International Journal of Genetics
ISSN: 0975-2862 & E-ISSN: 0975-9158, Volume 11, Issue 3, 2019, pp.-567-570.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000226

Review Article

RECENT ADVANCES IN GENETIC STUDIES OF BELL PEPPER

SEEMA THAKUR*[1], RADHIKA NEGI[2] AND PAYAL SHARMA[2]
[1]Scientist, ICAR-Krishi Vigyan Kendra, Kandaghat, 173213, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, 173230, Himachal Pradesh
[2]Department of Vegetable Science, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, 173230, Himachal Pradesh, India
*Corresponding Author: Email - thakurseema76@gmail.com

Received: March 01, 2019; Revised: March 14, 2019; Accepted: March 15, 2019; Published: March 30, 2019

Abstract: Bell Pepper (*Capsicum annuum* L.) popularly known as sweet pepper, capsicum or Shimla Mirch is one of the important cash crops for temperate regions. Genetic restructuring of the bell pepper germplasm in public sector is the need of the hour. In this direction, the first and foremost step is the evaluation of the available germplasm so as to identify the potential genotype for their use either directly as varieties or as parent's in future breeding programme. The determination of genetic variability and its partitioning into various components like genotypic, phenotypic and environmental variability is necessary to have an insight into the genetic nature of yield and its components which enable the breeders to adopt a suitable strategy and formulate a comprehensive breeding program, required for the necessary crop improvement. 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.

Keywords: *Bell Pepper, Germplasm*

Citation: Seema Thakur, *et al*., (2019) Recent Advances in Genetic Studies of Bell pepper. International Journal of Genetics, ISSN: 0975-2862 & E-ISSN: 0975-9158, Volume 11, Issue 3, pp.- 567-570.

Academic Editor / Reviewer: Dr Muthana I Maleek, Dr Satish Baburao Shelke

Introduction

Bell Pepper (*Capsicum annuum* L.) popularly known as sweet pepper, capsicum or Shimla Mirch is a member of family Solanaceae with chromosome number 2n=24. It is a high value vegetable and an important cash crop for temperate regions. It is an important vegetable crop grown worldwide for its delicate taste, pleasant flavour and colour. It is native to Mexico with secondary centre of origin in Guatemala [1]. Fruits of bell pepper are generally blocky, square or triangular in shape, thick fleshed, three to four lobed having low to mild pungency. 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. Besides, bell pepper is also rich in certain nutrients, by virtue of which it possesses medicinal properties, hence recommended for the treatment of dropsy, colic, toothache and cholera [2]. Nutritionally, it is a rich source of vitamin C ranging from 150-180 mg per 100 g and vitamin A, constituting up to 12 percent of total pigment content. It is also rich in ascorbic acid content which has an antioxidant property and aids in prevention of certain types of cancer, cardiovascular diseases, stroke, atherosclerosis and cataracts [3]. 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 [4] 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 Summers. It is now widely cultivated in Himachal Pradesh, Jammu and Kashmir, hills of Uttar Pradesh, Andhra Pradesh and Nilgiris during summer and as an autumn crop in Karnataka, Tamil Nadu, Maharashtra, Bihar, West Bengal and Madhya Pradesh. In India, bell pepper is cultivated over an area of about 46,000 ha with a production of 288,000 MT [5].

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 [6]. Recently, bell pepper has attained a status of high value vegetable in India due to its high nutritional value and export potential. Despite of its economic importance, growers are not in a position to produce good quality capsicum with high productivity due to various biotic (diseases and pest), abiotic (rainfall, temperature, relative humidity and light intensity) and crop factors (flower and fruit drop). There are a very few varieties available for cultivation in bell pepper in the public sector which has led to near genetic uniformity among these cultivars. Few old introductions like California Wonder are still recommended for commercial cultivation. Now a day's farmers are largely dependent on the private sector for the supply of seed. Genetic restructuring of the bell pepper germplasm in public sector is the need of the hour. In this direction, the first and foremost step is the evaluation of the available germplasm so as to identify the potential genotype for their use either directly as varieties or as parents in future breeding programme.

Breeding objectives in bell pepper

-High yield and Earliness
-Desirable fruit shape and size: oblate or round
-Superior fruit qualities like high vitamin C and pigment content, pleasing flavour
-Resistance to diseases like fruit rot, cercospora leaf spot, powdery mildew common TMV, *etc*.
-Resistance/tolerance to insects like thrips, mites, aphids, fruit borer
-Resistance/tolerance to abiotic stresses like heat, water stress, salinity.

