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Morphological Characterization of Advanced Breeding Lines of Bell Pepper (*Capsicum annuum* L.) in North Western Himalaya

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Abstract—*Present study was conducted at ICAR-VPKAS under North-West Himalayan conditions. The objective of the study was to characterized advanced lines on the basis agro-morphological attributes. Sixty three advanced lines were evaluated including two exotic lines from AVRDC, Taiwan. The highly significant difference in mean squares inferred that there is apparent confirmation of inherent genetic variability among the genotypes with respect to all the attributes under study. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) results indicate the presence of considerable amount of genetic variability Correlated studies showed that fruit yield per plant is highly correlated with fruit girth (r= 0.419), fruit pericarp thickness (r=0.350) and fruit weight (r=0.341). Thus, selection for the improvement of fruit yield can be efficient if it is based on fruit girth, fruit pericarp thickness and fruit weight in North-West Himalayan region.*

INTRODUCTION

Capsicum or Bell Pepper (*Capsicum annuum* L. var. grossum Sendt), also popularly called as Simla Mirch in India is one of the leading vegetables grown in open conditions as well as under protected conditions. Bell pepper (*Capsicum annuum* L. var. grossum Sendt) is different from chilli (*Capsicum annuum* L. var. longum) belongs to the family solanaceae. Because of its economic importance as a high value vegetable crop both in domestic and overseas markets due to more consumer preferences and use in various culinary products, quality production of capsicum is the need of the day. This has led to production of capsicum under protected conditions to meet the standards of different markets prompting popularity of this crop as an enterprise in urban and peri urban areas. The crop, once the domain of only the rich and elite farmers has today become a successful and profitable enterprise for small and marginal farmers also. Capsicum fruit is rich in Vitamin A (8493 IU), Vitamin C (283 mg) and minerals like Calcium (13.4 mg), Magnesium (14.9 mg) Phosphorus (28.3 mg)

The present study was initiated with following objective :

1. Characterization of *Capsicum* genotypes based on agro-morphological parameters
2. Genetic variability for agro-morphological attributes and their association

MATERIAL METHOD

Plant material:

In the present study, sixty one advanced lines along with two exotic lines from AVRDC (Asian Vegetable Research and Development Centre renamed as World Vegetable Centre), Taiwan of bell pepper (Table1) were sown on expanded polystyrene trays. The transplanting of the seedlings to the experimental field was done in first fortnight of April, 2016 at ICAR-VPKAS under North-West Himalayan conditions. The experiment was carried out with sixty three treatments, genotype spaced as 1.0 × 1.0 m among rows and plants. All standard cultivation practices were followed with regard to nutrition supply, irrigation and plant protection measures during the entire growing season [2]

Table 2.1: List of bell pepper (*Capsicum annuum* L.) lines under study and source

Sl no	Advance breeding lines/ cultivers	Source
1	VLCP-2016-1	ICAR-VPKAS, Almora
2	VLCP-2016-3	ICAR-VPKAS, Almora
3	VLCP-2016-4	ICAR-VPKAS, Almora
4	VLCP-2016-9	ICAR-VPKAS, Almora
5	VLCP-2016-10	ICAR-VPKAS, Almora
6	VLCP-2016-11	ICAR-VPKAS, Almora
7	VLCP-2016-12	ICAR-VPKAS, Almora
8	VLCP-2016-13	ICAR-VPKAS, Almora
9	VLCP-2016-14	ICAR-VPKAS, Almora
10	VLCP-2016-15	ICAR-VPKAS, Almora
11	VLCP-2016-16	ICAR-VPKAS, Almora
12	VLCP-2016-5	ICAR-VPKAS, Almora
13	VLCP-2016-6	ICAR-VPKAS, Almora
14	VLCP-2016-7	ICAR-VPKAS, Almora
15	VLCP-2016-8	ICAR-VPKAS, Almora
16	VLCP-2016-17	ICAR-VPKAS, Almora

