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Characters Association and Path Analysis among CMS and SI Based Cabbage Hybrids under Mid Hill Conditions of Himachal Pradesh, India

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A B S T R A C T

A field trial was conducted for evaluation of 38 hybrids of cabbage at the Experimental Farm, Department of Vegetable Science and Floriculture, CSK HPKV, Palampur, (H.P.) during *Rabi* 2015-16 to generate information on correlation and path analysis. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Estimates of correlation coefficient revealed that plant spread, gross head weight, net head weight, polar diameter, equatorial diameter, marketable heads per plot, ascorbic acid content and TSS showed significant positive association with marketable head yield per plot at both genotypic and phenotypic levels indicating that selection based on these characters either in combination or alone will result in identifying the genotypes having high yield potential. Estimates of direct effects showed that net weight of head had the highest positive direct effect on marketable head yield per plot followed by polar diameter, compactness of head, ascorbic acid content, number of non-wrapper leaves and TSS at genotypic level. Therefore, net weight of head, polar diameter and compactness of head should be considered as selection criteria for yield improvement in cabbage breeding.

Introduction

Cabbage, *Brassica oleracea* var. *capitata* L. (2n=2x=18) member of family *Brassicaceae* is one of the most important cole-group vegetable crops originated from *Brassica oleracea* var. *oleracea* L. (syn. *Brassica oleracea* var. *sylvestris* L.) commonly known as wild cabbage through mutation, human selection and adaptation. It is rich source of sulphur containing amino acids, minerals, carotenes, ascorbic acid and anti-carcinogenic property (Kopsell *et al.,* 2004 and Singh *et al.*, 2009). Cabbage is grown throughout the world and the leading countries are China, India, Russia, Korea, Japan, Indonesia, Poland, Romania and USA. It is next to cauliflower in India with acreage and production statistics of 394 thousand hectares and 8,720 thousand MT, respectively (Anonymous, 2016).

In Himachal Pradesh, it is being cultivated extensively as an off-season vegetable with an area of 4,905ha and production of 1,60,744 MT (Anonymous, 2015). Hybrids are preferred over the open-pollinated varieties on account of their certain advantages viz., uniform maturity, higher yield and better adaptability under adverse growing conditions. In developed countries more than 90% cabbage growing area is under hybrid varieties, whereas it is only 31% in India (Kumar *et al.,* 2013). Thus, it is important to identify the high yielding hybrid(s) with better quality and adaptability. The yield and its component characters are polygenic in nature, hence influenced by the environmental factors. The knowledge of the inter relationship among the various yield components and their direct and indirect effects on yield are the important pre-requisites to bring genetic improvement in cabbage. Path analysis facilitates partitioning of correlation coefficients into direct and indirect effects of various characters on head weight which can prove useful in providing information about improvement of yield or yield related characters. The information regarding the correlation and path coefficient analysis in cabbage is inadequate. Therefore the present study was conceived with objective to estimate the correlation coefficient and path analysis among the different traits of cabbage.

Materials and Methods

The present investigation was carried out at the Experimental Farm (32°6′ N latitude, 76°3′ E longitudes and 1290.8 m altitude) of the Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, (H.P.) during *Rabi*, 2015-16 in RBD with three replications at intra and inter-row spacing of 45cm each. The experimental materials comprised of 38 cabbage hybrids from public and private sector. The standard cultural practices to raise the crop were followed as per the recommended package of practices for vegetable crops by CSKHPKV, Palampur. Observations were recorded on five competitive randomly marked plants for characters namely plant spread (cm), number of non-wrapper leaves, gross head weight (g), net head weight (g), polar and equatorial diameters of head (cm), days to harvest, head shape index, compactness of head (g/cm^3), marketable heads per plot, marketable head yield per plot (kg), ascorbic acid content (mg/100g) and TSS (^{0}Brix) in each treatment and each replication. The mean values obtained from the experiment were used for estimating the analysis of variance as suggested by Burton and De Vane (1953). Correlation and path coefficient analysis were calculated as per formulae suggested by Al-Jibouri *et al.,* (1958) and Dewey and Lu, (1959), respectively. The statistical analysis was carried out by using OPSTAT software.

