



Screening of germplasm of *Abelmoschus* against biotic stresses

MAHESH BADIGER¹ and R K YADAV²

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

Received: 22 March 2019; Accepted: 20 May 2019

ABSTRACT

Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable of which India is the leading producer, but its yield potential is hampered due to Bhendi Yellow Vein Mosaic Virus (BYVMV) disease and insect pests like whitefly, leafhopper, and shoot and fruit borer. The present study was done to identify the stable sources of resistance. Total 44 accessions of 6 wild *Abelmoschus* species and 2 check cultivars of *A. esculentus* (Pusa Sawani and Pusa A-4) were screened under natural field conditions at Division of Vegetable Science, ICAR-IARI, New Delhi during *kharif* season 2015. Both the check varieties were found susceptible to BYVMV, Jassids, whiteflies, and shoot and fruit borer. Out of 44 accessions of 6 wild *Abelmoschus* species, 3 accessions, viz. IC306722, IC90476-1 and IC141055 were found highly resistant to BYVMV, only two accessions, viz. IC141055 and IC140986 were resistant to Jassids and only one accession 141055 was resistant to whiteflies. While all the accessions of *A. tuberculatus* and more than 50% of the accessions of *A. manihot* var. *tetraphyllus* and *A. moschatus* were found resistant to fruit borer. However, one of the wild accession IC141055 showed multiple resistance, i.e. Jassids, whiteflies and fruit borer along with resistance to BYVMV disease indicated its possible importance as source of multiple biotic stress resistance. The mentioned promising accessions can be further screened at different hotspots for confirmation and can be exploited in future breeding programmes for okra improvement.

Key words: *Abelmoschus esculentus*, BYVMV, Jassids, Shoot and fruit borer, Whiteflies

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the important warm-season vegetable grown extensively in tropics, sub-tropics and during warmer seasons of the temperate areas across the world. It is a good source of iron, calcium, manganese, and magnesium, vitamins A, B, C, and K, as well as iodine (Moaward *et al.* 1984). Okra mucilage has its potential use in food, non-food and medicinal purposes. Okra is an important vegetable that contributes to India by earning foreign exchange through its fresh export to different parts of the world accounting 13% of export of fresh vegetables (Singh *et al.* 2014). Although India is the largest producer of okra with 6.0 million tonnes production from 0.5 million hectare area in the world (Anonymous 2018), its yield potential is low due to an array of biotic stresses adversely affecting the yield and quality of the produce. The important biotic bottlenecks are Bhendi Yellow Vein Mosaic Virus (BYVMV), Enation Leaf Curl Virus and insects like whitefly (*Bemisia tabaci*), leafhopper (*Amrasca biguttula biguttula*) and shoot and fruit borer (*Earias vitella*). BYVMV is a major menace responsible for 50–90% yield losses depending upon the age of the plant at the time of

infection (Chakraborty *et al.* 1997). Shoot and fruit borer is responsible for 8.4–73.2% fruit damage depending on the season (Kumar and Urs 1988). Chemical control of these pests has several ecological problems like toxicity hazards, environmental pollution, pest resurgence, etc. Therefore, use of genetic resistance is an effective strategy to manage these biotic stresses. Wild relatives of okra are important genetic sources of resistance to biotic stresses specifically BYVMV (Dhankar *et al.* 2005). Frequent breakdowns of viral disease resistance have been observed in popular okra varieties like Parbhani Kranti, P-7, Arka Anamika, Arka Abhay (Sanwal *et al.* 2014). Keeping these facts in view, present study aimed at shedding light on alternative sources of resistance to major biotic stresses such as BYVMV, whiteflies, leafhopper, and shoot and fruit borer.

MATERIALS AND METHODS

The present investigation was carried out at the Research Farm of Division of Vegetable Science, during *kharif* of the year 2015 ICAR-Indian Agricultural Research Institute, Pusa, New Delhi India, located at 28°35'N, 70°18'E, altitude 226 m amsl. Experimental material consisted of 44 accessions of 6 wild okra species and 2 check cultivars – Pusa Sawani and Pusa A-4 of cultivated species (*A. esculentus*). The species were *Abelmoschus caillei* (3), *A. manihot* var. *tetraphyllus* (17), *A. moschatus* (16), *A. tuberculatus* (3), *A. ficulneus* (2) and *A. angulosus* var. *grandiflorus* (3). The experiment

¹Breeder (Okra) (maheshhort536@gmail.com), Seed Works International Pvt Ltd, Hyderabad, Telangana; ²Principal Scientist (rkyadavneh@gmail.com), Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi.

