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Screening of genotypes against major biotic stresses in chilli (*Capsicum annum* L.)

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Abstract
Chilli pepper or hot pepper (*Capsicum annuum* L.,) is an important spice and vegetable crop worldwide belonging to the family *Solanaceae* and affected by various pathogens (viruses). Begomovirus causes chilli leaf curl disease and heavily losses yield. The present investigation was formulated to screen resistant genotypes against different major viruses. The disease was be identified by typical upward/downward leaf curling, crinkling, puckering and reduction in leaf area along with stunting of whole plants. Disease severity was scored 0-4 under six classes and observed that 13 genotypes were found tolerant against thrips, 15 genotypes against mites, 15 against anthracnose, 13 against chilli leaf curl viruses and Punjab lal (393.45 grams per plant) variety produced maximum fruit yield followed by Jayanti and KDSC-810 (both 348.45 grams per plant) because of resistant/tolerant traits causes under considerations.

Keywords: Thrips, mites, anthracnose, chilli leaf curl virus, yield

Introduction
Lentil *(Lens culinaris* Medik) is a member of Leguminaceae family and it is commonly known as poor man's meat. It has a high nutritional value and major source of dietary proteins (25%) after soybeans (Zia *et al.*, 2011). Lentil (*Lens culinaris* Medik L.) is the most important pulse crop in India and mostly grown in north east plain zone & central part of India. It is a diploid and self-pollinated crop which is grown in winter season and belonging to Order- Rosales, suborder-Rosnee, Family-Leguminaceae (fabaceae), subfamily- papilionaceae, genus- *Lens* and species- *culinaris* with chromosome number 2n=14. Among *rabi* pulses, lentil is next to chickpea. The total area under lentil in India was 1.49 m ha with a total production of 1.61 MT and 1006 Kg/ha productivity (Anonymous, 2018). In Uttar Pradesh, it is grown on 4.78 lakh hac. Area with 4.47 lakh tones production and productivity 936 kg/ha (Anonymous, 2018).
Lentil suffers from attack of a number of diseases such as vascular wilt; collar rots, root rot, stem rot, rust, powdery mildew downy mildew and fusarium wilt which are caused by *Fusarium oxysporum* f. sp. *lentis*. Average yield of lentil is low due to various diseases. Among the disease, foot and root rot of lentil caused by *Fusarium oxysporum* and *Sclerotium rolfisii* are common and the most serious disease in India. The fusarium wilt of lentil caused by *Fusarium oxysporum* f. sp. *lentis* is one of the most important and destructive disease in India wilt pathogen minimize crop yield and deteriorate the seed quality (Khare, 1991). The disease was first reported the cultivars tested. Lentil wilt caused by *Fusarium oxysporum* f. sp. *lentis* is a major disease in lentil growing areas in the country reported that the annual yield losses 10-15 % due to this disease alone from Hungary but in India it was first observed in 1941 from Delhi and Karnal. If infection takes place in early stage the plant do not produced seeds, formed few in number when infection occurred in later stage. Wilt causes more damage at flowering and pod formation stage of the crop. *Fusarium oxysporum* f. sp. *lentis*. infection range from 25-95 % depending on the cultivars tested. Lentil wilt caused by *Fusarium oxysporum* f. sp. *lentis* is a major disease in lentil growing areas in the country reported that the annual yield losses 10-15 % due to this disease alone which valued approximately Rs. 2000-2500 crores by **(**Chaudhary and Amarjit, 2002).
Resistant sources are available against wilt disease of lentil but they are unstable. At present wilt is being managed by using fungicide through seed and soil treatment. However, fungicides are more costly and pollutant to environment. Many plant extract are known to have antifungal activity.