Results and Discussion

The effectiveness of any breeding or selection programme depends upon the nature of association between yield and other component characters, as more directly a character is associated with yield in the desirable direction; more will be the success of the selection programme. Genotypic correlation coefficients in general were higher than the phenotypic correlations which revealed that though there is a strong inherent association between various characters, the phenotypic expression of the correlation gets modified under the influence of environment. The perusal of data from Table 1 revealed that at phenotypic level, marketable head yield/plot exhibited significant positive correlation with net head weight (0.940), gross head weight (0.833), equatorial diameter (0.651), marketable heads per plot (0.647), polar diameter (0.538), plant spread (0.427) and compactness of head (0.397). Earlier reports of many research workers have also indicated positive and significant correlation of marketable head yield with net head weight (Singh *et al.,* 2013, Soni *et al.,* 2013 and Kibar *et al.,* 2014), gross head weight (Meena *et al.,* 2009 and Sharma, 2010), equatorial diameter (Meena *et al.,* 2009 and Kibar *et al.,* 2014), polar diameter (Soni *et al.*, 2013 and Kibar *et al.*, 2014), plant spread (Soni *et al.*, 2013), compactness of head (Sharma, 2010). Plant spread had positive significant correlation with gross head weight (0.520), net weight of head (0.469), number of non-wrapper leaves (0.359), equatorial diameter (0.464), polar diameter (0.435) and compactness of head (0.194). Singh *et al.*, (2010) had also reported positive correlation of frame spread with polar diameter, equatorial diameter, gross weight and net weight of head.

A significant and positive correlation of number of non-wrapper leaves was recorded only with gross head weight (0.259) at phenotypic level. These results are in consonance with findings of Sharma (2010). Gross head weight had positive and significant correlation with net weight of head (0.891), equatorial diameter (0.672), polar diameter (0.548), marketable heads per plot (0.352) and compactness of head (0.270) and significant negative correlation with days to harvest (-0.404) and head shape index (-0.254). These results are in conformity for net head weight (Singh *et al.*, 2010 and Sharma, 2010), equatorial diameter (Singh *et al.*, 2010) and polar diameter (Singh *et al.*, 2010).

Net head weight had significant positive correlation with equatorial diameter (0.635), polar diameter (0.577), marketable heads per plot (0.379), compactness of head (0.315) and ascorbic acid content (0.225) and significant negative correlation with days to harvest (-0.490). These results are in agreement with various workers for polar and equatorial diameter (Sharma, 2010 and Kibar *et al.*, 2014). Polar diameter exhibited positive significant correlation with equatorial diameter (0.635), marketable heads per plot (0.256) and head shape index (0.231) and significant negative correlation with days to harvest (-0.254). Similar findings have also been reported for equatorial length (Singh *et al.*, 2010). Equatorial diameter was positively and significantly correlated with marketable heads per plot (0.415) and TSS (0.192). Its association was negative and significant with head shape index (-0.564) and days to harvest (-0.340). Singh *et al.*, (2013) also reported that equatorial diameter had negative but non-significant correlation with days to maturity. Head shape index had negative and significant correlation with marketable heads per plot (-0.301). Days to harvest had significant negative correlation with marketable heads per plot (-0.483), TSS (-0.220) and compactness of head (-0.199). Compactness of head was significantly and positively correlated with marketable heads per plot (0.285). Sharma (1994) reported compactness of head had positive and significant association with shape of head. Relationship of marketable heads per plot was positive and significant with ascorbic acid content (0.220) and TSS (0.312). Soni *et al.*, (2013) reported positive and significant correlation of ascorbic acid content with plant spread, number of non-wrapper leaves, head weight, head polar diameter and equatorial diameter.

Knowledge of correlation alone, however, is often misleading as the correlation observed may not be true. Two characters may show correlation just because they are correlated with a common third one. In such cases, it becomes necessary to study a method, which takes into account the casual relationship in addition to the degree of relationship. Path coefficient analysis is one such method that takes into account both kind of relationship. The data pertaining to path coefficient analysis (Table 2) revealed that at phenotypic level, net head weight (0.849) and marketable heads per plot (0.327) are the two main characters which showed the maximum direct positive effect on marketable head yield per plot. Whereas, the maximum negative direct effects were observed via gross head weight (-0.054) and head shape index (-0.024).

