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Response of mutated okra [*Abelmoschus esculentus* L. (Moench)] seeds to yellow vein mosaic virus

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Abstract
A field experiment was conducted at Experimental farm, Krishi Vigyan Kendra, Kangra, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, H.P., during rainy season, 2016 to find out the effect of YVMV incidence on different mutated seeds of P-8 okra variety. According to the description of disease scale for YVMV, the results from the experiment revealed that mutants from three treatments possessing resistance against YVMV were 1.6% EMS, combination of 65kR with 1.2% EMS and 85kR with 1.4% EMS while others are moderately resistant as compared to check variety Pusa Sawani which is highly susceptible. The resistant lines have been isolated and will be tested again in the next generation.

Keywords: Mutated okra, *Abelmoschus esculentus* L. (Moench), yellow vein mosaic virus

1. Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] commonly known as lady's finger or bhendi is most delicious vegetable relished world over, belongs to the family Malvaceae. Okra fruits are rich in proteins (20-24%) and their seeds contain 13-22% edible oil (Sheikh *et al.*, 2013) [16]. In general, okra is of African origin but the cultivated species *i.e*. *Abelmoschus esculentus* is probably of Indian origin (Dhankar *et al.*, 2005) [9]. It is very important vegetable cultivated all over India particularly in the states of Andhra Pradesh, West Bengal, Jharkhand, Orissa, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Maharashtra and constitutes 70% of the total fresh vegetable earnings, excluding onion (APEDA, 2000) [6]. Globally, okra is grown in an area of 11,17,806 hectares with a production of 87,06,312 metric tonnes and 7.8 tonnes/ha productivity (Anonymous 2016) [3]. India ranks first in the world with annual production of 63,46,000 metric tonnes produced from over 5,33,000 hectare area with a productivity of 11.9 tonnes/ha (Anonymous 2014) [4]. In Himachal Pradesh, it is grown during summer and rainy season in low and mid-hills in about 2,760 hectares with an annual production of 34,030 metric tonnes (Anonymous 2015) [2].

The productivity of okra has been low in recent times due to various reasons *viz*. inadequate use of fertilizers, irrigation and occurrence of various diseases and pests. Diseases are one of the major constraints for low productivity of bhendi (Das *et al.*, 2011) [8] and numerous fungal, bacterial, viral diseases have been reported in India. Amongst the viral diseases, Yellow vein mosaic virus is one of the important and of common occurrence wherever this crop is grown.

It was first reported in okra plants in 1924 in India (Kulkarni, 1924) [11]. The disease is characterized by alternate green and yellow patches, different degrees of chlorosis of leaves and in severe cases, the chlorosis may extend to the interveinal area and may result in complete yellowing of leaves. Fruits are dwarfed, malformed and turn yellow green. Fruit yield is greatly reduced (upto 96%) if the crop is infected at an early stage (Pun and Doraiswamy, 1999) [14]. The whitefly *Bemisia tabaci* (Genn.) species group is the insect vector. The whitefly vector reproduces to significant numbers during the summer season when it transmits the virus between okra plants. The causal agent is the single-stranded DNA *Bhendi yellow vein mosaic virus* (BYVMV), which is associated with a small satellite DNA β component (Jose and Usha, 2003), both of which are required for infection. Several YVMV resistant bhendi varieties have been released, but none have retained resistance for long (Usha, 2008) [10]. In recent times, many new varieties resistant to YVMV has been released but their resistance level is still of concern and is location specific.

Hence, an experiment was planned with the objective to find out YVMV incidence on different physical and chemical mutated okra lines.

Materials and methods

An experiment was conducted at Experimental farm, Krishi Vigyan Kendra, Kangra, CSKHPKV, Palampur. The experiment was carried out in augmented design during rainy season, 2016. Treatment with 15 different mutagens consisting of physical mutagen (gamma rays) i.e. 65kR, 75kR, 85kR and chemical mutagen (EMS) i.e 1.2%, 1.4%, 1.6% along with their combinations. After treatment with these mutagens, M_2 generation was screened for diseases incidence of YVMV against susceptible variety Pusa Sawani.

