

Evaluation of hybrids and parents of chilli (*Capsicum annuum* L.) for yield and resistance to chilli leaf curl virus

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Abstract

Chilli (*Capsicum annuum* L.) is one of the most important commercial vegetable cum spice crops that belongs to family Solanaceae. Leaf curl virus disease is a most destructive threat to chilli production which adversely affect yield. Twenty four F₁ hybrids were developed by crossing eleven diverse parents in line x tester mating design and were screened for yield, yield related traits and for resistance to leaf curl virus under natural epiphytotic condition and artificial inoculation using viruliferous white flies at College of horticulture, Bagalkot (University of horticulture science, Bagalkot) during 2021-2023. The analysis of variance indicated the presence of significant variation among the chilli hybrids and parents for the characters observed and reaction to disease. Based on the *per se* performance, the hybrid Byadgi Dabbi x IC284628 recorded the highest individual fruit weight, hybrid Byadgi Kaddi x Punjab Sindhuri observed highest number of fruits per plant and hybrid Byadgi Kaddi x Punjab Lal recorded highest green fruit yield per plant among all the hybrids. The hybrids Byadgi Kaddi x Punjab Surkh, Byadgi Dabbi x Punjab Surkh, Byadgi Dabbi x Punjab Sindhuri and Byadgi Kaddi x Punjab Sindhuri were found to have higher tolerance to chilli leaf curl disease.

Keywords: Hybrids, Chilli leaf curl virus, Yield, Resistance, Parents, Heterosis

Introduction

Chilli (*Capsicum annuum* L.) is a most important commercially exploited crop popularly called hot pepper or red pepper belongs to family Solanaceae (nightshade) and origins back to tropical America (Sood *et al.*, 2011). The name *Capsicum* is derived from Latin word “*Capsa*” which means “hallow pod.” *Capsicum* genus has wide diversity in plant and fruit characteristics, which make it extremely versatile and suitable for innumerable uses. It is reported as an essential industrial crop, with pungency (capsaicin) being an important pharmaceutical property and also used in the food industry as a colouring agent for colouring a processed food, hence it is major cash crop which is exclusively grown in tropical and sub-tropical countries. India is the world leader in chilli production followed by China, Thailand, Ethiopia and Indonesia. India is the largest producer, consumer and exporter of chilli, accounting for more than 36.57% of the World’s total dry chilli production (Geetha and Selvarani 2017). Important states growing chilli are Andhra Pradesh, Telangana, Karnataka, Orissa, Maharashtra, West Bengal, Rajasthan and Tamil Nadu. Karnataka ranks second with an area of 48.25 thousand hectares, production of 615.25 thousand MT and productivity of 12.75 MT/ha (Anonymous, 2022). Total production of dry chilli in Karnataka is drastically decreased by 59.7 per cent in last 10 years *i.e.* from 1998-99 (1.29 lakh ha) to 2009-10 (0.52 lakh ha) (Stephan *et al.*, 2016). This reduction in area of dry chilli production is mainly due to several biotic stresses especially caused by virus. It is reported that chilli is attacked by more than 65 viruses (Nigam *et al.*, 2015).

The yield of chilli crop is adversely affected due to leaf curl disease, caused by chilli leaf curl virus (Kumar *et al.*, 2015) belonging to genus Begomovirus and family Geminiviridae (Raiet *al.*, 2014). The white fly (*Bemisia tabaci*) acts as a vector for the transmission of virus into the host plant. The symptoms of the disease include stunting of plant growth, upward curling of leaves, puckering, rosette appearance of the leaves on the top of the plant, reduced internodes and petioles, thickening of veins. The older leaves become leathery and brittle and the affected plant fails to produce flowers and fruits (Sinha *et al.*, 2011, Srivastava *et al.*, 2021). The reduction in yield of chilli due to leaf curl disease may extend up to 100 per cent thus causing a great loss to the farmers (Senanayake *et al.*, 2007; Zehra *et al.*, 2010). Among the various management techniques available to check this viral disease in chilli, the most efficient way is by controlling the vector population using systemic insecticides but it makes chilli cultivation costly and hazardous to human health and environment. On the other hand, growing of chilli varieties/ hybrids with resistant to leaf curl disease will serve as a simplest and convenient method to the farmers to control the disease

