Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(2): 646-649
Received: 26-01-2019
Accepted: 27-02-2019

Ankita Sharma
Department of Vegetable Science, College of Horticulture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Manish Kumar
Department of Seed Science and Technology, College of Horticulture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Nitish Kumar
Department of Vegetable Science, College of Horticulture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

RK Dogra
Department of Fruit Science, College of Horticulture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Santosh Kumari
Department of Vegetable Science, College of Horticulture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Correspondence
Ankita Sharma
Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Studies on interrelationships among yield and yield contributing traits in bell pepper (*Capsicum annuum* L. var. *grossum*)

Ankita Sharma, Manish Kumar, Nitish Kumar, RK Dogra and Santosh Kumari

Abstract
Thirty five genotypes including three check cultivars were grown in a RCBD with three replications during Kharif, 2013 at Vegetable Experimental Research Farm, Nauni, Solan, HP to study the correlation and path analysis of yield and other different economic characters in bell pepper. From the correlation study among different characters a highly significant and positive phenotypic and genotypic correlation of yield was found with number of fruits per plant, fruit length, fruit breadth, average fruit weight, pericarp thickness and harvest duration. Therefore, main emphasis should be given on these characters, while making the selection in bell pepper genotypes. Maximum positive direct effect towards yield was contributed by number of fruits per plant, followed by average fruit weight and pericarp thickness. The studies on path coefficient analysis suggested that selection for average fruit weight, number of fruits per plant and pericarp thickness would be effective for improving yield in bell pepper.

Keywords: Bell pepper, correlation, path analysis, yield and traits

Introduction
Bell pepper (*Capsicum annuum* L. var. *grossum*) commonly known as Sweet pepper or Shimla mirch is an important solanaceous vegetable crop cultivated throughout the world. It occupies a pride place among the vegetables in Indian cuisine because of its delicate taste and pleasant flavour coupled with rich ascorbic acid and other minerals and vitamins. In Himachal Pradesh, it is grown for off season produce during the summer and rainy months and bulk of bell pepper is transported to the nearby and distant markets in Punjab, Haryana, Delhi and UP, thus fetching good economic returns to the small and marginal farmers. There are very few varieties available for cultivation in bell pepper developed by public sector which has led to near genetic uniformity among these cultivars. Hence, there is need to develop and identify new genotypes having desirable horticultural traits including quality. For formulating effective crop improvement programmes, the knowledge regarding the extent and nature of correlation between component characters and their effect on yield is essential. Yield is polygenic in nature and influenced by environmental factors which complicate the selection process, thus, the knowledge of correlation of the traits is necessary for effective selection process. Knowledge of inter character relationship is equally important in plant breeding for indirect improvement of characters which are difficult to quantify especially those that exhibit low heritability. Further, path coefficient analysis helps for sorting out the total correlation into direct and indirect effects and is useful tool in selecting the component characters exerting more effect directly or indirectly on the yield. Thus, the present investigation was carried out with the objective to study the correlation and association among yield and important horticultural traits.

Materials and Methods
The experimental material for the present investigation comprised of thirty five diverse genotypes of bell pepper (*Capsicum annuum* L. var. *grossum*) including three checks viz., Nishat-1, California Wonder and Solan Bharpur. The present study was carried out at the research farm of Department Vegetable Science, Dr YS Parmar University of Horticulturea nd Forestry, Nauni, Solan (HP), India during Kharif, 2013. The bell pepper genotypes along with their sources of collection have been given in table 1. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Seedlings of each entry were transplanted on 1st May, 2013 at a spacing of 60 cm x 45 cm in a plot size of 3.0 m x 1.80 m in each replication.

The standard cultural practices recommended for growing bell pepper crop in the mid hills as finalised in the "Package of Practices of Vegetable Crops" published by the Directorate of Extension Education, Dr YSPUHF, Nauni, Solan (HP) were followed. Data were recorded on ten 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 on days to first flowering, days to first marketable picking, number of fruits per plant, fruit length (cm), fruit breadth (cm), average fruit weight (g), pericarp thickness (mm), plant height (cm), harvest duration (days), number of seeds per fruit, number of lobes per fruit, ascorbic acid content (mg/100g), capsaicin content (mg/g) and fruit yield (kg/plant, kg/plot and q/ha). Ascorbic acid content of fruits was determined as per 2,6- dichclorophenol-indophenol visual titration method as described by (Ranganna, 1986) [8]. Capsaicin content was calculated according to the colorimetric method given by Sadasivam and Manickam (1997) [9]. The purpose of recording capsaicin content in study was to identify promising genotypes having relatively very low or no pungency (our objective was not at all to develop a pungent pepper). The correlation coefficients were calculated as per (Al-Jibouri *et al.*, 1958) [2]. The direct and indirect effects were obtained following Dewey and Lu (1959) [3].

