Evaluation of F_2 segregating population of chilli (*Capsicum annuum*. L.) for yield and leaf curl virus resistance

Abstract

Chilli (*Capsicum annuum* L.) is an important vegetable crop, cultivated worldwide for its fruits which are valued for pungency, flavor, and nutritional benefits. However, chilli production is significantlyrestricted by various biotic stresses, especially the *Chilli leaf curl virus* (CLCV). The present study was conducted at the Department of Vegetable Science, College of Agriculture, Vellayani, Kerala Agricultural University during 2020-2021 to evaluate the F_2 segregating population of chilli crosses *viz.*, CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3 for yield and leaf curl virus resistance. Evaluation of vegetative and yieldrelated traits was conducted on these populations under the field conditions. Significant variability was observed for various traits such as plant height, fruits per plant, fruit length, yield per plant and resistance to leaf curl virus. The scoring for chilli leaf curl virus was done and based on the scoring the segregants were categorized into highly resistant, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible. Among the F_2 population of the first cross, fruits per plant, plant height, fruit weight and fruit girth showed high and positive correlation with yield per plant. The segregants of the second cross recorded significant positive correlation for fruits per plant, plant height and fruit length with yield. The results of the study provide valuable insights into breeding for both high yield and leaf curl virus resistance, crucial for enhancing chilli production under the challenging situations.

Key words: *Capsicum annuum*, Mean performance, F_2 segregating population, Yield, Leaf curl virus resistance

1. Introduction

Chilli (*Capsicumannuum*L.) is an important vegetable crop belonging to the Solanaceae family, having a diploid chromosome number of 2n=2x=24.Chilli can be used in different forms, such as fresh or cooked vegetable, spices or herbs and as various processed products. It is valued for pungency, flavor, and wide range of uses in culinary practices, and

food industry. Chilli is a rich source of vitamins and minerals and due to its nutritional and antioxidant value it is being used in medical industry and pharmacology[1] (Takashi et al., 2001). India is the largest producer, consumer and exporter of chilli in the world.

The occurrence of various biotic and abiotic stresses has led to a decline in the productivity and quality of chilliin the country, which can lead to significant economic losses for farmers. Chilli is susceptible to various pathogens including viruses, which cause heavy production losses and so far 65 viruses have been reported, including begomo viruses infecting chilli throughout the world(Nigamet al.,2015). In India, *Chilli leaf curl virus* (ChiLCV) transmitted by whitefly is the most destructive virus in terms of incidence and yield loss, in severe cases 100% marketable losses have been reported (Senanayakeet al.,2012). This virus, causes severe yield losses by stunting plant growth, distorting leaves, and reducing fruit quality.Challenges in chilli cultivation include the development of new varieties and hybrids for dynamic production systems. In the segregating generations, selection of the superior genotypes is the important factor to be considered in the breeding programs. The selection should commence from the F_2 generation of the crop. The selection in the F_2 generationinvolves, choice of the desirable crosses and selection of the best progenies within the selected crosses. This strategy will effectively exploit the transgressive variability available within a cross population.Hence the study of segregating the population of chilli would help in formulating further chilli breeding program.

2. Methodology

The experiment was conducted at the Department of Vegetable Science, College of Agriculture, Vellayani, from 2020 to 2021. The investigation was carried out as a continuance work of the previous Ph.D research work done at the Department during 2015-2018. From the previous experiment, based on *per se*performance two crosses *viz.,* CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3 were selected for the present study. The seeds of the F_2population were developed by selfing the F_1 plants. Two hundred F_2 segregants from each of the two crosses were evaluated for yield characters and leaf curl virus incidence along with their parents. The seeds were sown in protrays and one month old chilli seedlings were transplanted to the main field at a spacing of 45 cm x 45 cm. The crop was grown as per the package of practices recommendations of Kerala Agricultural University (KAU, 2016). The performance of all the segregants were evaluated throughout the growing period for various characters. In this study, the data of various characters such as plant height, primary branches per plant, days to first