The experimental field was having medium fertility and good drainage. During this period, maximum rainfall (45.08 mm) was received in the month of August and minimum rainfall (3.51 mm) was received in the month of September. The average maximum temperature was 31.57 ºC during June and minimum temperature was 16.02 ºC during May. Maximum morning and evening relative humidity was 94.14 percent and 94.42 percent, respectively. The mean bright sunshine hours was 11 hrs day-1, evaporation was 9.00 mm week-1 and wind velocity was 7.21 km hr-1 during the crop growth period (Anonymous, 2016) [5].

All the varieties were sown on 20th May, 2016 with spacing 60 × 30 cm. The sowing of seed was done by dibbling method. Recommended dose of fertilizers @ 80-40-40 NPK kg ha^{-1} was applied. Half dose of nitrogen and complete dose of phosphorus and potassium was applied at the time of sowing and remaining half dose of nitrogen was applied at 30 DAS. First fruit picking was done at 60 DAS and subsequent pickings were done at every third day, a total of 10 pickings were obtained. Recommended agronomic practices were followed to raise the crop.

Diseases incidence as calculated with the help of diseases scale shown in Table 1.

Table 1: Description of disease scale for Yellow Vein Mosaic Virus (Ali *et al*., 2005) [1]

Scale	Reaction category	Type of infection
0	No disease	No plants infected
1	Highly resistant (HR)	<1% plants showing symptoms
3	Resistant (R)	1-10% plants showing mottling of leaves
5	Moderately resistant (MR)	11-20% plants showing mottling and yellow discoloration on leaves
7	Susceptible (S)	21-50% plants showing mottling, yellow discoloration on leaves and stunting of plants
9	Highly susceptible (HS)	>50% plants affected, stunting of plants pronounced, flower and fruit set reduced and yellow mottling severe

Data on YVMV affected plants were recorded on ten plants from each line when disease was at its peak during different growth stages i.e. seedling stage, flowering, fruit setting and fruit maturity. Disease severity index (%) was calculated as under:

Disease severity index (%) =

$$\frac{\text{Sum of all ratings}}{\text{Total number of ratings} \times \text{Maximum grade given}} \times 100$$

Results and discussion

M_2 plants obtained from different mutagenic treatments were screened against Yellow Vein Mosaic Virus (YVMV) in open conditions at KVK, Kangra. Homogenous interwoven network of yellow veins enclosing islands of green tissues within are developed in YVMV infected plant. In extreme cases, the entire leaf turn complete yellow or cream coloured. The infested plants are stunted and bear very few, yellow coloured fruits.

The understanding of inheritance of these diseases is very essential for formulating a systematic breeding program for developing a resistant variety with desirable horticultural traits. Disease resistance is the most desirable trait in any breeding program. A genotype is of little or no importance unless it is resistant to disease even if it is best for all other traits.

The check variety 'Pusa Sawani' was found to be highly susceptible to YVMV. Of the various mutants screened, only few mutants under three treatment mutants i.e. 1.6% EMS, combination of 65kR with 1.2% EMS and 85kR with 1.4% EMS showed resistance reaction (Table 2), whereas mutants under remaining treatments were moderately resistant to YVMV. The range of disease severity index varies from 3.87-22.80%, 6.35-39.80% and 9.52-53.50% at seedling stage, at flowering stage, at fruiting setting stage and at fruit maturity stage, respectively (Plate 1).