Results and Discussion

The correlation coefficients among different characters were worked out at phenotypic and genotypic levels in the present study (table 2). In general, genotypic correlations were higher than the phenotypic correlations for most of the characters depicting strong inherent association among the characters studied. The low phenotypic value might be imputed to differential interaction of the genotypes with the environment. The phenotypic correlation coefficients among fourteen characters showed that yield per plant had positive and significant association with number of fruits per plant (0.690), fruit length (0.707), fruit breadth (0.420), average fruit weight (0.655), pericarp thickness (0.534), plant height (0.454), harvest duration (0.512) and number of lobes per fruit (0.262). Similarily number of fruits per plant was significantly and positively correlated with plant height (0.350) and harvest duration (0.203) at phenotypic level. Days to first marketable picking was significantly correlated with days to first flowering (0.567). Fruit length was significantly correlated with fruit breadth (0.569), pericarp thickness (0.666) and average fruit weight (0.709). However, number of seeds per fruit was having significant negative correlation with ascorbic acid content (-0.412).

The genotypic correlation coefficients presented in table 2 further revealed that fruit yield per plant had positive and significant association with number of fruits per plant (0.696), fruit length (0.799), fruit breadth (0.482), average fruit weight (0.688), pericarp thickness (0.632), plant height (0.489), harvest duration (0.571) and number of lobes per fruit (0.306). Similarily, number of fruits per plant was positively and significantly correlated with plant height (0.360) and harvest duration (0.219). Days to first marketable picking was also significantly correlated with days to first flowering (0.773). Similarly, fruit length was significantly correlated with fruit breadth (0.616), pericarp thickness (0.780) and average fruit weight (0.824). Number of seeds per fruit was having significant but negative correlation with ascorbic acid content (-0.453).Correlation studies revealed that yield had positive association with number of fruits per plant, fruit length, fruit breadth, average fruit weight, pericarp thickness and harvest duration indicating that selection for these traits would necessarily lead to achieve improvement in yield. Hence, on the basis of correlation studies, it is summarized that the selection for number of fruits per plant, fruit length (cm), fruit breadth (cm), average fruit weight (g), pericarp thickness (mm) and harvest duration will be effective for isolating plants with higher fruit yield in bell pepper. Similar results were reported by (Madosa *et al.*, 2010) [6], (Sood *et al.*, 2011) [12], (Lahbib *et al.*, 2012) [5] and (Afroza *et al.*, 2013) [1]. A high positive and significant correlation of days to first flowering and days to first marketable picking suggested that early flowering genotypes would provide an appropriate selection criterion to get early marketable fruit yield. Such findings have also been reported by (Sharma *et al.*, 2010) [11].

Path coefficient analysis was carried out as it helps for sorting out the total correlation into direct and indirect effects and is useful in selecting the component characters exerting more effect on the yield. In the present study, maximum positive direct effect towards yield (table 3) per plant was revealed by number of fruits per plant (0.712) followed by average fruit weight (0.431) and pericarp thickness (0.250), whereas maximum negative direct effect on fruit yield was recorded by days to first flowering (-0.173), fruit breadth (-0.119), plant height (-0.078), number of seeds per fruit (-0.003) and ascorbic acid content (-0.015). However, pericarp thickness, fruit breadth, harvest duration, number of lobes per fruit and plant height exerted maximum positive indirect effect towards yield via average fruit weight. Plant height, fruit length and harvest duration also showed maximum positive indirect effect towards yield via number of fruits per plant. In view of the direct and indirect contributions of component traits towards fruit yield, selection on the basis of average fruit weight and number of fruits per plant appears to be rewarding in the genotypes included in the study. Similar results were reported by (Johri *et al.*, 2010) [4], (Naik *et al.*, 2010) [7], (Sharma *et al.*, 2010) [11] and (Sasu *et al.*, 2013) [10]. 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 that is fruit yield per plant.

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

Source	Genotype
IIVR, Varanasi	HACAV-271, VLCP-13, PRC-1, DARL-72, PT-12-3, CP-40, VLCP-3, Kt- 1
Department of Vegetable Science UHF, Nauni, Solan (HP)	UHF-1, UHF-2, UHF-3, UHF-4, UHF-5, UHFBP-6, UHFBP-7, UHFBP-8, UHFBP-18, UHFBP-19, UHFBP-20, UHF-14, UHFBP-21, Yolo Wonder, ACC-16, PC-2
World Vegetable Centre, Taiwan	EC-579997
HRS, Kandaghat, Distt. Solan (HP)	Kandaghat Sel – 9
Collections from district Solan and Sirmour(HP)	UHFBP-22, UHFBP-23, UHFBP-24, UHFBP-25, UHFBP-26, UHFBP-27
IIVR, Varanasi	Nishat-1*
IARI, Regional Station Katrain, Kullu (HP)	California Wonder*
Department of Seed Science and Technology, UHF, Nauni, Solan (HP)	Solan Bharpur*