and pave way to reduce the yield loss, cost of cultivation and enables an eco-friendly cultivation. Therefore, the present study was conducted to identify the high yielding hybrids combined with resistance to leaf curl disease among twenty-four F₁ hybrids developed utilizing eleven parents through line x tester mating design.

Materials and methods

The present investigation about the evaluation of chilli hybrids and parents for yield, yield related traits and resistance to chilli leaf curl virus at College of horticulture Bagalkot (University of Horticulture Science, Bagalkot) during 2020-2023. The experimental material consisting of 24 hybrids and 11 parents during 2020-21. Based on the genotypic reaction for leaf curl virus resistance, the resistant lines were used as donor parents to transfer the virus resistance to the popular Byadgi varieties. Total eight resistant genotypes and three susceptible parents were used for crossing in line × tester fashion as suggested by Kempthorne (1957) to produce twenty-four F₁ hybrids. The experiment was laid out in Randomised Block Design with two replications and a standard check. Seedlings of chilli hybrids and parents were raised in protrays and 35 days old seedlings were transplanted at a distance of 60 x 45 cm in the month of February during the summer season. The experimental site and season were found to be favourable for white fly build up in the past years (Sirawata and Karcho 2023). All the cultural practices were followed as per package of practice of UHS, Bagalkot.

Table 1. Details of chilli lines, testers and commercial check used in the study

Sl. No.	Entry	Genotypes
Lines		
1.	L1	Byadgi Dabbi
2.	L2	Byadgi Kaddi
3.	L3	Sankeshwar
Testers		
1.	T1	EC391087
2.	T2	IC342426
3.	T3	IC342464
4.	T4	IC284628
5.	T5	Punjab Lal
6.	T6	Punjab Tej
7.	T7	Punjab Sindhuri
8.	T8	Punjab Surkh
Commercial check		
1.	CC	Sarphan hybrid 102

Observations recorded

Five plants in each entry in each replication were randomly selected, tagged and the following observations were recorded from the tagged plants. The data on growth, yield and yield related parameters viz., plant height, number of primary branches per plant, number of secondary branches per plant, number of fruits per plant, fruit length, fruit width, individual green fruit weight and green fruit yield per plant. Per cent of disease infection and disease severity under natural field conditions and artificial screening under mass inoculation were recorded based on the scales for classifying leaf curl disease reactions as developed by Kumar *et al.*, (2006). From the recorded observation percent disease incidence (PDI) was calculated. The data on scoring value of chilli leaf curl disease were subjected to suitable statistical analysis, and the hybrids were categorized into six categories based on methods adopted by Reddy *et al.* (2001)

Percent disease incidence (PDI): The incidence of leaf curl virus was calculated by using the following formula developed by (Kumar *et al.*, 2006) and statistically analysed.

$$\text{Percent disease incidence (\%)} = \frac{\text{Number of diseased plants}}{\text{Total number of plants observed}} \times 100$$

Table 2: Indexing of leaf curl virus in chilli

Symptom severity grade	Symptoms	Reaction (%)	Category
0	No symptom	0	Immune
1	0-5% Curling and clearing of upper leaves	1 – 10	Highly Resistant
2	6-25% Curling, clearing of leaves and swelling of veins	11 – 25	Resistant
3	26-50% Curling, puckering and yellowing of leaves and swelling of veins	26 – 40	Moderately Resistant
4	51-75% leaf curling and stunted plant growth and blistering of internodes	41 – 60	Susceptible
5	>75% curling and deformed small leaves, stunted plant growth with small flowers and no or small fruit set	>60	Highly Susceptible