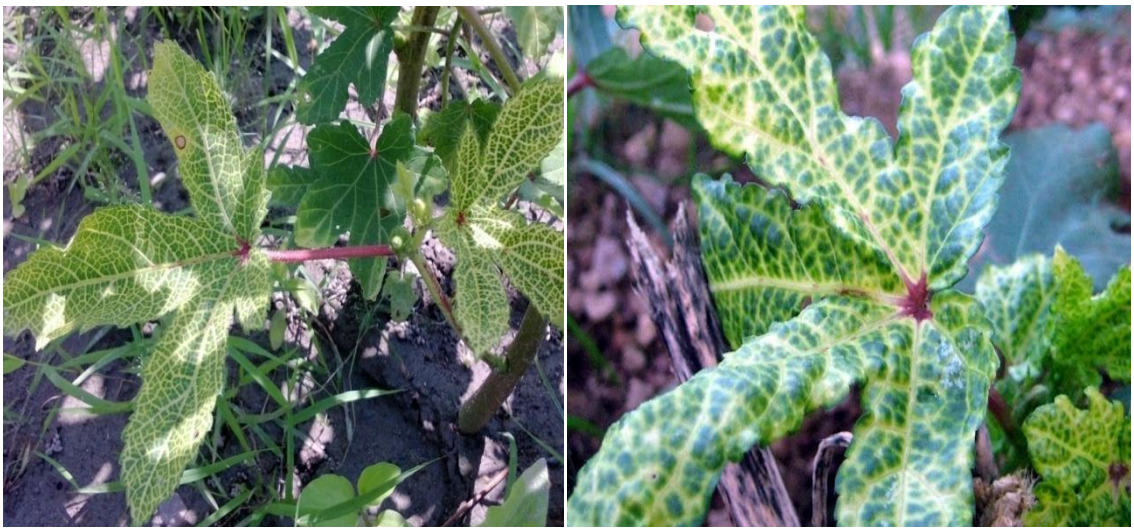
However the resistance observed in these plants need confirmation in the further generations. Since the mutations are random, there are less chances of getting all the genes mutated at a particular locus. This might have been the reason of not getting many resistant mutants. The results are in conformity with the research findings of Phadvibulya *et al*. (2004) [13], irradiated seeds of Annie and Okura varieties of okra by gamma rays to induce mutations for resistance to YVMV disease and they identified a single YVMV resistant mutant plant, B-21, in the M_4 generation from 400Gy gamma-irradiation; Pushaparajan *et al*. (2004) [15] who also irradiated okra seeds with gamma rays as 100Gy, 150Gy, 200Gy, 300Gy, 400Gy and 500Gy and found 400Gy be YVMV resistant compared to others; Dalve *et al*. (2012) [7] also found that the treatments with higher mutagenic doses (40kRgamma rays + 0.1% EMS and 30kR gamma rays + 0.1% EMS) had shown resistance against yellow vein mosaic virus; Singh *et al*. (2012) [17] screened twenty five genotypes of okra for disease incidence of YVMV under field conditions. The percent disease incidence and coefficient of infection ranged from 13.45% to 100% and 3.36% to 75%, respectively. Out of twenty five genotypes, three, four, eight, three, three and four genotypes were categorized as highly resistant, resistant, moderately resistant, highly susceptible, susceptible and moderately susceptible, respectively. Kumar *et al*. (2015) [12] also found genotypes DOV-12 and DOV-66 most desirable for YVMV resistance and higher yield. The resistant lines found in this research have been isolated and will be tested again in the next generation.

Table 2: Disease Severity Index of Yellow Vein Mosaic Virus (%) in okra at KVK Kangra

Treatment	Percentage of disease index				Reaction category
	At seedling stage	At flowering stage	At fruit setting stage	At fruit maturity stage	
65kR	-	8.32	12.52	18.56	MR
75kR	-	9.78	12.53	15.30	MR
85kR	-	7.00	8.52	11.50	MR
1.2% EMS	-	4.52	6.82	12.10	MR
1.4%EMS	-	3.87	8.00	11.23	MR
1.6%EMS	-	4.20	6.87	10.00	R
65kR +1.2%EMS	-	5.52	7.00	9.98	R
65kR +1.4%EMS	-	5.32	8.53	11.00	MR
65kR +1.6%EMS	-	4.83	8.20	10.85	MR
75kR +1.2%EMS	-	6.00	8.23	13.53	MR
75kR +1.4%EMS	-	5.53	7.38	12.89	MR
75kR +1.6%EMS	-	4.23	7.23	11.37	MR
85kR +1.2%EMS	-	3.89	6.35	10.89	MR
85kR +1.4%EMS	-	5.32	7.53	9.52	R
85kR +1.6%EMS	-	4.14	8.32	10.32	MR
Pusa Sawani (SC)	-	22.80	39.80	53.50	HS
Range		3.87-22.80	6.35-39.80	9.52-53.50	

MR: Moderately Resistant, R: Resistant, HS: Highly Susceptible

a) At flowering stage b) At fruiting stage



c) At fruit maturity stage

Plate 1 (a, b, c): Incidence of yellow vein mosaic virus at different stages

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