

Original Research Article

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Correlation and Path Coefficient Studies in Bell pepper (*Capsicum annuum* L. var. *grossum*) under Mid Hill Conditions of Solan District of Himachal Pradesh, India

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ABSTRACT

Bell Pepper (*Capsicum annuum* L var. *grossum*) popularly known as sweet pepper, capsicum or Shimla Mirch is a high value vegetable and an important cash crop for temperate regions. The correlation between different quantitative characters provides an idea of association that could be effectively exploited to formulate selection strategies for improving yield components. For any effective selection programme, it would be desirable to consider the relative magnitude of association of various characters with yield. The present investigations were carried out at the Experimental Farm of Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan HP during Kharif, 2017. The results concluded that a highly significant and positive genotypic and phenotypic correlation of yield per plant was found with number of fruits per plant, fruit weight, fruit breadth, number of lobes per fruit and number of primary branches. Therefore, main emphasis should be given on these characters, while making the selection in bell pepper genotypes for high yield. Maximum positive and direct effect towards yield was contributed by fruit weight followed by number of fruits per plant, fruit breadth, thousand seed weight, fruit length and number of seeds per fruit. The improvement in these characters will lead to higher yield in bell pepper.

Keywords

Correlation, Path coefficient, Bell pepper, Solan, Mid Hill Conditions

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Introduction

Bell Pepper (*Capsicum annuum* L.) popularly known as sweet pepper, capsicum or Shimla Mirch is a high value vegetable and an important cash crop for temperate regions. It is mostly consumed raw in green mature forms, cooked as vegetable or widely used in stuffings, bakings, pizza making, and preparation of soups and stews for imparting

flavour, aroma and colour. Bell peppers are available in different colours viz., yellow, red, green, purple and orange.

These plump, bell shaped vegetables were cultivated more than 900 years ago in South and Central America and were given the name 'pepper' by the European colonizers of North America. These can easily grow in different types of climate. Sweet peppers are a great

combination of tangy taste and crunchy texture. In India, it was first introduced by the Britishers in Nineteenth century in Shimla hills (Singh *et al.*, 1993) therefore, known as 'Shimla Mirch'. It is an important remunerative crop of temperate and sub-temperate regions, growing best at a temperature ranging between 20–30°C in summer season. In India, bell pepper is cultivated over an area of about 46,000 ha with a production of 288,000 MT (NHB, 2016). In Himachal Pradesh, bell pepper is grown as an off season crop during the summer and rainy seasons and is economically important to small and marginal farmers.

Existence of sufficient variability in the genetic stock is a pre-requisite for initiation of any breeding programme. The correlation between different quantitative characters provides an idea of association that could be effectively exploited to formulate selection strategies for improving yield components. For any effective selection programme, it would be desirable to consider the relative magnitude of association of various characters with yield. The correlation coefficient being the result of cause and effect relationship between different characters may not always provide complete information. Thus, a better understanding of association between the characters is provided by path coefficient analysis. Knowledge of relationship between the characters is important for indirect improvement of characters which are difficult to quantify and having low heritability.

Materials and Methods

The present investigations were carried out at the Experimental Farm of Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan HP during Kharif, 2017. The experimental site of the Department of Vegetable Science is located at, at an altitude of 1276 m above

mean sea level lying between latitude 30°52' 30" North and longitude 77° 11' 30" East. It falls in sub-humid, sub temperate and mid- hill zone of Himachal Pradesh. The experiment was laid out in a Randomized Complete Block Design (RCBD) with twenty five genotypes in three replications at spacing of 60 × 45 cm in a plot size of 2.4 m × 1.80 m in each replication. The genotypes along with their sources have been presented in table 1. Data was recorded on five randomly taken plants from each plot/treatment and the average was worked out to record the mean value in each replication for all the characters under study. The observations were recorded for various horticultural and yield traits viz., Days to first picking, Number of branches per plant, Plant height (cm), Fruit shape, Fruit colour, No. of lobes per fruit, Fruit length (cm), Fruit breadth (cm), Fruit Weight (g), Pericarp Thickness (mm), No. of fruits per plant, Fruit yield /plant (g), No. of seeds / fruit, Thousand seed weight (g), Total Soluble Solids (° B) and Ascorbic acid content (mg/100 g), *Phytophthora* fruit rot incidence, *Phytophthora* leaf blight incidence. The genotypic and phenotypic correlations were calculated as per Al-Jibouri *et al.*, (1958) by using analysis of variance and covariance matrix in which total variability split into replications, genotypes and errors Path coefficient was obtained according to the procedure as suggested by Wright (1921) and as elaborated by Dewey and Lu (1959).

