *et al.* (2014) also reported positive direct effect of number of non-wrapping leaves on yield of cabbage.

From the above findings it can be concluded that gross plant weight, leaf length and head width are the important characters to be considered in breeding programmes aimed at improvement of yield in tropical cabbages.

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