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Screening for resistance to yellow vein mosaic virus of okra (*Abelmoschus esculentus* (L.) Moench) genotypes under field conditions in Karnataka

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Abstract
Okra (*Abelmoschus esculentus* (L.) Moench), is an important vegetable grown throughout the tropical and subtropical regions of the world. One of the major limiting factors of okra is the incidence of Okra Yellow Vein Mosaic Virus, its vector being whitefly. Infection of 100% plants in a field is very common and yield losses range from 50 to 94 per cent, depending on the stage of crop growth at which infection occurs. A total of 50 okra genotypes were screened for reaction to Okra Yellow Vein Mosaic Virus in three replications in Randomized block design under unprotected condition during summer 2016. The results exhibited that four lines were highly resistant (IC43735, VRO103, IC45818and IC45980), nine lines were moderately resistant, 13 lines were tolerant, 20 lines were moderately susceptible and four lines were susceptible to disease reaction. The highest yield per plant was observed in IC45980 (317.53g/plant) followed by VROB178 (312.50g/plant) and HRB-55 (305.15g/plant).

Keywords: Okra Yellow Vein Mosaic Virus, genotypes under field

Introduction
Okra or lady's finger (*Abelmoschus esculentus* or *Hibiscus esculentus* L.) is one of the most popular vegetable crop cultivated in many parts of the world and is thought to be native either of tropical Africa or Asia (Khoso, 1994 and Akanbi *et al*., 2010) [1, 2]. It is believed to have been cultivated in 12th century BC in Egypt. It is good source of vitamin A, B, C and is also rich in protein, carbohydrates, fats, minerals, iron and iodine (Baloch. *et al.*, 1990) [3]. The stem of the okra plant provides fibre which is used in the paper industry. Okra is also used as medicinal plant used to prevent kidney stones. In addition to this, the seed pods of okra are consumed to treat diabetes, jaundice and constipation (http://www.arihantagro.org/okra-exports-from-india/) [4].

India is top producer of okra in the world with a production of 6.146 mt (66.3% of the total world production) from over 0.528 mha area. Okra or lady's finger is available throughout the year in India and its production can be tailored according to the demand. After onion, okra has the major share in revenue generation through export of fresh vegetables.

Okra production in tropical regions is constrained by several abiotic and biotic factors and yield losses due to biotic factors are quite substantial (Jellis, 2009) [5]. With increasing crop intensity and the crop rotations being more congested, the disease control measures and management issues have become more pronounced (Roychaudhary *et al.*, 1997) [6]. This problem has been compounded further with spread of very few superior cultivars and hybrids leading to development of disease infestations in epidemic proportions which may pose disastrous consequences. Under such circumstances, yielding capacity and quality can be improved by addressing the factors which limit yield maximization, such as susceptibility to diseases (Ram 2012) [7].

YVMV belongs to the genus *Begomovirus*, family Geminiviridae. Recently, it was found that at least 27 begomoviruses infest okra (Table2). Begomoviruses have high recombination rate and the emergence of 'B' biotype. Whiteflies are contributing to epidemics of begomoviruses in okra. The YVMV disease is characterized by a homogenous interwoven network of yellow vein enclosing islands of green tissues within the leaf.

In extreme cases, infected leaves become completely yellowish or creamy. If plants are infected within 20 days after germination, their growth is retarded with few leaves and malformed fruits resulting in loss ranging from 94% to 100%. The extent of damage declines with delay in infection of the plants. A loss of 49–84% has been reported when infection occurred after 50–65 days of germination. The objective of this study was to Screen different okra genotypes against OYVMV resistance under field condition and to identify the resistance source.

Material and methods

The present investigation on screening of okra genotypes for Yellow Vein Mosaic resistance in Okra (*Abelmoschus esculentus* L. Moench) was carried out during *summer* seasons of 2015-16 at Zonal Agricultural and Horticultural Research Station, Brahmavar. The base experimental material for the present investigation comprised the genotypes selected for the study was collected from National Bureau of Plant Genetic Resources (NBPGR) Regional Research Station Akola, Indian Institute of Horticultural Research (IIHR) Bangalore and open pollinated varieties of different commercial private seed companies.