Genetic Variability Studies

Existence of sufficient variability in the genetic stock is a pre-requisite for initiation of any breeding programme. The determination of genetic variability and its partitioning into various components like genotypic, phenotypic and environmental variability is necessary to have an insight into the genetic nature of yield and its components which enable the breeders to adopt a suitable strategy and formulate a comprehensive breeding program, required for the necessary crop improvement. In this direction, moderate to high heritability estimates of variability was observed for all the traits in twenty-five genotypes of bell pepper [7]. High genotypic coefficients of variation (GCV), high heritability and genetic advance (GA) were found for number of lobes per fruit, fruit width at blossom end and fruit weight at marketable stage. Moderate GCV, GA and moderate to high heritability were recorded for plant height, number of fruits per plant, fruit length, fruit width (middle/centre and stem end) and fruit yield per plant. High phenotypic and genotypic coefficients of variability for average fruit weight were observed in an experiment with genotypes of bell pepper. High heritability coupled with high genetic gain was recorded for plant height, plant spread, flesh thickness, number of fruits per plant, weight per fruit and seed yield per plant [8]. In another study, Sood *et al*. (2006) conducted an experiment on twenty-five genotypes of bell pepper and concluded that Phenotypic Coefficients of Variation were high for fruit yield, fruits per plant and marketable fruits per plant [9]. High heritability along with high genetic advance was recorded for fruit yield per plant. High to moderate heritability with low genetic advance was recorded for days to 50 percent flowering, days to first picking, branches per plant and harvest duration. The phenotypic coefficients of variation (PCV) were slightly higher than their corresponding genotypic coefficients of variation (GCV) due to the influence of environment. Higher PCV and GCV were observed for capsaicin content and marketable fruit yield and moderate to low for TSS, ascorbic acid and pericarp thickness. High degree of variation was observed for all characters in a study on about eighty chilli accessions. The difference between phenotypic coefficient of variation and genotypic coefficient of variation was found to be narrow for most of the traits except primary and secondary branches, tertiary branches, 50 percent flowering and fruit yield per plant. High estimates of heritability were found for plant height (93.40%), days to first flowering (83.50%), percent fruit set (70.70%), number of fruits per plant (81.10%), fruit length (92.40%), average fruit weight (92.40%) and total green fruits per plant (88.40%). Most of these characters also showed moderate to high estimates of genetic advances as a percent over mean except days to first flowering [10]. In another study, Sood *et al*. (2009) studied genetic variation for marketable fruit yield, fruits per plant, average fruit weight, pericarp thickness, number of lobes per fruit, TSS, ascorbic acid, capsaicin content and quantified the relationship among these traits. Difference among bell pepper genotypes indicated the presence of significant variation for all the traits. The phenotypic coefficient of variation (PCV) indicated higher values than genotypic coefficient of variation (GCV) for all traits, indicating close association between phenotype and genotype. High heritability estimates along with high genetic advance was recorded for marketable fruits per plant, pericarp thickness, and lobes per fruit thereby, indicating the role of additive gene action for their inheritance. Days to 50 percent flowering, harvest duration and ascorbic acid had high heritability estimates along with low genetic advance indicating non-additive gene action. Sharma *et al*. (2010) worked out genetic variability including mean, genotypic and phenotypic variances, coefficient of variation, heritability, and genetic advance on twenty-three genotypes of bell pepper [11]. Significant differences were observed among the genotypes for all the traits under study. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were high for fruit yield per plant. High heritability along with high genetic advance was recorded for average fruit weight, fruit yield per plant, fruit diameter, number of lobes per fruit, days to first harvest, leaf area and ascorbic acid content, indicating the role of additive gene action for the inheritance of these traits. Luitel (2011) evaluated sweet pepper germplasm for various fruit yield and fruit quality characters and found the presence of appreciable variability in fruit yield and quality traits [12]. Thus, these genotypes can be utilized to develop high yielding sweet pepper varieties with better quality traits. Sood *et al*. (2011) studied nineteen diverse genotypes to assess genetic variation for yield, days to first picking, days to harvest, fruits per plant, fruit length, fruit girth, pericarp thickness, average fruit weight and lobes per fruit. Significant differences were observed for all the traits except days to first picking and lobes per fruit, which revealed the presence of sufficient variability for these traits. The Phenotypic Coefficient of Variation (PCV) exhibited higher values than Genotypic Coefficient of Variation (GCV) for all the traits, indicating close association between phenotype and genotype. High estimates of PCV for fruit yield and fruits per plant indicated the importance of additive genes. High heritability coupled with high to moderate genetic advance was observed for fruit yield per plant, fruits per plant, fruit length, fruit girth, pericarp thickness and average weight, indicating role of additive gene action for its inheritance. In another experiment, Ahmed *et al*. (2012) studied thirty-four genotypes of bell pepper for nine quantitative characters [13]. The