Results and discussion

Based on the genotypic reaction for leaf curl virus resistance, the resistant lines identified during previous experiments were used as donor parents to transfer the virus resistance to the popular Byadgi varieties. These hybrids were tested for leaf curl virus resistance in the natural field condition in the hot spot area and artificial screening under mass inoculation, which are the best measures to know the resistance or tolerance against virus. The phenotypic reactions of host plants were recorded in terms of symptomatic expression following a disease scoring scale (0-5) given by (Banerjee and Kallo, 1987 and Kumar *et al.*, 2006). The analysis of variance for various characters observed in chilli parents and hybrids under the study are presented in the table 3. The analysis of variance indicated the presence of significant variation among the hybrids for characters under study. The mean performance of the parents and hybrids for yield and yield related characters are presented in table 4.

Plant height

Heterosis for plant height traits is directly related to yield as the growth and yield parameter are strongly associated for increased production. The *per se* range for plant height of 41.43 cm (Byadgi Kaddi x IC342426) to 125.83 cm (Shankeshwar x IC342464) was recorded by F₁ hybrids as compared to parents 50.99 cm (IC342426)– 89.07 cm (IC342464) and check (63.55 cm). Wide range of heterosis was exhibited by F₁ hybrids for plant height. Similar results were also reported by Rekha *et al.* (2016), Abrham *et al.* (2017), Rao *et al.* (2017) and Rohini and Lakshmanan (2017).

Number of primary branches

Primary branches are the essential growth parameter which acts as source for supporting yield and its component traits. The parents showed the variation from 3.21 (Punjab Tej) – 5.06 (EC391087) for number of primary branches whereas, the hybrid crosses had the range from 3.60 (Byadgi Dabbi x IC342464) – 6.62 (Shankeshwar x EC391087). For number of primary branches, positive heterosis was noticed in majority of the crosses. These results are in agreement with Rekha *et al.* (2016), Rao *et al.* (2017) and Rohini and Lakshmanan (2017), Thilak *et al.* (2017), Vijeth *et al.* (2019) and Aiswarya *et al.* (2020).

Number of secondary branches

The number of secondary branches is important as the fruits are borne on the axils of secondary branches which directly favours to number of fruits per plant. The parents showed the variation for number of secondary branches which ranged from 6.90 (Punjab Tej) - 11.59 (EC391087) whereas, among the F₁ hybrid crosses it ranged from 7.01 (Byadgi Dabbi x IC342464) – 14.17 (Shankeshwar x IC342426). These findings are in conformity with those of Gawali *et al.* (2015), Rekha *et al.* (2016) and Rao *et al.* (2017).

Number of fruits per plant

Number of fruits per plant is the most important primitive component which directly influence the fruits yield. Heterosis for yield is mainly attributed to heterosis for number of fruits per plant. The parents varied from 42.67 (Byadgi Dabbi) to 174.49 (Punjab Sindhuri) for number of green fruits per plant. Among F₁ hybrids number of fruits per plant ranged from 41.30 (Shankeshwar x IC342464) to 166.31 (Byadgi Kaddi x Punjab Sindhuri). These results are in conformity with work of Patel *et al.* (2015), Spaldon *et al.*, (2015), Gawali *et al.* (2015), Reka *et al.* (2016), Rao *et al.* (2017) and Mopidevi *et al.* (2017), Thilak *et al.* (2017), Ganefianti and Fahrurrozi (2018), Chakrabarty *et al.* (2019), Vijeth *et al.* (2019) and Aiswarya *et al.* (2020).