Table.1 Estimates of correlation at phenotypic (P) and genotypic (G) levels between different traits of cabbage

Traits		No of non wrapper leaves	Gross head weight (g)	Net head weight (g)	Polar diameter (cm)	Equatorial diameter (cm)	Days to harvest	Head shape index	Compactness of head (g/cm^3)	Marketable heads per plot	Ascorbic acid (mg/ 100g)	TSS	Marketable head yield (kg/plot)
Plant spread(cm)	P	0.359**	0.520**	0.469**	0.435**	0.464**	-0.134	-0.133	0.194*	0.154	0.044	0.156	0.427**
	G	0.478**	0.574**	0.524**	0.651**	0.721**	-0.166	-0.424**	0.277**	0.222*	0.043	0.184	0.462**
No of non wrapper leaves	P		0.259**	0.114	0.137	0.182	0.043	-0.092	-0.082	-0.007	-0.062	-0.123	0.090
	G		0.361**	0.209*	0.420**	0.419**	0.013	-0.189*	-0.167	0.121	-0.062	-0.137	0.190*
Gross head weight (g)	P			0.891**	0.548**	0.672**	-0.404**	-0.254**	0.270**	0.352**	0.165	0.119	0.833**
	G			0.950**	0.887**	0.973**	-0.531**	-0.434**	0.354**	0.586**	0.224*	0.144	0.902**
Net head weight (g)	P				0.577**	0.635**	-0.490**	-0.172	0.315**	0.379**	0.225*	0.176	0.940**
	G				0.833**	0.871**	-0.644**	-0.373**	0.507**	0.669**	0.267**	0.234*	0.982**
Polar diameter(cm)	P					0.635**	-0.254**	0.231*	-0.047	0.256**	0.174	0.108	0.538**
	G					0.874**	-0.536**	-0.185*	0.382**	0.597**	0.146	0.169	0.799**
Equatorial diameter (cm)	P						-0.340**	-0.564**	0.063	0.415**	0.147	0.192*	0.651**
	G						-0.633**	-0.621**	0.455**	0.754**	0.305**	0.292**	0.866**
Days to harvest	P							0.172	-0.199*	-0.483**	-0.119	-0.220*	-0.553**
	G							0.447**	-0.312**	-0.842**	-0.220*	-0.281**	-0.712**
Head shape index	P								-0.164	-0.301**	0.057	-0.150	-0.255**
	G								-0.244**	-0.551**	-0.223*	-0.297**	-0.424**
Head Compactness (g/cm^3)	P									0.285**	0.068	0.149	0.397**
	G									0.526**	0.264**	0.233*	0.600**
Marketable heads per plot	P										0.220*	0.312**	0.647**
	G										0.446**	0.347**	0.776**
Ascorbic acid (mg/100g)	P											0.111	0.270**
	G											0.181	0.379**
TSS	P												0.255**
	G												0.278**

*Significant at 5% level of significance ** Significant at 1% level of significance

Table.2 Direct and indirect effects of component traits on marketable yield of cabbage at phenotypic and genotypic level