Therefore, keeping in view the importance of the crop, seriousness of Chilli pepper or hot pepper (*Capsicum annuum* L.) is an important spice and vegetable crop of Solanaceae family. India is considered to be the secondary centre of diversity for chilli, especially of *C. annuum*, the most important cultivated species [1]. *C. annuum* having pungent (chilli syn. hot pepper) and non-pungent fruits (sweet pepper syn. capsicum, bell pepper) is the most widely cultivated species in India, among the five cultivated species of the genus Capsicum. The cultivation of *C. frutescens*, *C. chinense* and *C. baccatum* is confined to homestead gardening in different regions [2]. India is the largest producer, consumer and exporter of chillies in the world. According to an estimate for 2015–16, in India, green chillies were cultivated on 0.29 million hectares with a total production of 3.4 million tonnes. India is at the top in terms of international trade by sharing about 40% of the total world production and exports 17% of its total production. Chilli is susceptible to various pathogens including viruses, which can cause drastic production losses. Various insect-pests, pathogens and viruses play havoc in chilli's normal metabolic pathways. Thrips, yellow mites, anthracnose and chilli leaf curl virus are the most dreadful biotic stresses of chilli in India that cause severe yield loss. These biotic stresses make run short of capsaicin and oleoresin contents and deteriorate the fruits quality in chilli. So far 65 viruses have been reported, including begomoviruses causing chilli leaf curl virus disease (ChiLCVD) infecting chilli all over the world [4]. ChiLCVD is the most destructive virus in terms of incidence and yield loss. In severe cases, 100 per cent losses of marketable fruit have been reported [5, 6, 7, 8]. The typical symptoms consisting of leaf curling, rolling and puckering; blistering of intervenes areas, thickening and swelling of the veins, shortening of internodes and petioles, crowding of leaves and stunting of the whole plant. Evasive measures, such as pesticide sprays to control vectors, removal of diseased plants and agronomic interventions have been tried without much success. Exploitation of host plant resistance is effective, economical, ecologically safe and durable approach to disease management, especially the ones caused by viruses.

So, the present investigation was planned to be carried to draw baseline information on major biotic stresses resistance genotypes of chilli for eastern India.

Materials and Methods

The present investigation Screening and identification of chilli leaf curl virus resistant genotype in chilli was carried out at Research farm of Nalanda college of Horticulture, Noorsarai, Nalanda, (Bihar Agricultural University, Sabour, Bhagalpur), Bihar during 2014 – 16. The experimental material consisting of 90 germplasms *viz*., Kalayanpur Chanchal (Check-1), Pusa Jwala (Check-2), Pant C-1 (Check-3) and Punjab Lal (Check-4) collected from different locations/SAU's and Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh. The experiment was laid out in Augmented Block Design. The experimental soil was alluvial soil with pH around neutral. Seedlings of the germplasms were planted at a distance of 60 × 45 cm in the month of February. All the cultural practices were followed as per recommended for chilli cultivation. Observations were recorded on plant height (cm), number of leaves/plant, number of secondary branches/plant, number of white flies/plant, fruit length (cm), fruit diameter (mm), number of fruits/plant and fruit weight (g). Scoring of the chilli leaf curl virus on a scale of 0-4 (Table-1) at 15 days intervals (30, 45, 60 and 75 days) after transplanting and Per cent Disease Infection (PDI) and Coefficient of Infection (CI) values were calculated [9].

$$\text{Per cent Disease Infection} = \frac{Total\ grain\ weight}{Total\ biomass} \times 100$$

CI (%) = PDI × RV

Where,
RV= Response Value.

Table 1: Scale for classifying disease reaction in chilli

Symptom	Severity grade	Response value	Coefficient of infection	Reaction
Symptoms absent	0	0	0-4	HR
Very mild symptoms upto 25 % leaves	1	0.25	4.1-9	R
Appearance of disease between 26 to 50 % leaves	2	0.50	9.1-19	MR
Symptom between 51 to 75% leaves	3	0.75	19.1-39	MS
Severe disease infection at 75% leaves	4	1.00	39.1-69	S
Above 75 % leaves	>4	>1.00	69.1 to 100	HS

Note: HR= Highly resistant, R=Resistant, S=Susceptible, HS=Highly Susceptible, MR=Moderately resistant, MS=Moderately susceptible.

Results and Discussion

Reaction of chilli genotypes against thrips (*Scirtothrips dorsalis*)

The characteristics symptoms of chilli thrips are leaves develop crinkles and curl upwards, petioles become elongated and buds become brittle and drop down. At early stage, infestation leads to stunted growth and flower production, fruit set are arrested.

The results presented in the Table 2 revealed that there was high variation in thrips damage among different lines when recorded at every 15 days interval. As per the observations, out of 90 genotypes screened, 13 genotypes were found field tolerant against thrips namely, EC-492576, EC-622087, EC-587052, EC-519636, EC-518968, EC-38758, EC-570007, CO-5671, EC-605713, EC-519626, EC-517057, EC-454697, EC-622052 and 77 genotypes were found susceptible against thrips. 13 genotypes showed a lower percentage leaf curl due to thrips and mites than local checks, and two (KDSC-6 and KDSC-210-3) also gave very high yields [10, 11] have also worked and selected genotypes against the thrips.