Results and Discussion

Correlation coefficient analysis

The correlation coefficients among the different characters were worked out at phenotypic and genotypic levels. In general, the genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients. The correlation coefficients among fourteen characters showed that fruit yield per plant had positive

and significant association with number of fruits per plant (0.421 and 0.459), fruit weight (0.370 and 0.342), fruit breadth (0.339 and 0.211), number of lobes per fruit (0.273 and 0.244) and number of primary branches (0.229 and 0.133), whereas it was negative and significantly correlated with thousand seed weight (-0.254 and -0.226). Similar results were reported by Aliyu *et al.*, (2000), Chatterjee and Kohli (2001), Bindal *et al.*, (2005), Bharadwaj *et al.*, (2007) and Afroza *et al.*, (2013).

Besides this, significant positive correlation of fruit weight was observed with number of primary branches (0.283 and 0.198), number of lobes per fruit (0.482 and 0.431) and fruit length (0.292 and 0.281). The results are in line with the findings of Feipeng and Huang (2004). Significant positive correlation of plant height was observed with days to first picking (0.256 and 0.232). Number of lobes per fruit was significantly and positively correlated with number of primary branches (0.364 and 0.235). Fruit length was significantly and positively correlated with number of lobes per fruits (0.545 and 0.488) whereas, it had significant negative correlation with plant height (-0.468 and -0.450). Fruit breadth was significantly and positively correlated with days to first picking (0.267 and 0.169), number of primary branches (0.457 and 0.233), and plant height (0.536 and 0.430). Pericarp thickness was significantly and positively correlated with number of lobes per plant (0.248 and 0.175) and fruit weight (0.275 and 0.245).

Number of fruits per plants were significantly and positively correlated with fruit breadth (0.288 and 0.203) whereas it had significant negative correlation with fruit weight (-0.696 and -0.639) and pericarp thickness (-0.323 and -0.277). Similar results were reported by Singh *et al.*, (2014) and Kumari (2013). Number of seeds per fruit was significantly

and positively correlated with number of primary branches (0.432 and 0.219), number of lobes per fruit (0.329 and 0.314) and fruit length (0.229 and 0.207) whereas it had significant negative correlation with days to first picking (-0.258 and -0.189). Thousand seed weight was significantly and positively correlated with days to first picking (0.327 and 0.257) and pericarp thickness (0.334 and 0.319) whereas it had significant negative correlation with number of primary branches (-0.274 and -0.100) and fruit length (-0.261 and -0.256). Total soluble solids were significantly and positively correlated with fruit breadth (0.246 and 0.224) and number of seeds per fruit (0.424 and 0.388). Ascorbic acid content was significantly and positively correlated with number of primary branches (0.638 and 0.466), number of lobes per fruit (0.412 and 0.329) and fruit breadth (0.503 and 0.332). Rest of trait combinations had non-significant genotypic and phenotypic correlation coefficient. The present investigation is in the confirmation with Sood *et al.*, (2007), Madosa *et al.*, (2008), Sharma *et al.*, (2010), Sood *et al.*, (2011), Lahbib *et al.*, (2012), Afroza *et al.*, (2013) and Kumari (2013).

Based on correlation coefficients, it may be concluded that number of fruits per plant, fruit length, fruit breadth, number of primary branches and number of lobes were main fruit yield contributing characters which should be considered during selection for improving fruit yield per plant.

Path coefficient analysis

Although correlation studies are helpful in determining the components of yield, but it does not provide a clear picture of nature and extent of contributions made by number of independent traits. Path coefficient analysis devised by Dewey and Lu (1959), however, provides a realistic basis for allocation of

appropriate weightage to various attributes while designing a pragmatic programme for the improvement of yield. Path coefficient analysis depicts the effects of different independent characters individually and in combination with other characters on the expression of different characters on yield. The observed correlation coefficients of yield with its contributing traits were partitioned into direct and indirect effects. Path coefficient analysis provides an effective means of a critical examination of specific force action to produce a given correlation and measure the relative importance of each factor. In this analysis, green fruit yield per

plant was taken as dependent variable and rest of the characters were considered as independent variables. The results obtained have been presented in Table 3.