Traits		Plant spread (cm)	No of non wrapper leaves	Gross head weight (g)	Net head weight (g)	Polar diameter (cm)	Equatorial diameter(cm)	Days to harvest	Head shape index	Head Compactness (g/cm^3)	Marketable heads per plot	Ascorbic acid content (mg/100g)	TSS	Correlation with marketable yield
Plant spread(cm)	P	**-0.014**	0.006	-0.028	0.398	0.004	-0.003	-0.002	0.003	0.010	0.050	0.001	0.001	0.427**
	G	**-0.134**	0.054	-0.100	0.517	0.148	-0.149	0.016	0.075	0.041	-0.015	0.005	0.004	0.462**
No of non wrapper leaves	P	-0.005	**0.017**	-0.014	0.097	0.001	-0.001	0.001	0.002	-0.004	-0.002	-0.001	-0.001	0.090
	G	-0.064	**0.113**	-0.063	0.206	0.095	-0.087	-0.001	0.033	-0.025	-0.008	-0.008	-0.003	0.190*
Gross head weight(g)	P	-0.007	0.004	**-0.054**	0.756	0.006	-0.004	-0.006	0.006	0.014	0.115	0.003	0.000	0.833**
	G	-0.077	0.041	**-0.174**	0.939	0.201	-0.201	0.053	0.076	0.052	-0.039	0.027	0.003	0.902**
Net head weight(g)	P	-0.006	0.002	-0.048	**0.849**	0.006	-0.004	-0.007	0.004	0.017	0.124	0.004	0.001	0.940**
	G	-0.070	0.024	-0.165	**0.988**	0.189	-0.180	0.064	0.066	0.075	-0.044	0.033	0.005	0.982**
Polar diameter(cm)	P	-0.006	0.002	-0.030	0.489	**0.010**	-0.004	-0.004	-0.006	-0.003	0.084	0.003	0.000	0.538**
	G	-0.087	0.047	-0.154	0.823	**0.227**	-0.181	0.053	0.033	0.057	-0.040	0.018	0.003	0.799**
Equatorial diameter(cm)	P	-0.006	0.003	-0.036	0.539	0.007	**-0.006**	-0.005	0.014	0.003	0.136	0.002	0.001	0.651**
	G	-0.097	0.047	-0.169	0.861	0.198	**-0.207**	0.063	0.110	0.067	-0.050	0.037	0.006	0.866**
Days to harvest	P	0.002	0.001	0.022	-0.415	-0.003	0.002	**0.014**	-0.004	-0.011	-0.158	-0.002	-0.001	-0.553**
	G	0.022	0.001	0.092	-0.637	-0.122	0.131	**-0.099**	-0.079	-0.046	0.056	-0.027	-0.006	-0.712**
Head shape index	P	0.002	-0.002	0.014	-0.146	0.002	0.003	0.002	**-0.024**	-0.009	-0.098	0.001	-0.001	-0.255**
	G	0.057	-0.021	0.075	-0.368	-0.042	0.129	-0.044	**-0.176**	-0.036	0.037	-0.027	-0.006	-0.424**
Head Compactness (g/cm^3)	P	-0.003	-0.001	-0.015	0.267	0.000	0.000	-0.003	0.004	**0.053**	0.093	0.001	0.001	0.397**
	G	-0.037	-0.019	-0.062	0.501	0.087	-0.094	0.031	0.043	**0.148**	-0.035	0.032	0.005	0.600**
Marketable heads per plot	P	-0.002	0.000	-0.019	0.321	0.003	-0.002	-0.007	0.007	0.015	**0.327**	0.004	0.001	0.647**
	G	-0.030	0.014	-0.102	0.661	0.135	-0.156	0.084	0.097	0.078	**-0.066**	0.055	0.007	0.776**
Ascorbic acid content(mg/100g)	P	-0.001	-0.001	-0.009	0.191	0.002	-0.001	-0.002	-0.001	0.004	0.072	**0.016**	0.000	0.270**
	G	-0.006	-0.007	-0.039	0.264	0.033	-0.063	0.022	0.039	0.039	-0.030	**0.123**	0.004	0.379**
TSS	P	-0.002	-0.002	-0.006	0.149	0.001	-0.001	-0.003	0.004	0.008	0.102	0.002	**0.004**	0.255**
	G	-0.025	-0.016	-0.025	0.231	0.038	-0.060	0.028	0.052	0.034	-0.023	0.022	**0.020**	0.278**

** Significant at $P \leq 0.01$; *Significant at $P \leq 0.05$ level; Residual effect (P): 0.014; (G): -0.098; the bold values indicate direct effect with marketable yield per plot

Earlier researchers also reported positive direct effects of net head weight (Singh *et al.*, 2010, Sharma, 2010 and Soni *et al.*, 2013), marketable heads (Sharma, 2010). Direct negative effects were reported for gross head weight by Sharma (2010). Direct positive effects were observed for gross head weight by Meena *et al.*, (2010) and Singh *et al.*, (2010).

At phenotypic level, the maximum positive indirect effects on marketable yield per plot were observed by gross head weight (0.756) followed by equatorial diameter (0.539), polar diameter (0.489), plant spread (0.398), marketable heads per plot (0.321) and compactness of head (0.267) via net head weight. Therefore the net head weight is the single most important character which is required to be considered to improve upon marketable head yield and other horticultural traits. The results are in consonance with the findings of Sharma (2010) and Soni *et al.*, 2013.

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