was laid out in Randomized Complete Block Design (RCBD) with two replications. All the scientific agronomic packages of practices were followed to raise a healthy crop. No insecticides were applied to control the pests. The accessions were screened under natural epiphytotic condition for BYVMV following the infector row method (Nene *et al.* 1972). To ensure even distribution of viral disease pressure throughout the experimental field a susceptible check cv. Pusa Sawani was used as 'infector line' after every three treatments (test accessions) and also as 3 rows around each block to ensure adequate source of virus inoculums. The disease incidence was recorded at 15 days interval during the crop growing season (*kharif* 2015) starting 15 days after sowing (DAS). The response of the virus was assessed based on per cent disease incidence [$PDI = (\text{Number of diseased plants} / \text{Total number of plants}) \times 100$] in a given accession and disease severity designated with numerical values of 0–4 were assigned against each accession and a scale of response value (0–1) corresponding to such grades were denoted (Table 1) as described by Bag *et al.* (2014). The coefficient of infection (CI) was calculated by multiplying the PDI and Response value (Bag *et al.* 2014). The disease reaction was finally deduced based on the CI value and six levels of response-categories were developed (Table 1).

Abelmoschus germplasm was screened under field condition against leafhopper and whiteflies as per Mudgalkar *et al.* (2014). Population of leafhoppers (nymphs) and whiteflies (adults) were recorded on five randomly selected tagged plants from three leaves (top, middle and bottom) in each replication during morning hours (6.30 AM to 8 AM) from 15 DAS to 105 DAS at 15 days interval. Later the population was averaged and expressed in mean number of insects per leaf. All the accessions were categorized into resistant (<5), moderately resistant (5–10), moderately susceptible (>10–20), susceptible (>20–30) and highly susceptible (>30) as suggested by Iqbal *et al.* (2008) in

okra. For shoot and fruit borer infestations, the number of infested fruits along with total number of healthy fruits in each accession were counted at each harvest and added up to get the per cent infestation. All the accessions were categorized into resistant (<20 %), moderately resistant (20–40 %), moderately susceptible (>40–60 %), susceptible (>60–80 %) and highly susceptible (>80 %) based on the per cent fruit infestations (Mishra *et al.* 1988). The quantitative data was analysed for statistical significance as suggested by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Screening for BYVMV under field condition revealed that PDI and CI values ranged from 7.73 (IC141055) to 71.33 (Pusa Sawani) and 1.93 (IC141055) to 71.33 (Pusa Sawani) respectively (Table 2). The disease pressure was high in the experimental plot as evident from the susceptible check Pusa Sawani that showed highly susceptible reaction (CI = 71.33). Species wise disease reaction category (Table 3) revealed that two varieties of cultivated okra (Pusa Sawani and Pusa A-4) were found to be highly susceptible. In *A. caillei* accessions only (IC306722) was highly resistant. In the accessions of *A. manihot* var. *tetraphyllus* only IC90476-1 was highly resistant to BYVMV disease. While, among 16 accessions of *A. moschatus* only IC141055 was found highly resistant and 4 more accessions were resistant. Among the *A. tuberculatus* accessions, one was moderately resistant (IC90343). Both the accessions of *A. ficulneus* were moderately susceptible to BYVMV. Among the 3 accessions of *A. angulosus* var. *grandiflorus*, only IC470752 was moderately resistant. Availability of resistance to BYVMV in *A. manihot* spp. *tetraphyllus* was earlier reported by Prabhu *et al.* (2009), Rajmony *et al.* (1995), Bag *et al.* (2014) and Gangopadhyay *et al.* (2016). Prabhu *et al.* (2009) opined that higher amount of phenols and their oxidation products like quinines formed by increased peroxidase and polyphenol oxidase may be responsible for reduced virus multiplication which finally could have led to resistance reaction in wild okra and their interspecific hybrids.

None out of *A. tuberculatus*, *A. ficulneus* and *A. angulosus* var. *grandiflorus* was resistant to BYVMV. Rajmony *et al.* (1995) extracted some BYVMV resistant accessions from *A. ficulneus* and *A. angulosus*, respectively, which indicated prevalence of accessional variation within the species. Many BYVMV resistant varieties have been developed using wild species *A. manihot* since 1970 (Thakur 1976) including Parbhani Kranti (Jambhale and Nerkar 1985). Later breakdown of resistance was observed due to pan India use of sole species as source of resistance. Therefore, BYVMV resistant accessions identified in the present investigation can be further screened under hotspots to reaffirm their resistance potential across the regions and thereafter deployed into breeding programmes. Combining resistance from diverse species into cultivated background helps in development of broad based and durable source of resistance.