results revealed that PCV was greater than corresponding GCV for all traits. High GCV and heritability accompanied by moderate to high genetic gain was observed for number of fruits and fruit weight. Fruit length and fruit diameter exhibited high heritability coupled with moderate GCV and low genetic gain. The genetic variability in ten diverse lines of sweet pepper was assessed by Afroza *et al*. (2013) [14]. Analysis of variance revealed significant differences among the parents and crosses indicating diversity in the germplasm. The magnitudes of phenotypic and genotypic coefficients of variation were moderate to high depicting the ample scope for improvement through selection. The heritability (broad sense) was high for all the traits, except number of locules. Datta and Chakraborty (2013) conducted an experiment to study the growth, yield and quality characters in fifty-one genotypes of chilli [15]. Significantly highest number of fruits per plant was recorded in genotype CA-29 Ascorbic acid content in red ripe fruit varied from 75.89 to 167.21 mg/ 100g fresh. Datta and Das (2013) collected fifty-three genotypes of *Capsicum annuum* L. from different parts of India. Variability studies revealed a wide range of variability for all the characters under study. High heritability along with high genetic advance was found for capsaicin content, number of fruits per plant, yield per plant and primary branches per plant. These characters may be considered as reliable selection indices as governed by additive gene action. Kumari (2013) studied genetic variability in bell pepper and recorded higher genotypic and phenotypic coefficients of variation for number of fruits per plant (30.49 % and 30.63%), average fruit weight (30.85% and 30.03%) and fruit per plant (32.12% and 32.26%) in bell pepper indicating wide genetic variability for these traits [16]. High heritability coupled with high genetic gain was observed for number of fruits per plant (57.85% and 57.85%), average fruit weight (60.62% and 60.62%) and fruit yield per plant (65.80% and 65.80%), suggesting the role of additive gene action for the inheritance of these traits. Significant variation was observed among all the genotypes for quantitative and qualitative traits in sweet pepper by Pandey *et al*. (2013) [17]. The researcher observed high heritability along with high GCV and high genetic gain was observed for fruit weight, fruit yield per plant, number of fruits per plant, total chlorophyll and fruit width. Kumari and Sharma (2014) screened fifteen genotypes of bell pepper for resistance against Phytopthora leaf blight and fruit rot disease. Analysis of variance indicated significant differences among genotypes for the disease under study. Genotypes *viz*., Feroz and LC-1 were found to be moderately resistant to both diseases with lowest apparent infection rate. Pandit and Adhikary (2014) estimated variability and heritability for important yield and yield contributing traits in fourty one chilli genotypes and recorded very high genetic advance as percent of mean in fruit yield per plant and moderately high genetic advance as percent of mean in days to fifty percent flowering, placenta length, fruit length, number of fruits per plant and number of seeds per plant. Naik *et al*. (2014) evaluated two F2 populations of the commercial hybrids. F_2 populations of the commercial hybrids *viz*., Bombay and Atlas were evaluated to study the extent of variability [18]. Considerable variation was observed between and within the populations which was also confirmed by high mean and wider range as evidenced by high PCV and GCV values. The studies concluded that selection strategy for yield improvement should rely on characters *viz*., fruit weight, fruits per plant, fruit length, fruit surface area, seeds per fruits and pericarp thickness during selection, since these characters exhibited highest direct effect on the yield. Patel *et al*. (2015) studied genetic variability in forty diverse genotypes of chilli [19]. The analysis of variance revealed the significant differences among the genotypes for all the character studied which indicated the presence of genetic variability for different traits. The high estimates of GCV and PCV were obtained for number of primary branches per plant, number of secondary branches per plant, number of fruits per plant, average fruit length (cm). High heritability was observed for secondary branches per plant, number of fruits per plant, fruit length, fruit weight, green fruit yield per plant, chlorophyll content, ascorbic acid content and capsaicin content. High heritability coupled with high genetic advance indicated better scope for improvement. Swamy *et al*. (2015) evaluated varieties and hybrids of capsicum for different quality attributes under 50 percent shade net house. The hybrid, Angel recorded significantly high ascorbic acid content closely followed by the variety, Arka Gaurav. The capsaicin content was found meagre in all the varieties and hybrids. Whereas, high Total Soluble Solids was recorded in the variety, Arka Gaurav followed by the hybrid, Angel. In another study, Rekha *et al*. (2016) assessed forty three genotypes of chilli (*Capsicum annuum* L.) and recorded high coefficient of variation both at phenotypic and genotypic level for the traits like fruit set percent, number of fruits per plant, dry fruit yield per plant, number of seeds per fruit and average dry fruit weight [20]. Murmu *et al*. (2017) studied genetic variability in twenty-four genotypes of chilli and revealed the significant differences among the genotypes for almost all the characters. The results revealed the presence of a good amount of genetic variability for different traits. Thakur *et al*. (2017) observed high heritability coupled with high genetic gain for average fruit weight, fruit yield per plant and fruit length which indicated the presence of additive gene action and thus, offered more scope for reliable and effective selection [21].