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17	VLCP-2016-19	ICAR-VPKAS, Almora
18	VLCP-2016-20	ICAR-VPKAS, Almora
19	VLCP-2016-21	ICAR-VPKAS, Almora
20	VLCP-2016-22	ICAR-VPKAS, Almora
21	VLCP-2016-23	ICAR-VPKAS, Almora
22	VLCP-2016-50	ICAR-VPKAS, Almora
23	VLCP-2016-59	ICAR-VPKAS, Almora
24	VLCP-2016-2	ICAR-VPKAS, Almora
25	BLCPN.4	ICAR-VPKAS, Almora
26	VLCP-2016-60	ICAR-VPKAS, Almora
27	VLCP-2016-61	ICAR-VPKAS, Almora
28	VLCP-2016-62	ICAR-VPKAS, Almora
29	VLCP-2016-24	ICAR-VPKAS, Almora
30	VLCP-2016-25	ICAR-VPKAS, Almora
31	VLCP-2016-26	ICAR-VPKAS, Almora
32	VLCP-2016-28	ICAR-VPKAS, Almora
33	VLCP-2016-29	ICAR-VPKAS, Almora
34	VLCP-2016-30	ICAR-VPKAS, Almora
35	VLCP-2016-31	ICAR-VPKAS, Almora
36	VLCP-2016-32	ICAR-VPKAS, Almora
37	VLCP-2016-33	ICAR-VPKAS, Almora
38	VLCP-2016-34	ICAR-VPKAS, Almora
39	VLCP-2016-35	ICAR-VPKAS, Almora
40	VLCP-2016-36	ICAR-VPKAS, Almora
41	VLCP-2016-37	ICAR-VPKAS, Almora
42	VLCP-2016-38	ICAR-VPKAS, Almora
43	VLCP-2016-39	ICAR-VPKAS, Almora
44	VLCP-2016-40	ICAR-VPKAS, Almora
45	VLCP-2016-41	ICAR-VPKAS, Almora
46	VLCP-2016-42	ICAR-VPKAS, Almora
47	VLCP-2016-43	ICAR-VPKAS, Almora
48	VLCP-2016-44	ICAR-VPKAS, Almora
49	VLCP-2016-45	ICAR-VPKAS, Almora
50	VLCP-2016-47	ICAR-VPKAS, Almora
51	VLCP-2016-48	ICAR-VPKAS, Almora
52	VLCP-2016-49	ICAR-VPKAS, Almora
53	VLCP-2016-51	ICAR-VPKAS, Almora
54	VLCP-2016-52	ICAR-VPKAS, Almora
55	VLCP-2016-53	ICAR-VPKAS, Almora
56	VLCP-2016-54	ICAR-VPKAS, Almora
57	VLCP-2016-55	ICAR-VPKAS, Almora
58	VLCP-2016-56	ICAR-VPKAS, Almora
59	VLCP-2016-57	ICAR-VPKAS, Almora
60	VLCP-2016-58	ICAR-VPKAS, Almora
61	VLSM-3	AVRDC Taiwan,
62	VHC 45 (Mkt)	ICAR-VPKAS, Almora
63	VLCP-2	AVRDC Taiwan,

AGRO-MORPHOLOGICAL ANALYSIS:

The descriptors (Table.2.2) used were proposed for *Capsicum* in 1995 by IPGRI (International Plant Genetic Resources Institute, renamed Biodiversity International). To obtain good morphological traits for each line, the average of 8 randomized plants was taken, as the fruits got ripe.

Statistical analysis

Data represent the mean of three replicate samples for each genotype were subjected to analysis of variance as per Gomez and Gomez [1] for randomized block design. The Principal Component Analysis based on Pearsons correlation matrix cluster analysis and heat map were performed using a demo version of XLSTAT–Pro (Addinsoft). Pearsons correlation was calculated by SPSS software

RESULTS

The present investigation was conducted on sixty three genotypes of bell pepper (*Capsicum annuum* L.) to study the genetic variability for different growth characters, association among them. An attempt has also been made to categorize the genotypes on the basis of morphological features, to assess the genetic diversity using principal component analysis. The salient findings of the investigation are expressed under following sub-heads:

ANALYSIS OF VARIANCE

ANOVA is a statistical method that indicates the causes which explain the variation of a process and the factors with significant influence. In this study analysis of variance was carried out for all the characters and results are presented in Table 3.1. The differences among treatments (varieties) are highly significant for all nine agro-morphological traits except fruit wall thickness (mm) and days to first picking (Days). These two traits are significant for treatments. The highly significant difference in mean squares inferred that there is apparent confirmation of inherent genetic variability among the genotypes with respect to all the attributes under study. It is also indicates that there is lots of variation with reference to traits of bell pepper lines which has to be quantified for using in crop improvement programme.