flowering, days to harvest, fruits per plant, fruit length, fruit girth, fruit pedicel length,fruit weight, seeds per fruits, fruit yield per plant, carotenoid and ascorbic acid were analysed. R based web application GRAPES was used for the analysis(Gopinath et al.,2020). Vitamin C content of fruit was estimated by 2,6-dichlorophenol indophenol dye method(Sadasivam and Manickam, 1992).The occurrence of leaf curl virus disease was regularly monitored and studied.The disease symptom severity was recorded following the severity scale 0-5 [6] (Banerjee and Kallo, 1987). On the basis of Coefficient of Infection (CI) all the segregants were assigned specific disease reaction as suggested byKumar et al. (2006).

3. Results and discussion

The segregating population from the crosses CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3 were raised in the field, and the data were recorded and analysed. The estimation of mean performance and the range of the F_2 segregants of the crosses CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3 are given in the table1.The present study revealed the significant variability present in the F_2 population for both yield and resistance to Chilli Leaf Curl Virus. The high degree of phenotypic variability observed in traits such as plant height, fruitsper plant, and fruit yield per plant provides an opportunity for selection of superior segregants. Similar findings have been reported by previous studies, where F_2 population demonstrated broad variability due to genetic recombination and segregation.

The vegetative characters that influence the growth and development of chilli crop, include plant height and primary branches per plant. In the present study, ample variability was observed for plant height as obvious from the wide range obtained. The plant height varied from 10.00 cm to 146.00 cm among both the F_2 population. Similar variability for the characters was reported in previous investigations. Manju and Sreelathakumary (2002), Yakwad (2005)and Vijeth (2019). A mean value of 41.91 cm and 59.10 cm was observed respectively for F_2 population of cross CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3. Variability for plant height was observed among the F_2 population of chilli during previous studies which support this present investigation. (Jogi et al. 2017). The number of primary branches per plantexhibited a mean value of 2.09 among the F_2 population of cross CHIVAR-6 x Sel-4 which was in conformity with the findings of Sharma (2014) and Vijeth (2019).In the F_2 population of the cross CHIVAR-10 x Sel-3 the value of mean for this character was 2.15.

Earliness to flowering is an important attribute to yield in chilli. The segregants of the first cross exhibited early flowering compared to the segregants of the second cross in this study. The latest to flower occurred by 39 days among the F_2 generations. The result is in accordance with the observations made byPawar (2016) and Vijeth (2019) in chilli.In this study, days to first harvest recorded a narrow range of variation. Among the segregants, the days to first harvest ranged from 51 to 58 days with a mean value of 56.19 and 52 to 58 days with a mean value of 55.19 in the F_2 population of cross CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3 respectively. Similar observations were given byZehra et al. (2017) and Vijeth (2019) in chilli.

The segregant population displayed wide variability for the character, fruits per plant. Among the segregants, the total number of fruits ranged from 14.00 to 103.00 among the F_2 population of the cross CHIVAR-6 x Sel-4 and from 20.00 to 160.00 among the F_2 population of the cross CHIVAR-10 X Sel-3. Considering the both population, segregants of the cross CHIVAR-10 x Sel-3 recorded a highest value of 160.00 with a mean of 62.11 for fruitsper plant indicating the cross as a good source for this character.The wide variation among the segregants for fruits per plant can be exploited for this character, considering the number of fruits and fruit size.These results are in accordance with Shirshatet al. (2006) in chilli.

Considerable variation was noticed for fruit length and fruit girth among the population of two crosses in the study. Maximum fruit length was observed in the population of second cross (10.16 cm). The overall mean value was 6.09 and 6.49 for F_2 population of CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3 respectively. A similar observation was made by Farhad et al. (2008) and Awasthi et al. (2021). Among both the F_2 population, fruit girth ranged from 1.00 cm to 5.03 cm which was in accordance with the observation made byKabilan et al. (2021). The variability observed for these two characters points out to the ample scope for further selection based on the smaller and larger fruits withdesirable yield characters and resistance to leaf curl virus. Fruit pedicel length varied from 0.60 cm to 4.49 cm among the segregant population of the two crosses. Similar observation for pedicel length was reported bySrinivas et al.(2017).