The experiment was laid out in randomized block design with three replications during January, 2016. Every genotype in each replication was grown in three rows of each in 4 m with a spacing of 60 cm between rows and 30 cm between plants. The seeds were hand dibbled at given spacing in the respective blocks and recommended agronomic practices were followed to raise the crop.

The number of plants showing okra Yellow Vein Mosaic Disease from 10 randomly chosen plants was counted. Counting was done early in the morning between 7 and 10 am. The disease on each test entry was assessed according to Prakasha *et al.* (2001) [8], following disease rating scale by Ali *et al.* (2005a, b) [9] presented in the following table2.

Table 1: Disease rating scale of OYVMV

Rating scale	Type	Severity Range (%)
0	Immune	0
1	Highly resistant	1-10
2	Moderate resistant	11-25
3	Tolerant	26-50
4	Moderate susceptible	51-60
5	Susceptible	61-70
6	Highly susceptible	71-100

Table 2: Begomovirus associate with yellow vein mosaic disease of okra (Sanwal *et al*., 2016 [10])

Disease	Viruses	Genome	Transmission	Distribution
Yellow vein mosaic disease	Bhendi yellow vein mosaic virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Bhendi yellow vein Bhubhanewar virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Bhendi yellow vein Haryana virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Bhendi yellow vein Maharashtra virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Cotton leaf curl Bangalore virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Cotton leaf curl Allahabad virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Bhendi yellow vein Delhi virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Tomato leaf curl New Delhi virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Radish leaf curl virus	Monopartite	*Bemisia tabaci*	India
Yellow vein mosaic disease	Okra yellow vein mosaic virus	Monopartite	*Bemisia tabaci*	Pakistan
Yellow vein mosaic disease	Bhendi yellow vein mosaic virus	Monopartite	*Bemisia tabaci*	Pakistan

Result and discussion

The data presented in the table (3) indicated that none of the genotype was immune to the disease, while four genotypes viz., IC43735, VRO103, IC45818 and IC45980 showed highly resistant reaction to the disease incidence with a severity range of 1-10 per cent. IC96230, Parbani Kranti,VRO109, UAHS 1-1, VROB178,IC43720, Arka Abhay, VRO106 and HRB-55 showed moderately resistance with the severity range of 11-25 per cent, thirteen genotypes *viz*., IC43587, IC90244, Khashi Vibhuti, Kashi Sathadari, Khashi Kiranti, Khashi Leela, Khashi Mangala, 301-10-1, Phule Utkarsh, Arka Anamika Varsha Upahar, IC12934 and IC90235 recorded 26-50 per cent severity and were categorised into the tolerant group with the range of 51-60 per cent severity twenty genotypes *viz*., IC43732, IC90243, IC90247,IC90234, No.135, EC693226, EC693227, IC90285, EC693222, IC90245, IC90236, IC90242,S-11, IC18536, IC42518, IC42530, IC13664, Naveen, EC693224 and SB-2 were grouped into moderately susceptible group based on disease incidence. There were four genotypes which were susceptible *viz.*, IC90284, Pusa Makhmali, Halubende and IC690270. Further it was noticed that none of the genotypes were highly susceptible. The results were in accordance with Sharma and Sharma (1984) [11] who carried out similar type of screening and reported that *Abelmoscus manihot* subspecies manihot is a good source of resistance to Yellow Vein Mosaic Virus. Arora *et al*. (1992) [12] evaluated 157 advanced germplasm and 7 cultivars/hybrids of okra for two years and observed that Punjab Padmini and EMS 8 remained free from the Yellow Vein Mosaic Virus. Srivastava *et al.* (1995) [13] studied the reaction of 12 okra varieties against YVMV in the field at three sites. Varsha Upahar and HRB 55 were free of the disease at Karnal and HY6 at Andhra Pradesh. Arka Anamika showed moderate resistance at Karnal. It was found that, two varieties VRO-3 and HRB were found to be moderately resistant besides that high degree of resistance was obtained in variety VRO-6 under field condition. The two varieties *i.e.*, Pusa Makhamali and Pusa Sawani showed moderate susceptible and highly susceptible reaction respectively (Tiwari *et al*., 2012) [14]. Sixteen genotypes of okra were evaluated for YVMV by Talavia *et al*., during 2014. The results revealed that none of the genotypes was found completely free (immune) to YVMV incidence. However, two genotypes, (JOL-08-5 and AOL-08-2) were highly resistant, while one genotype (JOL-07-12-15) was moderate resistant and 7 genotypes (JOL-7-K-3, JOL-07K-13, AOL-05-1, JOL-63-K-5, JOL-07-16, JOL-07-K16 and JOL-09-8) were tolerance against YVMV. GO-2 was moderate susceptible, Selection-2, GJO-3, AOL-07-8 and AOL-08-10 were susceptible, while the remaining all the genotypes showed highly susceptible reaction. Kumar and Raju (2017) [15] screened eighteen genotypes for YVMV resistance and observed that, VRO6 and IIVR-11 was found resistance and Pusa Sawani found highly susceptible among all the genotypes.