The path coefficient analysis at genotypic level showing the direct and indirect effects of significant characters over marketable fruit yield per plant have been represented in Table 3. The data revealed that fruit weight (1.362) had maximum positive direct effect on fruit yield per plant followed by number of fruits per plant (1.182), fruit breadth (0.331), thousand seed weight (0.057), fruit length (0.022) and number of seeds per fruit (0.016).

Table.1 Bell pepper genotypes along with sources of collection used in the present study

S.NO.	Genotype	Source
1.	Palam Bell	IARI Regional Station, Katrain (Kullu Valley)
2.	Yolo Wonder	IARI Regional Station, Katrain (Kullu Valley)
3.	Arka Basant	IARI Regional Station, Katrain (Kullu Valley)
4.	Nishat	IARI Regional Station, Katrain (Kullu Valley)
5.	Harit Red Fruit	IARI Regional Station, Katrain (Kullu Valley)
6.	HC-201 PL-3	IARI Regional Station, Katrain (Kullu Valley)
7.	CW-308	IARI Regional Station, Katrain (Kullu Valley)
8.	RY.PL-1	IARI Regional Station, Katrain (Kullu Valley)
9.	PT.12.3	IARI Regional Station, Katrain (Kullu Valley)
10.	KC-10	IARI Regional Station, Katrain (Kullu Valley)
11.	KC-11	IARI Regional Station, Katrain (Kullu Valley)
12..	KC-12	IARI Regional Station, Katrain (Kullu Valley)
13..	IIVR CW	IIVR, Varanasi, UP
14.	Nirmal Karol	Village Karol, P.O – Kandaghat
15.	Dyarag Selection	Village Dyarag, P.O – Juanji, Solan
16.	Deothi Selection	Village Deothi, P.O – Solan
17.	Kadar Selection	Village Kadar, P.O – Kandaghat
18.	Ghalai Selection	Village Ghalai, P.O – Kandaghat
19.	Tikker Selection	Village Tikker, P.O – Solan
20.	YW.PL-4	Department of Vegetable Science, UHF, Nauri
21.	UHFBP-3	Department of Vegetable Science, UHF, Nauri
22.	UHFBP-5	Department of Vegetable Science, UHF, Nauri
23.	UHFBP-6	Department of Vegetable Science, UHF, Nauri
24.	CW.PL-2	Department of Vegetable Science, UHF, Nauri
25.	Solan Bharpur*	Department of Vegetable Science, UHF, Nauri

Solan Bharpur* = check variety

Table.2 Genotypic and Phenotypic coefficients of correlation among different characters in bell pepper (*Capsicum annuum* L.)

Charact ers		DTFP	NPB	PH	NLPF	FL	FB	FW	PT	NFPP	NSPF	TSW	TSS	AA
NPB	G	-0.103												
	P	-0.146												
PH	G	0.256*	-0.101											
	P	0.232*	-0.079											
NLPF	G	-0.068	0.364*	-0.114										
	P	-0.040	0.235*	-0.094										
FL	G	-0.104	0.157	-0.468*	0.545*									
	P	-0.069	0.064	-0.450*	0.488*									
FB	G	0.267*	0.457*	0.536*	0.151	-0.119								
	P	0.169*	0.233*	0.430*	0.118	-0.110								
FW	G	0.043	0.283*	0.119	0.482*	0.292*	-0.063							
	P	0.011	0.198*	0.121	0.431*	0.281*	-0.057							
PT	G	-0.016	0.147	-0.064	0.248*	0.175	-0.115	0.275*						
	P	-0.049	0.132	-0.046	0.175*	0.130	-0.088	0.245*						
NFPP	G	-0.058	-0.100	-0.143	-0.185	-0.196	0.288*	-0.696*	-0.323*					
	P	-0.060	-0.072	-0.132	-0.153	-0.183	0.203*	-0.639*	-0.277*					
NSPF	G	-0.258*	0.432*	-0.104	0.329*	0.229*	0.027	0.119	0.064	-0.001				
	P	-0.189*	0.219*	-0.089	0.314*	0.207*	0.051	0.103	0.041	-0.011				
TSW	G	0.327*	-0.274*	0.026	0.096	-0.261*	0.097	-0.130	0.334*	-0.056	-0.126			
	P	0.257*	-0.100*	0.027	0.074	-0.256*	0.045	-0.121	0.319*	-0.061	-0.131			
TSS	G	-0.179	0.037	0.116	0.138	-0.037	0.246*	0.208	-0.200	-0.169	0.424*	0.101		
	P	-0.143	-0.017	0.117	0.134	-0.030	0.224*	0.197	-0.138	-0.165	0.388*	0.079		
AA	G	0.009	0.638*	0.090	0.412*	0.080	0.503*	0.163	0.100	0.028	0.010	0.075	-0.064	
	P	-0.034	0.466*	0.090	0.329*	0.085	0.332*	0.157	0.128	0.021	0.036	0.056	-0.035	
FYPP	G	-0.003	0.229*	0.011	0.273*	0.103	0.339*	0.370*	-0.080	0.421*	0.067	-0.254*	-0.022	0.190
	P	-0.053	0.133*	0.024	0.244*	0.103	0.211*	0.342*	-0.047	0.459*	0.038	-0.226*	-0.018	0.169