Fruit weight is one the main factors that influence the total yield of the chilli.In this study, fruit weight showed a wide variation with a lowest weight of 2.02 g to a highest fruit weight of 6.21 g. This indicatesthe presence of small and big sized chilli fruits among the segregants. Among the F_2 population of cross CHIVAR-10 x Sel-3 the highest fruit weight of

4.89 g was observed. A mean value of 3.58 g and 3.20 g were observed among the two crosses. The variation in fruit weight in chilli was recorded in many previous studies by Yatagiri et al. (2017), Rohini et al. (2017) and Kabilan et al. (2021) in chilli. The total number of seeds per fruitvaried from 9.50 to 119.00 which was in conformity with the observation madeby Yadwad(2015). In the F_2 population of the cross CHIVAR-6 x Sel-4 more number of seeds (115.40) were reported among the segregants, with a mean value of 62.28. Similar observation of maximum seedsper fruitwas observed by Farhad et al. (2008) in chilli.

One of the primary breeding objectives in any crop improvement program is to enhance fruit yield per plant. The present study revealed, high variabilityfor yieldper plant among the segregant population. Among the population of two crosses, the highest fruit yield recorded was 518.70 g among the population ofCHIVAR-10 x Sel-3, and 374.18 gin CHIVAR-6 x Sel-4. Similar high variability for yield in chilli was reported by Sreelathakumary (2000),Geleta and Labuschagne (2006), Lekshmi (2012), Rohini et al. (2017), Srinivas et al. (2017) and Vijeth (2019). Among the population of first cross, a range of 52.30 g to 374.18 g was observed for the fruit yield. In the case of second population, a range of 18.50 g to 518.70 g was observed. The higher yield observed in the population of the second cross could have been attributed by the higher number of fruits per plant. While breeding for disease resistance is crucial, it is equally important to consider potential trade-offs in yield, as some resistant varieties or segregants may have reduced overall productivity.

Ascorbic acid and carotenoid content were the quality characters studiedamong the chilli segregants in the present investigation.The segregants showed variability in quality charactersanalysed. Chilli is an excellent source of ascorbic acid. Significant variation in ascorbic acid among the accessions was noticed. The ascorbic acid content ranged from 36 mg 100 g^{-1} to 144.00 mg 100 $g^{-1}$and 40.00 mg 100 g^{-1} to 140.00 mg 100 g^{-1} among the segregants of both crosses. An almost similar pattern for ascorbic acid content was reported by Manju and Sreelathakumary (2006), Lekshmi and Sreelathakumary(2016) and Srinivas et al. (2017). The diverse colour of the chilli is due to the presence of different carotenoids accumulated in their pericarp. A highest carotenoid contentof 275.67 mg 100 g^{-1} was observed among the segregants.

Chilli leaf curl virus incidence is one of the key factor limiting the production of chilli in India. In this study, the segregants of the two crosses were assessed for the resistance to leaf curl virus disease. Chilli leaf curl virus disease incidence in the F_2 population of two

crosses were done at fortnightly interval from the date of transplanting.On the basis of the final scoring 53 individuals showed high resistance, 66 plants showed resistance, 33 plants showed moderate resistance, whereas 32 plants were moderate susceptible, 12 plants were susceptible and 4 plants were highly susceptible in the segregating population of cross CHIVAR-6 x Sel- 4. Out of the 200 segregants of the second cross CHIVAR-10 x Sel-3 studied, 51 segregants exhibited resistant reaction and 26 segregants exhibited moderately resistant reaction. Moderate susceptible reaction was shown by 25 segregants whereas 10 segregants were susceptible and 6 were highly susceptible in final scoring. The majority of the F_2 population of crosses CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3 exhibited resistance to chilli leaf curl virus indicating the potential resistant sources against the virus.Under the natural conditions, 200 segregants of the cross CHIVAR-6 x Sel-4, segregated into 152 resistant and 48 susceptible plants. The F_2 population of the CHIVAR-10 x Sel-3, had 159 resistant plants and 41 susceptible plants. Among the two population the nature of resistance towards chilli leaf curl virus incidence was comparable. Similar observations were reported by Jindalet al. *(*2018) and Thakur et al.(2019) in chilli. The present investigation showed variability within and between the segregants of the two crosses. The majority of the segregants exhibited resistant nature for chilli leaf curl virus incidence indicating ample resistant sources for further breeding strategies.