Correlation studies

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. Aliyu *et al*. (2000) studied correlation in bell pepper and observed a positive and highly significant association among fruit yield, fruit number, fruit diameter, number of seeds per plant and seed yield [22]. Chatterjee and Kohli (2001) studied correlation in bell pepper and observed significant differences for all the traits under study. Yield was found to be significantly and positively correlated with fruit weight, fruit width, pericarp thickness, number of seeds per fruit and 1000-seed weight. Feipeng and Huang (2004) conducted an experiment to study correlation for major horticultural traits in sweet pepper and reported that number of fruits per plant and fruit weight was closely related to total yield. Bindal *et al*. (2005) studied twenty-two genotypes of bell pepper and observed significant and positive correlation between fruit yield and number of marketable fruits per plant, harvesting duration, fruit length and fruit width [23]. The number of days to 50 percent flowering showed a negative and significant correlation with fruit yield. Bharadwaj *et al*. (2007) conducted an experiment on twenty-seven diverse genotypes of chilli to work out character association between fruit yield and nine other characters [24]. Results showed that fruit yield was positively associated with number of branches per plant and number of fruits per plant. Number of branches per plant was also found positively correlated with fruit width, number of fruits per plant and fruit yield. Gazala *et al*. (2007) concluded that seed yield was significantly and positively correlated with days taken to first flower appearance, days to first picking and pedicel length in bell pepper [25]. However, seed yield was found significantly and negatively correlated with fruit yield. Ukkund *et al*. (2007) studied eighty genotypically diverse indigenous and exotic genotypes of chilli for thirteen important horticultural traits. The phenotypic and genotypic association of fruit yield was significantly positive with all the characters except days to first flowering and average fruit weight. Narciso (2009) in his studies reported strong and negative correlation between fruit length and fruit diameter in sweet pepper [26]. Sood *et al*. (2009) found higher genotypic correlations than the corresponding phenotypic correlations, revealing inherent association among traits. Character association analysis revealed that fruit yield per plant was strongly associated with number of fruits per plant, hence it could be considered as one of the important selection criteria in the improvement of fruit yield. Sharma *et al*. (2010) studied twenty-three genotypes of bell pepper and revealed significant positive correlation of the traits *viz*., fruit length, fruit diameter and number of fruits per plant with fruit yield per plant. Afroza *et al*. (2013) studied the correlation in bell pepper and observed that fruit yield per plant exhibited significant positive correlation with days to first flowering, days to first fruit set, number of branches per plant, fruit length, fruit diameter, flesh thickness, average fruit weight, number of fruits per plant and average seed weight per fruit both at genotypic and phenotypic levels. Kumari (2013) studied nineteen genotypes of bell pepper and observed that fruit yield per plant had positive and significant correlation with number of fruits per plant and average fruit weight. Singh *et al*. (2014) conducted an experiment on twenty-three genotypes of chilli to study the correlation [27]. The number of fruits per plant was significantly and positively correlated with fruit weight per plant and red ripened fruit yield. Green fruit yield per plant and dry yield per plant were positively and significantly correlated with number of fruits per plant and fruit weight. Patel *et al*. (2015) studied forty diverse genotypes of chilli and concluded that genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic correlation coefficients for all the traits.