Table 2: Phenotypic and genotypic coefficients of correlation among different traits in Bell pepper (*Capsicum annuum* L. var. *grossum*)

Traits		Days to first Marketable picking	No of fruits per plant	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight (g)	Pericarp thickness (mm)	Plant height (cm)	Harvest duration	Number of seeds per fruit	Number of lobes per fruit	Ascorbic acid content (mg/100g)	Capsaicin Content (mg/g)	Fruit yield/ plant (kg)
Days to first Flowering	P	0.567*	0.147	-0.003	-0.128	-0.103	0.003	-0.008	0.003	0.160	-0.217*	-0.105	0.239*	0.003
	G	0.773*	0.117	0.015	-0.149	-0.083	0.036	-0.037	-0.008	0.193	-0.280*	-0.148	0.283*	-0.019
Days to first Marketable picking	P		0.060	-0.078	-0.083	-0.077	-0.013	-0.041	-0.198*	0.260*	-0.144	-0.155	-0.008	-0.045
	G		0.106	-0.085	-0.098	-0.100	-0.063	-0.024	-0.225*	0.287*	-0.176	-0.199*	-0.008	-0.033
No of fruits per plant	P			0.263*	-0.000	-0.073	-0.054	0.350*	0.203*	0.047	-0.091	0.041	0.013	0.690*
	G			0.290*	0.006	-0.024	-0.041	0.360*	0.219*	0.064	-0.102	0.062	0.025	0.696*
Fruit length (cm)	P				0.569*	0.709*	0.666*	0.483*	0.599*	0.082	0.239*	-0.241*	-0.007	0.707*
	G				0.616*	0.824*	0.780*	0.589*	0.718*	0.100	0.271*	-0.267*	-0.006	0.799*
Fruit breadth (cm)	P					0.603*	0.635*	0.181	0.425*	0.158	0.706*	0.131	-0.106	0.420*
	G					0.697*	0.716*	0.232*	0.472*	0.151	0.858*	0.172	-0.113	0.482*
Average fruit weight (g)	P						0.781*	0.278*	0.497*	0.123	0.484*	-0.140	-0.009	0.655*
	G						0.914*	0.342*	0.582*	0.143	0.568*	-0.141	-0.011	0.688*
Pericarp thickness (mm)	P							0.259*	0.477*	0.176	0.451*	-0.064	-0.022	0.534*
	G							0.336*	0.569*	0.178	0.535*	-0.095	-0.012	0.632*
Plant height (cm)	P								0.435*	0.057	-0.033	-0.243*	0.004	0.454*
	G								0.540*	0.069	-0.013	-0.302*	0.005	0.489*
Harvest duration	P									0.271*	0.265*	-0.172	-0.147	0.512*
	G									0.277*	0.287*	-0.173	-0.154	0.571*
No. of seeds per fruit	P										0.127	-0.412*	-0.157	0.128
	G										0.147	-0.453*	-0.155	0.150
No. of lobes per fruit	P											0.268*	-0.119	0.262*
	G											0.272*	-0.121	0.306*
Ascorbic acid content (mg/100g)	P												0.188	-0.084
	G												0.193	-0.072
Capsaicin content (mg/g)	P													-0.016
	G													-0.009