Fruit weight

Mean values for fruit weight among chilli genotypes varied significantly from 6.98 g (EC391087) to 19.54 g (Byadgi Dabbi) for parents while, the F₁ crosses varied from 5.24 g (Shankeshwar x EC391087) to 14.78 g (Byadgi Dabbi x IC284628). With respect to average fruit weight, the magnitude of heterosis over commercial check 11.08 g. These results are in agreement with those of Abraham *et al.* (2017), Rao *et al.* (2017), Rohini and Lakshmanan (2017), Mopidevi *et al.* (2017), Ganefianti and Fahrurrozi (2018) and Nikornpun *et al.* (2020).

Fruit length

Fruit length is one of the important yield parameters, which directly contributes to the fruit weight, thereby affecting the total yield. A critical analysis of the data for this trait shows the enormous variation among the parents, hybrids and standard check. The parents varied from 4.23 cm (EC391087) to 22.77 cm (Shankeshwar) for fruit length. Among F₁ hybrids fruit length ranged from 5.11 cm (Byadgi Dabbi x EC391087) to 18.35 cm (Shankeshwar

xIC284628).The results are in line with the work of Savitha *et al.* (2015), Spaldon *et al.* (2015), Naresh *et al.* (2016), Abrham *et al.* (2017),and Vijeth *et al.* (2019).

Fruit width

In the trait fruit width mean values among chilli genotypes varied significantly from 0.69 cm (Shankeshwar) to 2.22 cm (EC391087) for parents and among the F₁ hybrid crosses it varied from 0.58 cm (Shankeshwar x Punjab Sindhuri) to 2.02 cm (Byadgi Dabbi x EC391087).Similar results were obtained by Mopidevi *et al.* (2017), Silva *et al.* (2017), Shumbulo *et al.* (2018), Ganefianti and Fahrurrozi (2018) and Vijeth *et al.* (2019).

Green fruit yield

The fruit yield is the ultimate requirement for the farmers for attaining effective economic profit. The average fruit yield per plant varied from 440.76 g (EC391087) to 1413.44 g (Punjab Surkh) among parents and 340.74 g (Shankeshwar x EC391087) to 1686.92 g (Byadgi Kaddi x Punjab Lal) within F₁ hybrid crosses. These results are in agreement with the works of Rao *et al.* (2017), Mopidevi *et al.* (2017), Chakrabarty *et al.* (2019), Vijeth *et al.* (2019) and Nikornpun *et al.* (2020).

The per cent disease index and disease reaction of all the chilli hybrids and genotypes are presented in the table 5. There was high phenotypic variation for leaf curl virus disease incidence among chilli hybrids and parents in both natural and artificial screening. PDI during natural screening ranged from 4.50% (Punjab Lal) to 99.50% (Byadgi Dabbi) among parents and it ranged from 14% (Byadgi Kaddi x Punjab Surkh) to 88% (Shankeshwar x IC284628) among chilli hybrids. During artificial screening PDI ranged from 8% (Punjab Lal) to 99% (Byadgi Kaddi) among parents and it ranged from 17% (Byadgi Kaddi x Punjab Surkh) to 82% (Shankeshwar x EC391087) among hybrids. The variation in virus incidence among different genotypes may be due to tolerance of differential load of virus infection based on the morphological, biochemical or nutritional factors which act as a defence mechanism against the virus infection. The chilli hybrids and parents were categorized into 6 groups based on their reaction to leaf curl virus and the data is presented in the table 6. From per cent disease incidence, it is evident that hybrid Byadgi Kaddi x Punjab Surkh and Byadgi Dabbi x Punjab Surkh were found to be resistant to leaf curl virus showing least PDI

compared to other hybrids in both natural and artificial screening. Parents EC 391087, Punjab Lal, Punjab Surkh was observed to be highly resistant to leaf curl virus in both natural and artificial screening. Similar results were observed by (Ahmad *et al.*, 2016, Dhaliwal *et al.*, 2013, Awasthi and Kumar 2008)

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Table 3: Analysis of variance (mean sum of squares) for yield, yield related traits and disease resistance in chilli