Table 2: Reaction of chilli genotypes against thrips under field condition.

Resistant/ tolerant		Susceptible	
No. of genotypes	**Genotypes**	**No. of genotypes**	**Genotypes**
13	EC-492576, EC-622087, EC-587052, EC-519636, EC-518968, EC-38758, EC-570007, CO-5671, EC-605713, EC-519626, EC-517057, EC-454697, EC-622052	77	EC-257216, EC-519612, EC-519629, EC-119457-B, EC-497636, EC-578666, EC-587005, EC-519636, EC-622061, MI-2 , PBC-367, PBC-228, SM-1, Kashi Anmol (KA-2)

Reaction of chilli genotypes against yellow mites (*Polyphagotarsonemus latus*)

The characteristics symptoms of chilli yellow mites are downward curling and crinkling of leaves, leaves with elongated petiole and stunted plant growth. The results revealed that there was high variation in mite damage among different lines when recorded at every 15 days interval.

As per the data presented in Table 3, out of total genotypes screened, 15 genotypes namely, EC-492576, EC-622087, EC-587052, EC-519636, EC-518968, EC-38758, EC-570007, CO-5671, KA-2, EC-119457, EC-605713, EC-519626, EC-517057, EC-454697, EC-622052 were found tolerant to mites and amongst 75 genotypes (Kashi Anmol) were found susceptible against yellow mites. Out of 71, Four accessions (IC342390, IC572492, IC337281 and IC344366) were identified as resistant; 12 were found to be moderately resistant; 39 were susceptible and 16 were highly susceptible to *P. Latus* [12].

Table 3: Reaction of chilli genotypes against yellow mites under field condition.

Resistant/ tolerant		Susceptible	
No. of genotypes	**Genotypes**	**No. of genotypes**	**Genotypes**
15	EC-492576, EC-622087, EC-587052, EC-519636, EC-518968, EC-38758, EC-570007, CO-5671, KA-2, EC-119457, EC-605713, EC-519626, EC-517057, EC-454697, EC-622052	**75**	CMB-4, EC-341075, EC-622085, DC-25, CO-5617, EC-607920, EC-622059, EC-566320, LCA-407, IIHR-20, EC-119457, SDA-167, EC-518968, IC-119457

Disease reaction of Anthracnose (*Colletotrichum capsici*)

The characteristics symptoms of chilli anthracnose are small, black, circular spot appears on the leaves and fruits, badly diseased fruits turn straw colour or pale white colour, lose their pungency and ripe fruits turning red are affected, lower surface of the fruit skin is covered with minute, elevated scelerotia and at advanced stage the seeds were covered by a mat of fungal hyphae, turn rusty in colour.

Data recorded on disease reaction of anthracnose on chilli depicted that various genotypes of chilli showed differential reaction. 15 genotypes among the screened were found tolerance to anthracnose (EC-492576, EC-622087, EC-587052, EC-519636, EC-518968, EC-38758, EC-570007, CO-5671, KA-2, EC-119457, EC-605713, EC-519626, EC-517057, EC-454697, EC-622052) and 75 were shown susceptible reaction on chilli anthracnose (Table 4). The inheritance pattern of resistant gene against *Colletotrichum capsici* in the chilli genotypes is controlled by single recessive gene [13, 14] suggested a single gene model for resistant to each trait. Three different recessive genes were responsible for the resistances and Linkage analysis suggested that the resistances at green and red fruit were linked with 0.25 recombination frequency while the seedling resistance was not linked to the fruit resistances.

Table 4: Reaction of chilli genotypes against anthracnose under field condition.