Mean number of leafhoppers per leaf ranged from 4.43 (IC141055) to 24.85 (Pusa Sawani) (Table 2). Low mean

Table 1 Scale for wild *Abelmoschus* accessions against BYVMV under natural epiphytotic condition

Symptom	Severity Grade	Response value	Coefficient of Infection (CI)	Reaction
Absent	0	0	0 – 4.0	HR (Highly resistant)
Very mild up to 25% leaves	1	0.25	>4.0 – 9.0	R (Resistant)
Appearance in 26–50% leaves	2	0.50	>9.0 – 19.0	MR (Moderately Resistant)
Appearance in 51–75% leaves	3	0.75	>19.0 – 39.0	MS (Moderately Susceptible)
Severe disease infection (>75% leaves)	4	1.00	>39.0 – 69.0 >69.0 – 100	S (Susceptible) HS (Highly Susceptible)

Table 2 Incidence of BYVMV and infestation of Jassids, whiteflies and fruit borer

Genotype	BYVMV				Leaf hopper (Jassids)		Whiteflies		Shoot and fruit borer	
	PDI	R V	CI	Reaction category	Mean no./leaf	Reaction category	Mean no./leaf	Reaction category	Fruit borer infestation (%)	Reaction category
Pusa Sawani	71.33	1.00	71.33	HS	24.85	S	23.52	S	82.44	HS
Pusa A4	57.81	1.00	57.81	S	23.81	S	21.44	S	64.30	S
<i>A. caillei</i>	27.65	0.50	13.82	MR	21.16	S	7.48	MR	67.93	S
IC306722	14.71	0.25	3.68	HR	15.20	MS	10.14	MS	72.62	MR
<i>A. caillei</i> (SKM-1)	21.08	0.50	10.54	MR	11.40	MS	10.80	MS	61.9	MR
IC90511	26.18	0.50	13.09	MR	12.01	MS	10.55	MS	23.04	MR
IC141025	20.58	0.50	10.29	MR	9.11	MR	11.09	MS	45.97	MS
IC141040	34.74	0.75	26.05	MS	22.79	S	9.28	MR	40.03	MS
IC470735	24.80	0.50	12.40	MR	12.61	MS	11.03	MS	48.73	MS
IC470743	54.39	0.75	40.79	S	13.97	MS	9.09	MR	22.16	MR
IC141045	32.68	0.75	24.51	MS	13.07	MS	9.09	MR	27.25	MR
IC9548	55.37	0.75	41.53	S	13.67	MS	10.68	MS	49.79	MS
IC90409	22.63	0.25	5.66	R	11.96	MS	10.43	MS	7.22	R
IC90499	41.96	0.50	20.98	MS	15.22	MS	10.36	MS	19.79	R
IC90508	23.05	0.50	11.53	MR	23.79	S	10.51	MS	13.98	R
IC90476-1	8.61	0.25	2.15	HR	8.86	MR	8.23	MR	21.56	MR
IC90515	16.98	0.25	4.24	R	13.03	MS	9.26	MR	19.50	R
IC90505	28.77	0.75	21.58	MS	13.57	MS	9.87	MR	40.16	MS
<i>A. tetraphyllus</i>	28.47	0.50	14.24	MR	15.65	MS	11.07	MS	15.36	R
IC47092	11.00	0.50	5.50	R	14.76	MS	10.33	MS	14.54	R
IC111500	18.44	0.75	13.83	MR	15.06	MS	8.88	MR	12.26	R
IC385287	20.89	0.50	10.44	MR	13.18	MS	9.69	MR	21.14	MR
IC141065	22.60	0.50	11.30	MR	9.53	MR	6.15	MR	14.74	R
IC140985	23.06	0.50	11.53	MR	9.82	MR	5.90	MR	22.89	MR
IC140970	26.36	0.50	13.18	MR	11.13	MS	6.22	MR	16.85	R
IC316073	42.08	0.50	21.04	MS	10.39	MS	6.56	MR	20.18	MR
IC393008	28.85	0.50	14.42	MR	12.23	MS	7.00	MR	39.37	MR
IC469584	27.44	0.75	20.58	MS	12.09	MS	5.65	MR	15.75	R
IC339520	54.86	1.00	54.86	S	10.47	MS	6.49	MR	48.99	MS
IC470737	41.45	0.50	20.73	MS	10.99	MS	5.48	MR	23.62	MR
IC140986	17.29	0.25	4.32	R	4.84	R	4.67	MR	9.60	R
IC140113	19.41	0.25	4.85	R	12.84	MS	5.51	MR	25.71	MR
IC212557	33.63	0.25	8.41	R	10.55	MS	5.64	MR	7.25	R
IC141056	49.90	0.75	37.43	MS	11.03	MS	7.44	MR	9.98	R
EC316077	18.97	0.25	4.74	R	11.74	MS	6.54	MR	10.84	R
IC141055	7.73	0.25	1.93	HR	4.43	R	4.55	R	12.59	R
NIC4676	35.64	0.75	26.73	MS	10.70	MS	8.30	MR	31.87	MR
Egypt-R	40.04	0.50	20.02	MS	9.97	MR	6.29	MR	41.59	MS
IC436706	50.72	0.50	25.36	MS	13.93	MS	11.17	MS	14.45	R
IC90396	40.44	0.50	20.22	MS	13.90	MS	11.61	MS	5.43	R
IC90343	24.56	0.50	12.28	MR	12.78	MS	9.47	MR	14.02	R
IC90364	44.18	0.50	22.09	MS	12.45	MS	10.60	MS	31.66	MR
IC550661	55.27	0.50	27.64	MS	10.14	MS	10.61	MS	23.34	MR
IC213314	46.47	0.50	23.23	MS	10.71	MS	10.84	MS	21.10	MR
IC470752	32.26	0.50	16.13	MR	11.38	MS	12.17	MS	39.01	MR
IC203834	41.44	0.50	20.72	MS	11.23	MS	10.99	MS	16.91	R