Sl. No.	Characters	Replication	Genotypes	Parents	Parents (Line)	Parents (Tester)	Parents (L vs T)	Parents vs Crosses	Crosses	Error
	d.f.	1	34	10	2	7	1	1	23	34
Parameters										
1	Plant height	41.56	947.56***	225.03**	66.65*	301.58***	5.92	45.76	1300.91***	24.34
2	No. of primary branches	0.06	1.16***	0.70***	0.24***	0.93***	0.05	4.97***	1.13***	0.11
3	No. of secondary branches	0.05	9.79***	5.19***	2.05*	6.75***	0.55	19.41***	11.37***	0.43
5	No. of fruits per plant	110.35	2533.12***	3945.23***	570.42***	3932.19***	10786.08**	23.15***	2028.29***	192.64
6	Fruit weight	0.02	22.39***	38.81***	17.98**	31.16***	134.03**	12.63***	15.67***	2.57
7	Fruit length	0.18	30.30***	50.01***	48.21***	22.86***	243.75***	6.75***	22.75***	0.62
8	Fruit width	0.00	0.45***	0.46***	0.77***	0.43***	0.03*	0.77***	0.42***	0.01
9	Green fruit yield	19001.41	276081.18***	165275.41***	25143.71***	203584.56**	177374.77***	43863.19***	334354.03***	7799.50
11	Disease incidence	15.56	1727.78***	3112.10***	2.00	131.42***	30197.06***	1021.59***	1156.61***	22.88

* indicates significance of values at p = 0.05, ** indicates significance of values at p = 0.01

*** indicates significance of values at p = 0.001

Table 4: Estimation of *per se* performance of parents and hybrids for yield, yield related parameters and disease resistance in chilli

Sl.No.	Genotypes	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Green fruit yield (g/plant)
Parents									
1	Byadgi Dabbi	67.69	3.63	7.80	42.67	19.54	13.03	1.92	829.09
2	Byadgi Kaddi	75.60	4.19	9.19	55.62	18.23	19.01	1.49	1018.34
3	Shankeshwar	78.93	4.25	9.77	76.16	13.82	22.77	0.69	1027.91
4	EC391087	61.53	5.06	11.59	63.13	6.98	4.23	2.22	440.76
5	IC342426	50.99	4.96	11.10	65.34	16.79	13.66	1.44	1099.63
6	IC342464	89.07	3.50	7.00	85.29	12.54	11.89	1.12	1071.91
7	IC284628	73.53	4.10	8.85	77.13	17.54	15.16	1.62	1271.82
8	Punjab Lal	72.46	4.16	10.02	96.13	12.53	9.73	0.93	1204.42
9	Punjab Tej	81.02	3.21	6.90	161.87	8.66	10.50	0.99	1390.52
10	Punjab Sindhuri	71.07	4.49	10.66	174.49	7.95	8.72	0.77	1388.00
11	Punjab Surkh	83.61	3.57	8.09	139.56	10.23	12.48	1.20	1413.44
12	Standard Check	63.55	3.64	8.86	75.81	11.08	11.73	1.11	839.48
Hybrids									
1.	BD x EC391087	51.05	4.80	12.38	52.78	7.25	5.11	2.02	382.71
2.	BD x IC342426	42.96	5.72	13.23	73.54	14.23	14.92	1.42	1041.10