* Significance at 5% level of significance

Table.3 Estimates of direct and indirect effects of different traits on yield of bell pepper (*Capsicum annuum* L.)

Characters	DTFP	NPB	PH	NLPF	FL	FB	FW	PT	NFPP	NSPF	TSW	TSS	AA	rg with FYPP
DTFP	-0.118	0.005	-0.029	0.009	-0.002	0.089	0.059	0.001	-0.068	-0.004	0.019	0.037	-0.001	-0.003
NPB	0.012	-0.046	0.011	-0.050	0.004	0.151	0.386	-0.008	-0.118	0.007	-0.016	-0.008	-0.096	0.229
PH	-0.030	0.005	-0.105	0.016	-0.010	0.177	0.162	0.003	-0.169	-0.002	0.001	-0.024	-0.013	0.011
NLPF	0.008	-0.017	0.012	-0.138	0.012	0.050	0.657	-0.013	-0.218	0.006	0.005	-0.029	-0.062	-0.273
FL	0.012	-0.007	0.049	-0.075	0.022	-0.040	0.398	-0.009	-0.232	0.004	-0.015	0.008	-0.012	0.103
FB	-0.032	-0.021	-0.056	-0.021	-0.003	0.331	-0.086	0.007	0.340	0.000	0.006	-0.051	-0.075	0.339
FW	-0.005	-0.013	-0.012	-0.066	0.006	-0.021	1.362	-0.015	-0.822	0.002	-0.007	-0.043	-0.024	0.342
PT	0.002	-0.008	0.007	-0.034	0.004	-0.038	0.375	-0.053	-0.382	0.001	0.019	0.042	-0.015	-0.080
NFPP	0.007	0.005	0.015	0.025	-0.004	0.095	-0.948	0.017	1.182	0.000	-0.003	0.034	-0.004	0.421
NSPF	0.030	-0.020	0.011	-0.045	0.005	0.009	0.162	-0.003	-0.001	0.016	-0.007	-0.088	-0.002	0.067
TSW	-0.039	0.013	-0.003	-0.013	-0.006	0.032	-0.177	-0.018	-0.066	-0.002	0.057	-0.021	-0.011	-0.254
TSS	0.021	-0.002	-0.012	-0.019	-0.001	0.081	0.283	0.011	-0.199	0.007	0.006	-0.208	0.010	-0.022
AA	-0.001	-0.029	-0.009	-0.057	0.002	0.167	0.223	-0.005	0.033	0.000	0.004	0.012	-0.150	0.190

rg = genotypic correlation coefficient

Diagonal figures represent the direct effect

Residual effect: = 0.003

* Significance at 5% level of significance

Where,

DTFP- days to first picking, NPB- number of primary branches, PH- plant height (cm),NLPF- number of lobes per fruit FL- fruit length (cm), FB- fruit breadth (cm), FW- fruit weight (g), PT- pericarp thickness (mm), NFPP- number of fruits per plant, NSPF- number of seeds per fruit, TSW- thousand seed weight (g), TSS- total soluble solids (⁰B), AA- ascorbic acid content (mg/100 g) and FYPP- fruit yield per plant (g)