The yield and disease reaction of top five high yielding

genotypes are presented in Table 2. The genotype IC45980 yielded 317.53g per plant showed highly resistance reaction followed by VROB178 with 312.50g per plant, HRB-55 with 305.15g per plant and Parbhani Kranti with 285.27g per plant with moderately resistant reaction while Varsha Upahar 291.33g per plant with tolerant reaction. Similar results were observed by Vijaya and Joshi (2013) [16] for eleven entries among the entries screened for YVMV entry VRO-6 and JOL-2K-19 were found to be promising in terms of mild incidence and maximum fruit yield. Screening of yellow vein mosaic virus resistance and yield loss of okra under field conditions was also carried out by Benchasri (2011) [17] they observed that KN-OYV-03 was moderately resistance and nine other entries were moderately tolerant to OYVMV.

Resistance to YVMV is not stable and frequent breakdowns of resistance have been observed in developed verities so there is a need of continuous breeding of resistance varieties, Hence these resistant sources can be effectively employed for further development of improved varieties with respect to YVMV resistance which in turn leads to higher yield.

Table 3: Response of different genotypes of okra against YVMV incidence under field condition

Rating scale	Name of genotypes with percent disease incidence	Reaction or Level of Resistance
0 %	Nil	Immune
1-10%	IC43735, VRO 103, IC45818, IC45980	Highly resistant
11-25 %	IC 96230, Parbhani Kranthi, VRO109, Arka Abhay, UAHS1-1, VROB178, HRB-55, IC43720 and VRO 106	Moderate resistant
26-50 %	IC43587, IC90244, Kashi Vibhuti, Kashi Sathadhari, Kasi Kiranthi,Kashi Leela, Kashi Managala, 307-10-1, Arka Anamika, Phule Utkarsh, Varsha Uphar,IC12934 and IC90235	Tolerant
51-60 %	IC43732, IC90243, IC90234, No.135, EC693226, EC693227, IC90285, EC693222, IC90247, IC90245, IC90236, IC90242, IC18536, IC42518, IC42530, IC13664, EC 693224 and SB-2, S-11 and Naveen	Moderate susceptible
61-70 %	IC90284, Pusa Makhmali, Halubende and IC690270	Susceptible
71-100 %	Nil	Highly susceptible

Table 4: Yield and yield contributing characters of top yielding Okra genotypes

Genotypes	Yield /Plant(g)	Yield (qt ha^{-1})	PDI	Disease reaction
IC45980	317.53	17.64	9.33	HR
VROB178	312.50	17.38	16.33	MR
HRB-55	305.15	16.95	24.67	MR
Varsha Uphar	291.33	16.18	26.00	T
Parbhani Kranthi	285.27	15.85	17.67	MR

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