Table1. Mean performance and range of F_2 segregating population of cross CHIVAR-6 x Sel-4 and CHIVAR-10 x Sel-3

Sl.No.	Characters	Mean performance of the segregants of CHIVAR-6 x Sel-4	Mean performance ofthe segregants of CHIVAR-10 x Sel-3	Range of the segregants of CHIVAR-6 x Sel-4	Range ofthe segregants of CHIVAR-10 xSel-3
1.	Plant height (cm)	41.91	59.10	10.00-94.00	19.00-146.00
2.	Primary branchesper plant	2.09	2.15	1.00-4.00	2.00-4.00
3.	Days to first flowering	34.59	35.99	32.00-39.00	35.00-38.00
4.	Days to harvest	56.19	55.19	51.00-58.00	52.00-58.00
5.	Fruits per plant	48.29	62.11	14.00-103.00	20.00-160.00
6.	Fruit length (cm)	6.09	6.49	3.75-9.90	2.94-10.16
7.	Fruit girth (cm)	2.89	2.49	1.00-5.03	1.10-4.38
8.	Fruit pedicel length (cm)	2.58	2.02	1.13-4.16	0.60-4.49
9.	Fruit weight (g)	3.58	3.20	2.02-6.21	2.13-4.89
10.	Seeds perfruit	62.28	46.50	20.40-115.40	9.50-119.00
11.	Yield per plant (g)	171.37	198.96	52.30-374.18	18.50-518.70
12.	Ascorbic acid(mg 100 g^{-1})	89.77	89.14	36.00-144.00	40.00-140.00

13.	Carotenoid (mg 100 g^{-1})	199.72	203.60	104.74-275.67	137.33-275.67

Simple correlation for various characters with fruit yield per plant for both the crosses and parents was worked out which helped to understand the characters which contributes to the higher yield (Table 2). Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. Correlation provides information on the nature and extent of relationship between all pairs of characters.

In the present study, fruits per plant, plant height, fruit weight and fruit girth showed high and positive correlation with yield per plant among the F_2 population of first cross,. The segregants of the second cross exhibited significant positive correlation with fruits per plant, plant height and fruit length. Similarly yield per plant was significantly and positively correlated with number of fruits per plant and fruit weight as reported by Munshi et al.(2000).

Table 2.Simple correlation of various characters with yield per plant

	CHIVAR-6 x Sel-4	CHIVAR-10 x Sel-3
Plant height	0.292**	0.286**
Primary branches	-0.085	0.025
Days to flowering	-0.176*	0.131
Fruits per plant	0.718**	0.818**
Fruit length	0.131	0.184**
Fruit girth	0.16*	0.08
Fruit weight	0.286**	0.015

(** Correlation is significant at 1%

(* Correlation is significant at 5%)

4. Conclusion

The present study on the segregation population of chilli, showed variability within and between the segregants of the two crosses for the various characters studied. The study aimed to identify superior segregants with desirable combinations of high yield and resistance

to the leaf curl virus, which could serve for future chilli breeding programs.The majority of the segregants exhibited resistant nature for chilli leaf curl virus incidence indicating ample resistant sources for further breeding strategies. The superior segregants identified based on the yield and leaf curl resistance from the study can be taken to further segregation studies.The identification of superior segregants will contribute to the development of highyielding anddiseaseresistant varieties, providing a better solution to overcome challenging production systems in chilli cultivation.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing interests

Authors have declared that no competing interests exist.

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