3.	BD x IC342464	115.38	3.60	7.01	50.07	13.85	12.65	0.84	691.58
4.	BD x IC284628	43.85	5.76	13.43	81.90	14.78	15.49	1.72	1210.40
5.	BD x PL	68.01	4.47	10.61	118.37	13.70	10.54	0.72	1604.92
6.	BD x PT	60.44	4.62	11.32	112.23	13.01	10.99	0.77	1432.99
7.	BD x PS	76.47	4.30	8.80	109.83	12.20	8.70	0.66	1313.27
8.	BD x PSU	89.75	4.15	7.73	117.55	13.32	12.81	1.10	1544.58
9.	BK x EC391087	53.57	4.76	12.10	62.03	6.53	6.15	1.91	403.54
10.	BK x IC342426	41.43	5.60	12.87	85.03	14.10	16.06	1.24	1184.19
11.	BK x IC342464	120.28	3.86	7.26	69.11	13.80	12.92	0.78	923.85
12.	BK x IC284628	48.61	4.89	12.62	86.77	14.52	16.88	1.61	1242.76
13.	BK x PL	73.96	4.30	9.04	124.66	13.62	11.11	0.68	1686.92
14.	BK x PT	57.55	4.65	11.58	114.36	12.79	11.62	0.76	1460.49
15.	BK x PS	80.98	4.29	8.49	166.31	8.11	9.05	0.60	1347.66
16.	BK x PSU	93.49	4.76	7.62	119.88	13.17	13.03	0.94	1578.13
17.	SWR x EC391087	56.34	6.62	11.74	65.06	5.24	7.71	1.83	340.74
18.	SWR x IC342426	46.45	4.05	14.17	71.14	14.02	17.05	1.17	996.94
19.	SWR x IC342464	125.83	6.02	7.59	41.30	13.71	13.05	0.78	564.81
20.	SWR x IC284628	45.67	4.31	13.45	84.82	14.28	18.35	1.53	1200.50
21.	SWR x PL	71.34	4.40	9.30	113.33	13.39	12.56	0.67	1503.63
22.	SWR x PT	64.55	4.26	9.73	108.19	12.76	12.58	0.75	1380.14

23.	SWR x PS	86.13	3.96	8.13	150.85	8.53	9.59	0.58	1286.43
24.	SWR x PSU	101.56	4.76	7.34	114.05	13.10	13.07	0.90	1493.67
	S.Em ±	3.12	0.24	0.46	9.72	1.15	0.55	0.06	61.66
	C.D. at 5%	8.95	0.68	1.33	27.92	3.30	1.59	0.16	177.03
	C.D. at 1%	12.01	0.91	1.78	37.46	4.43	2.13	0.22	237.53

CD – Critical difference, S.Em ± - Standard error of mean

BD – Byadgi Dabbi, BK – Byadgi Kaddi, SWR – Sankeshwar, PL – Punjab Lal, PT – Punjab Tej, PS – Punjab Sindhuri, PSU – Punjab Surkh

Table 5: Screening of chilli hybrids and their parents for resistance to leaf curl virus under natural epiphytotic condition

Sl. No	Chilli hybrids	Natural screening		Artificial screening	
		Per cent disease index (%)	Disease reaction	Per cent disease index (%)	Disease reaction
1	BD x EC391087	54.00	S	57.00	S
2	BD x IC342426	66.00	HS	69.00	HS
3	BD x IC342464	74.00	HS	70.00	HS
4	BD x IC284628	78.00	HS	68.00	HS
5	BD x PL	57.50	S	51.00	S
6	BD x PT	29.00	MR	32.00	MR
7	BD x PS	25.00	R	22.00	R
8	BD x PSU	21.50	R	24.00	R
9	BK x EC391087	49.00	S	53.00	S
10	BK x IC342426	36.00	MR	42.00	MR
11	BK x IC342464	59.00	S	62.00	HS
12	BK x IC284628	68.00	HS	73.00	HS
13	BK x PL	52.00	S	57.00	S
14	BK x PT	29.00	MR	35.00	MR