*Significant at 5% level of significance

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

Traits	Days to first Flowering	Days to first marketable picking	No of fruits per plant	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight (g)	Pericarp thickness (mm)	Plant Height (cm)	Harvest duration	No. of seeds per fruit	No. of lobes per fruit	Ascorbic acid content (mg/100g)	Capsaicin content (mg/g)	*rg with yield per plant (kg)
Days to first Flowering	-0.173	0.073	0.084	0.002	0.018	-0.036	0.009	0.003	-0.000	-0.001	-0.009	0.002	0.009	-0.019
Days to first marketable picking	-0.133	0.094	0.075	-0.011	0.012	-0.043	-0.016	0.002	-0.009	-0.001	-0.005	0.003	-0.000	-0.033
No. of fruits per plant	-0.020	0.010	0.712	0.038	-0.001	-0.010	-0.010	-0.028	0.009	-0.000	-0.003	-0.001	0.001	0.696
Fruit length (cm)	-0.003	-0.008	0.207	0.131	-0.074	0.355	0.195	-0.046	0.029	-0.000	0.008	0.004	-0.000	0.799
Fruit breadth (cm)	0.026	-0.009	0.004	0.081	-0.119	0.300	0.179	-0.018	0.019	-0.000	0.026	-0.003	-0.004	0.482
Average fruit weight (g)	0.014	-0.009	-0.017	0.108	-0.083	0.431	0.228	-0.027	0.023	-0.000	0.017	0.002	-0.000	0.688
Pericarp thickness(mm)	-0.006	-0.006	-0.029	0.102	-0.085	0.394	0.250	-0.026	0.023	-0.001	0.016	0.001	-0.000	0.632
Plant height (cm)	0.006	-0.002	0.256	0.077	-0.028	0.148	0.084	-0.078	0.022	-0.000	-0.000	0.005	0.000	0.489
Harvest duration	0.001	-0.021	0.156	0.094	-0.056	0.251	0.142	-0.042	0.040	-0.001	0.009	0.003	-0.005	0.571
No. of seeds per fruit	-0.033	0.027	0.046	0.013	-0.018	0.062	0.044	-0.005	0.011	-0.003	0.005	0.007	-0.005	0.150
No. of lobes per fruit	0.048	-0.017	-0.073	0.036	-0.102	0.245	0.134	0.001	0.012	-0.000	0.031	-0.004	-0.004	0.306
Ascorbic acid content (mg/g)	0.026	-0.019	0.044	-0.035	-0.021	-0.061	-0.024	0.024	-0.007	0.001	0.008	-0.015	0.006	-0.072
Capsaicin content (mg/g)	-0.049	-0.001	0.018	-0.001	0.014	-0.005	-0.003	-0.000	-0.006	0.000	-0.004	-0.003	0.031	-0.009

*rg = genotypic correlation coefficient

Diagonal figures represents the direct effect

The studies on path coefficient analysis suggested that selection for average fruit weight (g), number of fruits per plant and pericarp thickness (mm) would be effective for improving yield in bell pepper.

Conclusion

From the present investigation it is concluded that the, main emphasis should be given on the characters like number of fruits per plant, fruit length, fruit breadth, average fruit weight, pericarp thickness, plant height, harvest duration and number of lobes per fruit, while making the selection in bell pepper genotypes.

Acknowledgements

A special thanks to Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) for providing me the financial help in the form of merit scholarship and necessary facilities to conduct the investigation.

References

1. Afroza B, Khan SH, Mushtaq F, Hussain K, Nabi A. Variability and correlation studies in sweet pepper (*Capsicum annuum* L.). Progressive Horticulture. 2013; 45(1):209-213.
2. Al-Jibouri HW, Miller PA, Robinson HF. Genotypic and environmental variances and co-variances in an upland cotton cross of interspecific origin. Agronomy Journal. 1958; 50:633-636.
3. Dewey JR, Lu KH. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy Journal. 1959; 51:515-518.
4. Johri S, Singh RV, Mishra AC. Correlation studies in capsicum (*Capsicum annuum* L.) varieties and their hybrids. Progressive Horticulture. 2010; 42(2):183-185.
5. Lahbib K, Bnejdi F, Gazzah MEl. Genetic diversity evaluation of pepper (*Capsicum annuum* L.) in Tunisia based on morphologic characters. African Journal of Agricultural Research. 2012; 7(23):3413-3417.
6. Madosa E, Sasu L, Ciulca S, Velicevici G, Ciulca EA, Avadanei, C. Possibility of use of Romanian pepper (*Capsicum annuum* L. var. *grossum*) local landraces in breeding process. Notulae Botanicae, Horti Agrobotanici, Cluj Napoca. 2010; 38(2):56-60.
7. Naik KB, Sridevi O, Salimath PM, Patil AA. Genetic architecture and trait relationship in segregating populations of sweet pepper (*Capsicum annuum*) under shade house conditions. Indian Journal of Agricultural Sciences. 2010; 80(10):902-906.
8. Ranganna S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. Edn 2, Tata McGraw Hill, New Delhi, 1986, 105-106.
9. Sadasivam S, Manickam A. Phenolics. In: Biochemical Methods. Edn 2, New Age International (O) Ltd, New Delhi, 1997, 193-194.
10. Sasu L, Madosa E, Velicevici G, Cicula S, Avadanei C, Gorinoiu G. Studies regarding correlations between the main morphological traits in a collection of bell pepper (*Capsicum annuum* L. var. *grossum*) local landraces. Journal of Horticulture, Forestry and Biotechnology. 2013; 17(2):285-289.
11. Sharma VK, Semwal CS, Uniyal SP. Genetic variability and character association analysis in bell pepper (*Capsicum annuum* L.). Journal of Horticulture and Forestry. 2010; 2(3):58-65.
12. Sood S, Kumar N, Chandel KS, Sharma P. Determination of genetic variation for morphological and yield traits in bell pepper (*Capsicum annuum* L. *var. grossum*). Indian Journal of Agricultural Sciences. 2011; 81(7):590-594.