Application of research: Green fruit yield per plant had significant and positive association with number of fruits per plant, average fruit weight, moisture content and chlorophyll content at both genotypic and phenotypic levels which concluded that these traits were major yield attributing traits.

Research Category: Vegetable Science

Acknowledgement / Funding: Authors are thankful to ICAR-Krishi Vigyan Kendra, Kandaghat, 173213, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, 173230, Himachal Pradesh, India

***Principal Investigator or Chairperson of research: Dr Seema Thakur**
University: Dr Y S Parmar University of Horticulture and Forestry, Solan, 173230
Research project name or number: Review study

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: ICAR-Krishi Vigyan Kendra, Kandaghat, 173213

Cultivar / Variety name: Bell Pepper (*Capsicum annuum* L.) Shimla Mirch

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

References

[1] Bukasov S.M. (1930) *Bulletin of Applied Botanical Genetics and Plant Breeding* 47 (Supple 4),261-73.
[2] Peirce L.C. (1987) *Vegetables, Characteristics, Production, and Marketing. John Wiley and Sons, New York*. 448.
[3] Maldonado S.H., Torres I., Pachecoy M. and Gonzalez C. (2002) In, *Proceedings of the XVI International Pepper Conference, held at Tampico, Tamaulipas, Mexico*. pp.10-12.
[4] Singh P.K., Kumar A. and Ahad I. (2014) *International Journal of Farm Sciences* 4,104-11.
[5] NHB (2016) www.nhb.gov.in
[6] Sood S., Sood R., Sagar V. and Sharma K.C. (2009) *Indian Journal of Vegetable Science* 15,272-84.
[7] Chatterjee R. and Kohli U.K. (2004) *Horticultural Journal* 17,241-44.
[8] Nazir G., Narayan R., Ahmed N. and Hussain K. (2005) *Environment and Ecology* 23,527-31.
[9] Sood S., Bindal A.K., Sharma A. (2006) *Scientific Horticulture* 10, 204-07.

[10] Ukkund K.C., Madalageri M.B., Patil M.P., Mulage R. and Kotlkal Y.K. (2007) *Karnataka Journal of Agriculture Science* 20,102-04.
[11] Sharma V.K., Semwal C.S. and Uniyal S.P. (2010) *Journal of Horticulture and Forestry* 2,58-65.
[12] Luitel B.P., Lee T. and Kang W. (2011) *Korean Journal of Breeding Science* 43,139-44.
[13] Ahmed N., Singh S.R., Lal S., Mir K.A. (2012) *Indian Journal of Plant Genetic Resources* 25,304-06.
[14] Afroza B., Khan S.H., Mushtaq F., Hussain K. and Nabi A. (2013) *Progressive Horticulture* 45,209-13.
[15] Datta S. and Chakraborty G. (2013) *Journal of Applied and Natural Science* 5,350-56.
[16] Kumari S. (2013) *The Asian Journal of Horticulture* 8,280-84.
[17] Pandey V., Chura A., Arya M.C. and Ahmed Z. (2013) *Vegetable Science* 40, 37-39.
[18] Naik K.B., Sridevi O., and Salimath P.M. (2014) *Bioinfolet* 11,474-80.
[19] Patel D.K., Patel B.R., Patel J.R. and Kuchhadiya G.V. (2015) *Electronic Journal of Plant Breeding* 6,472-78.
[20] Rekha G.K., Naidu L.N., Ramana C.V., Umajyothi K., Paratparara M. and Sasikala K. (2016) *Journal of Plant Development Sciences* 8,51-55.
[21] Thakur S., Thakur R. and Mehta D.K. (2017) *International Journal of Agricultural Sciences* 13,30-33.
[22] Aliyu L., Ahmed M.K. and Magaji M.D. (2000) *Crop Research Hisar* 19, 318-23.
[23] Bindal A.K., Sood S. and Kaul S. (2005) *Journal of Horticultural Sciences* 11,113-16.
[24] Bharadwaj D.N., Singh H. and Yadav R.K. (2007) *Progressive Agriculture* 7,72-74
[25] Gazala N., Ahmed N., Hussain K., Qadir R. and Dar Z.A. (2007) *Asian Journal of Horticulture* 2, 181-83.
[26] Narciso J.O. (2009) *Philippine Journal of Crop Science* 34,102-07.
[27] Singh D.P., Anand N. and Deshpande A.A. (1993) *Improvement of bell pepper. In, Advances in Horticulture (Chadha KL and Kalloo G eds). Malhotra Publishing House, New Delhi*. pp.87-04.