Table 3 Species wise reaction categories against BYVMV, leafhopper (Jassids), whiteflies, and shoot and fruit borer infestation

<i>Abelmoschus</i> species	Insect pest	Highly resistant	Resistant	Moderately resistant	Moderately susceptible	Susceptible	Highly susceptible
<i>A. esculentus</i>	BYVMV	--	--	--	--	Pusa A-4	Pusa Sawani
	Jassids	--	--	--	--	Pusa Sawani, Pusa A-4	--
	Whiteflies	--	--	--	--	Pusa Sawani, Pusa A-4	--
	fruit borer	--	--	--	--	Pusa A-4	Pusa Sawani
<i>A. caillei</i>	BYVMV	IC306722	--	<i>A. caillei</i> & <i>A. caillei</i> (Sikkim)	--	--	--
	Jassids	--	--	--	IC306722, <i>A. caillei</i> (Sikkim)	<i>A. caillei</i>	--
	Whiteflies	--	--	--	<i>A. caillei</i>	IC306722, <i>A. caillei</i> (Sikkim)	--
	fruit borer	--	<i>A. caillei</i>	--	--	IC306722, <i>A. caillei</i> (Sikkim)	--
<i>A. manihot</i> var. <i>tetraphyllus</i>	BYVMV	IC90476-1	IC90515, IC47092, IC90409	IC90511, IC141025, IC141040, IC470735, IC90505, IC90508, IC111500, IC385287, <i>A. tetraphyllus</i>	IC141045, IC90499, IC90505	IC470743, IC9548	--
	Jassids	--	--	IC141025, IC90476-1	IC90511, IC470735, IC141040, IC470743, IC141045, IC90508, IC9548, IC90409, IC90499, IC90515, IC90505, <i>A. tetraphyllus</i> , IC47092, IC111500, IC385287	--	--
	Whiteflies	--	--	IC141040, IC470743, IC90511, IC141025, IC141045, IC90476-1, IC470735, IC9548, 1, IC90515, IC90505, IC90409, IC90499, IC111500, IC385287	IC90508, <i>A. tetraphyllus</i> , IC47092	--	--
	fruit borer	--	IC90409, IC90499, IC90508, IC90515, IC111500, <i>A. tetraphyllus</i> , IC47092	IC90511, IC470743, IC141025, IC141040, IC141045, IC90476-1, IC385287	IC470735, IC9548, IC90505	--	--
<i>A. moschatus</i>	BYVMV	IC141055	IC140986, IC140113, IC212557, EC316077	IC141065, IC140985, IC140970, IC393008	IC316073, IC469584, IC339520, IC141056, NIC4676, Egypt-R, IC470737	--	--
	Jassids	--	IC140986, IC141055	IC141065, IC140985, Egypt-R	IC140970, IC316073, IC393008, IC469584, IC339520, IC470737, IC140113, IC212557, IC141056, EC316077, NIC4676	--	--

Contd.