Resistant/ tolerant		Susceptible	
No. of genotypes	**Genotypes**	**No. of genotypes**	**Genotypes**
15	EC-492576, EC-622087, EC-587052, EC-519636, EC-518968, EC-38758, EC-570007, CO-5671, KA-2, EC-119457, EC-605713, EC-519626, EC-517057, EC-454697, EC-622052	75	EC-587005, LCA-422, SHKC-502, EC-622085, EC-497636, 97-7116, COO-280, COO-712, EC-587019, EC-566320, EC-622061, IC-113361, LCA-427

Disease reaction of chilli leaf curl virus

The characteristics symptoms of chilli leaf curl virus are leaves curl towards midrib and become deformed, stunted plant growth due to shortened internodes and leaves greatly reduced in size, flower buds abcise before attaining full size and anthers do not contain viable pollen grains. In an experiment it is confirmed that the resistant reaction in the identified symptom-less resistant sources was because of the absence of viral genome and they were not symptom-less carrier [15]. The results have also proved that Chilli Leaf Curl Disease is caused by a complex consisting of the monopartite chilli leaf curl virus and a DNA-b satellite component [16].

Data presented on reaction of chilli leaf curl disease has been presented Table 5. A close perusal of the data showed that among the screened, 13 genotypes namely DIBER-207, PC-25, DC-16, AKC-906, Japani Longi, Kalyanpur Chanchal, Pant C-1, 97-7116, VKC-2, DC-24, PC-10, PBC-535, BC-54 were found tolerant against chilli leaf curl virus and 77 genotypes were showed susceptibility against chilli leaf curl virus. These genotypes having symptom-less carrier and may possess mechanism to avoid transmission of viral genome in their sap or does not allowing viral genome to amplify (true resistance).

Table 5: Reaction of chilli genotypes against chilli leaf curl virus under field condition.

Resistant/ tolerant		Susceptible	
No. of genotypes	**Genotypes**	**No. of genotypes**	**Genotypes**
13	DIBER-207, PC-25, DC-16, AKC-906, Japani Longi, Kalyanpur Chanchal, Pant C-1, 97-7116, VKC-2, DC-24, PC-10, PBC-535, BC-54	77	AKC-406, LCA-334, NCH-931, PBNC-1, PC-10, Tiwan-1, FC-578666, PBC-522, AMK-11, PDG-22, MCA-8, SDA-169, IIHR-9, Tiwan-2 , SM-2, Kashi Anmol (KA-2)

Fruit yield related traits

Observation of yield attributing traits were also recorded and observed that Punjab lal (393.45 grams per plant) variety produced maximum fruit yield followed by Jayanti and KDSC-810 (both 348.45 grams per plant) because of resistant/tolerant traits against biotic stresses and may be utilize in further chilli improvement programme.

Table 6: Performance of major resistant/tolerant chilli genotypes

Varieties	Plant Height (cm)	No. of leaves/plant	No. of secondary branches	Days to 50 % flowering	No of white fly/plant	Fruit length (cm)	Fruit diameter (mm)	No. of fruits/plant	Fruit weight/plant (g)
Kashi Gaurav	50.330	690.000	48.330	55.330	3.000	5.900	9.190	32.300	79.500
Pant C-1	54.670	455.330	60.000	54.330	2.330	2.340	7.513	107.300	160.430
Jayanti	84.670	549.000	46.330	61.330	3.130	4.100	9.240	61.000	348.450
CV-2	77.000	505.330	53.670	62.000	2.170	4.470	8.290	148.700	297.970
KDSC-810	38.170	344.330	69.670	59.000	1.170	3.780	7.420	186.300	348.450
Phule jyoti	48.000	256.000	58.067	53.670	2.130	4.160	8.900	148.700	304.980
AKC-89/38	62.000	248.000	113.000	53.000	2.230	0.930	11.060	37.000	69.980
Punjab Lal	55.500	242.330	85.330	51.000	3.030	3.720	6.870	196.700	393.450
Japani Longi	77.670	431.670	82.330	55.330	2.170	4.780	8.500	128.300	287.960
97-7116 (UP)	61.500	254.330	50.330	62.330	2.300	4.350	8.570	27.300	90.830
Check-1	63.670	20.000	69.000	56.670	2.400	3.820	9.620	76.300	281.250
Check-2	60.300	10.610	71.500	54.000	2.990	3.360	7.550	53.700	168.380
C.D.	2.606	115.145	7.761	1.629	0.524	0.838	1.017	1.868	2.774
SE(m)	0.883	39.008	2.629	0.552	0.178	0.284	0.345	0.633	0.940
SE(d)	1.249	55.166	3.718	0.781	0.251	0.401	0.487	0.895	1.329
C.V.	2.502	20.234	6.767	1.692	12.710	12.902	6.972	1.093	0.690

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