15	BK x PS	25.00	R	22.00	R
16	BK x PSU	14.00	R	17.00	R
17	SWR x EC391087	79.00	HS	82.00	HS
18	SWR x IC342426	76.00	HS	66.00	HS
19	SWR x IC342464	74.00	HS	67.00	HS
20	SWR x IC284628	88.00	HS	73.00	HS
21	SWR x PL	57.50	S	55.00	S
22	SWR x PT	36.50	MR	40.00	MR
23	SWR x PS	40.00	MR	52.00	S
24	SWR x PSU	31.50	MR	35.00	MR
Chilli Parents					
25	Byadgi Dabbi	99.50	HS	98.00	HS
26	Byadgi Kaddi	99.00	HS	99.00	HS
27	Shankeshwar	97.50	HS	98.00	HS
28	EC391087	9.00	HR	10.00	HR
29	IC342426	15.00	R	19.00	R
30	IC342464	22.50	R	27.00	MR
31	IC284628	29.00	MR	34.00	MR
32	Punjab Lal	4.50	HR	8.00	HR

33	Punjab Tej	18.50	R	22.00	R
34	Punjab Sindhuri	16.00	R	23.00	R
35	Punjab Surkh	8.00	HR	10.00	HR
36	Standard Check	80.00	HS	71.00	HS

Table 6: Categorization of chilli hybrids and their parents for resistance to leaf curl virus based on virus symptoms under natural condition and artificial inoculation

Disease reaction	Natural screening		Artificial screening	
	No. of genotypes	Hybrid and parents	No. of genotypes	Hybrid and parents
Immune	0	-	0	-
Highly resistant	3	EC 391087, Punjab Lal, Punjab Surkh	3	EC 391087, Punjab Lal, Punjab Surkh
Resistant	8	Byadgi Dabbi x Punjab Sindhuri, Byadgi Dabbi x Punjab Surkh, Byadgi Kaddi x Punjab Sindhuri, Byadgi Kaddi x Punjab Surkh, IC342426, IC342464, Punjab Tej, Punjab Sindhuri	7	Byadgi Dabbi x Punjab Sindhuri, Byadgi Dabbi x Punjab Surkh, Byadgi Kaddi x Punjab Sindhuri, Byadgi Kaddi x Punjab Surkh, IC342426, Punjab Tej, Punjab Sindhuri
Moderately resistant	7	Byadgi Dabbi x Punjab Tej, Byadgi Kaddi x IC342426, Byadgi Kaddi x	7	Byadgi Dabbi x Punjab Tej, Byadgi Kaddi x IC342426, Byadgi Kaddi x Punjab Tej,

		Punjab Tej, Shankeshwar x Punjab Tej, Shankeshwar x Punjab Sindhuri, Shankeshwar x Punjab Surkh, IC284628		Shankeshwar x Punjab Tej, Shankeshwar x Punjab Surkh, IC284628, IC342464
Susceptible	6	Byadgi Dabbi x Punjab Lal, Byadgi Dabbi x EC391087, Byadgi Kaddi x EC391087, Byadgi Kaddi x Punjab Lal, Byadgi Kaddi x IC342464, Shankeshwar x Punjab Lal	6	Byadgi Dabbi x Punjab Lal, Byadgi Dabbi x EC391087, Byadgi Kaddi x EC391087, Byadgi Kaddi x Punjab Lal, Shankeshwar x Punjab Lal, Shankeshwar x Punjab Sindhuri,
Highly susceptible	12	Byadgi Dabbi x IC342426, Byadgi Dabbi x IC342464, Byadgi Dabbi x IC284628, Byadgi Kaddi x IC284628, Shankeshwar x EC391087, Shankeshwar x IC342426, Shankeshwar x IC342464, Shankeshwar x IC284628, Byadgi Dabbi, Byadgi Kaddi, Shankeshwar, Standard Check	13	Byadgi Dabbi x IC342426, Byadgi Dabbi x IC342464, Byadgi Dabbi x IC284628, Byadgi Kaddi x IC284628, Shankeshwar x EC391087, Shankeshwar x IC342426, Shankeshwar x IC342464, Shankeshwar x IC284628, Byadgi Dabbi, Byadgi Kaddi, Shankeshwar, Standard Check, Byadgi Kaddi x IC342464,

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