Number of lobes per fruit (0.657) followed by fruit length (0.398), number of primary branches (0.386), pericarp thickness (0.375), total soluble solids (0.283), ascorbic acid (0.223), plant height (0.162), number of seeds per fruit (0.162) and days to first picking exerted (0.059) maximum positive indirect effect towards yield *via* fruit weight. Fruit breadth (0.340) followed by ascorbic acid (0.033) exerted maximum positive indirect effect towards yield *via* number of fruits per plant. Plant height (0.177) followed by ascorbic acid (0.167), number of primary branches (0.151), number of fruits per plant (0.095), days to first picking (0.089), total soluble solids (0.081), number of lobes per fruit (0.050), thousand seed weight (0.032) and number of seeds per fruit (0.009) exerted maximum positive indirect effect towards yield *via* fruit breadth. Days to first picking (0.019) and pericarp thickness (0.019) followed by total soluble solids and fruit breadth (0.006), number of lobes per fruit (0.005), ascorbic acid (0.004), and plant height (0.001) exerted maximum positive indirect effects towards yield *via* thousand seed weight. Number of lobes per fruit (0.012) followed by fruit weight (0.006), number of seeds per fruit (0.005), number of primary branches and pericarp thickness (0.004) and ascorbic acid (0.002) exerted maximum positive indirect effect towards yield *via* fruit length. Number of primary branches and total soluble solids (0.007) followed by number of lobes per fruit (0.006), fruit length (0.004), fruit weight (0.002) and pericarp thickness (0.001) exerted maximum positive indirect effect towards yield *via* number of seeds per fruit.

Number of seeds per fruit (-0.088) followed by fruit breadth (-0.051), fruit weight (-0.043), number of lobes per fruit (-0.029), plant height (-0.024), thousand seed weight (-0.021) and number of primary branches (-0.008) exerted maximum negative indirect

effect towards yield *via* total soluble solids. Number of primary branches (-0.096) followed by fruit breadth (-0.075), number of lobes per fruit (-0.062), fruit weight (-0.024), pericarp thickness (-0.015), plant height (-0.013), fruit length (-0.012), thousand seed weight (-0.011), number of fruits per plant (-0.004), number of seeds per plant (-0.002) and days to first picking (-0.001) exerted maximum negative indirect effect towards yield *via* ascorbic acid. Fruit length (-0.075) followed by fruit weight (-0.066), ascorbic acid (-0.057), number of primary branches (-0.050), number of seeds per fruit (-0.045), pericarp thickness (-0.034), fruit breadth (-0.021), total soluble solids (-0.019) and thousand seed weight (-0.013) exerted maximum negative indirect effect towards yield *via* number of lobes per fruit. Thousand seed weight (-0.039) followed by fruit breadth (-0.032), plant height (-0.030), fruit weight (-0.005) and ascorbic acid (-0.001) exerted maximum negative indirect effect towards yield *via* days to first picking. Fruit breadth (-0.056) followed by days to first picking (-0.029), Fruit weight and total soluble solids (-0.0012), ascorbic acid (-0.009) and thousand seed weight (-0.003) exerted maximum negative indirect effect towards yield *via* plant height. Thousand seed weight (-0.018) followed by fruit weight (-0.015), number of lobes per fruit (-0.013), fruit length (-0.009), number of primary branches (-0.008), ascorbic acid (-0.005) and number of seeds per fruit (-0.003) exerted maximum negative indirect effect towards yield *via* pericarp thickness. Ascorbic acid (-0.029) followed by fruit breadth (-0.021), number of seeds per fruit (-0.020), number of lobes per fruit (-0.017), fruit weight (-0.013), pericarp thickness (-0.008), fruit length (-0.007) and total soluble solids (-0.002) exerted maximum negative indirect effect towards yield *via* number of primary branches. In view of the direct and indirect contributions of component traits towards fruit yield, selection on the

basis of horticultural traits viz., average fruit weight and number of fruits per plant would be a paying proposition in the genotypes included in the study. Similar results were reported by Johri and Kumar (2007), Naik *et al.*, (2010), Sharma *et al.*, (2010) and Kumari (2013). Low magnitude of residual effect at genotypic level indicated that the traits included in the present investigation accounted for most of the variation present in the dependent variable *i.e.* fruit yield per plant. The studies on path coefficient analysis suggested that selection for fruit weight, number of fruits per plant, fruit breadth, thousand seed weight, fruit length and number of seeds per fruit would be effective for improving yield in bell pepper.

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