Table 2: Analysis of variance for different agro-morphological trait of bell pepper (*Capsicum annuum* L.)

Sl. no	Characters	Mean square		F_{Cal}
		Treatment	Error	
1	Plant height (cm)	1,426.862	143.84	9.919**
2	Internodal length (cm)	12.511	2.110	5.92**
3	Fruit length(mm)	579.838	60.395	9.601**
4	Fruit width(mm)	409.874	50.377	8.136**
5	pedicel length (mm)	293.089	26.490	11.064 **
6	Fruit wall thickness (mm)	5.226	1.460	3.579*
7	Days to first picking(Days)	49.873	50.824	3.181*
8	Fruit weight (g)	12,083.786	809.189	14.933**
9	Yield per plant (g)	283,768.747	13,830.774	20.517**

F_{tab} (2,62)= 3.15 (0.05 level of significance) and 4.97(0.01 level of significance)

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2 Principal component analysis for agro-morphological trait:

The principal component analysis (PCA) was performed to assess the variation considering 9 agro-morphological traits. Based on factor loadings of these traits, the five components of PCA explained 83.93% of the total variation as shown in Table 5. The first principal component (PC1) was contributing 40.10% of the total variation. Fruit girth, pedicle length, fruit pericarp thickness and fruit weight were highest loading on PC1. The principal component second (PC2) accounted for 14.61% of total variation and the variables, fruit length and first fruit picking had positive support whereas plant height and intermodal length had substantial negative involvement. Similar result was reported shubha *et al* [3]. The third principal component (PC3) explained 12.10% of total variation with positive association with fruit length but fruit yield had negative loading on this component. Remaining two principal components had low participation in total variation i.e., 9.57 and 7.54 %.

Character association

It was found that fruit girth (r= 0.419), fruit pericarp thickness (r=0.350) and fruit weight (r=0.341) are highly correlated with fruit yield. Fruit weight was found highly significant correlation with plant height (r=0.340), fruit length (r=0.391), fruit girth (r=0.815), pedicle length (r=0.487), fruit pericarp thickness (r=0.803) and first fruit picking (r=0.342). Fruit pericarp thickness was found highly correlated with fruit girth (r=0.817) and pedicle length (r=0.379). Fruit girth was found highly significant with internodal length (r=0.337) and pedicle length (r=0.360). Internodal length and plant height were found highly correlated with r value 0.442. yield association with other agro-morphological traits also reported in case of potato [4].

Table 3 Eigen vectors and eigen values of the first five principal components for agro-morphological traits of bell pepper germplasm

Traits	PC1	PC2	PC3	PC4	PC5
PH	0.256	-0.456	0.316	0.295	-0.290
IL	0.253	-0.500	0.176	0.417	0.103
Fl	0.146	0.510	0.592	0.061	0.169
Fg	0.464	0.057	-0.162	-0.158	-0.282
Pl	0.307	-0.158	0.310	-0.348	0.633
FPt	0.450	0.104	-0.167	-0.207	-0.331
FP	0.194	0.425	-0.208	0.730	0.179
Fw	0.481	0.206	0.067	-0.117	-0.114
Yld	0.262	-0.141	-0.566	-0.008	0.492
Eigenvalue	3.609	1.315	1.089	0.862	0.679
Variability (%)	40.101	14.612	12.101	9.578	7.546
Cumulative (%)	40.101	54.713	66.814	76.392	83.938

CONCLUSION

The main objective of the present study was to characterized advanced lines on the basis agro-morphological and biochemical attributes. Sixty three advanced lines were evaluated including two exotic lines from AVRDC (Asian Vegetable Research and Development Centre renamed as World Vegetable Centre), Taiwan. The highly significant difference in mean squares inferred that there is apparent confirmation of inherent genetic variability among the genotypes with respect to all the attributes under study. Correlated studies showed that fruit yield per plant is highly correlated with fruit girth (r= 0.419), fruit pericarp thickness (r=0.350) and fruit weight (r=0.341). Thus, selection for the improvement of fruit yield can be efficient if it is based on fruit girth, fruit pericarp thickness and fruit weight in North-West Himalayan region. The principal components analysis was also done for explaining the variation and association present in the genotypes.

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