Table 3 (Concluded)

<i>Abelmoschus</i> species	Insect pest	Highly resistant	Resistant	Moderately resistant	Moderately susceptible	Susceptible	Highly susceptible
	Whiteflies	--	IC141055	IC141065, IC140985, IC140970, IC316073, IC393008, IC469584, IC339520, IC470737, IC140986, IC140113, IC212557, IC141056, EC316077, NIC4676, Egypt-R	--	--	--
	Fruit borer	--	IC141065, IC140970, IC469584, IC140986, IC212557, IC141056, EC316077, IC141055	IC140985, IC316073, IC393008, IC470737, IC140113, NIC4676	IC339520, Egypt-R	--	--
<i>A. tuberculatus</i>	BYVMV	--	--	IC90343	IC436706, IC90396	--	--
	Jassids	--	--	--	IC436706, IC90396, IC90343	--	--
	Whiteflies	--	--	IC90343	IC436706, IC90396	--	--
	fruit borer	--	IC436706, IC90396, IC90343	--	--	--	--
<i>A. ficulneus</i>	BYVMV	--	--	--	IC90364, IC550661	--	--
	Jassids	--	--	--	IC9034, IC550661	--	--
	Whiteflies	--	--	--	IC90364, IC550661	--	--
	fruit borer	--	--	IC90364, IC550661	--	--	--
<i>A. angulosus</i> var. <i>grandiflorus</i>	BYVMV	--	--	IC470752	IC213314, IC203834	--	--
	Jassids	--	--	--	IC213314, IC470752, IC203834	--	--
	Whiteflies	--	--	--	IC213314, IC470752, IC203834	--	--
	fruit borer	--	IC203834	IC213314, IC470752	--	--	--

number of hoppers per leaf was also observed in IC140986 (4.84), IC90476-1 (8.86), IC141065 (9.53), IC140985 (9.82) and Egypt-R (9.97). After categorising into 5 different categories, IC141055 (4.43) and IC140986 (4.84) formed resistant category (Table 3). Both the cultivated varieties were found susceptible (Pusa Sawani, and Pusa A4). None of the accessions from *A. caillei* and *A. manihot* var. *tetraphyllus* were resistant. Out of 16 accessions of *A. moschatus* screened for jassids, only IC141055 and IC140986 were resistant. Present findings were in accordance with Prabhu *et al.* (2009) and Dharavath *et al.* (2016). Hooda and Dhankhar (1992) and Singh *et al.* (2007) who reported that the species *A. moschatus* due to its laminal hairiness was found to be highly resistant to hopper. Hopper (Jassid) resistant cultivars were reported to possess higher trichome density, longer trichome length and higher concentration of sugars, silica, potassium, tannins and phenols in the leaves.

Over all mean number of whiteflies per leaf ranged from 4.67 (IC140986) to 23.52 (Pusa Sawani). Data in Table 3

showed that cultivated varieties Pusa Sawani and Pusa A4 were found susceptible to whiteflies. Only IC141055 of *A. moschatus* was resistant. None of the accessions of *A. tetraphyllus*, *A. caillei*, *A. tuberculatus*, *A. ficulneus* and *A. angulosus* var. *grandiflorus* were found resistant. Resistance of *A. moschatus* might be attributed to presence of dense hairs on stem, upper and lower surface of leaves. Availability of whitefly resistance among wild relatives was also reported earlier by Dharavath *et al.* (2016), Prabhu *et al.* (2009) and Narayanan *et al.* (2016). Borad *et al.* (1993) and Pun *et al.* (2005) reported a highly significant positive correlation between adult whitefly population density and the incidence of BYVMV disease in okra. White fly resistant accession IC141055 was also found resistant to BYVMV indicating its importance in strategic BYVMV resistance breeding.

Data presented in Table 2 revealed that fruit borer infestation ranged from 5.43 (IC90396) to 82.44 (Pusa Sawani). Based on fruit borer infestation 46 accessions were divided into 5 categories (Table 3). All three *A. caillei*

accessions were found susceptible to fruit borer. Out of 17 accessions of *A. manihot* var. *tetraphyllus* only 7 were resistant to borer. Among 16 accessions of *A. moschatus* 8 were resistant. All the 3 accessions of *A. tuberculatus* were found resistant to fruit borer. Two *A. ficulneus* accessions included in the study were moderately resistant. In *A. angulosus* var. *grandiflorus* accessions, one accession was resistant. None of the wild species accessions were susceptible to fruit borer. These findings corroborated with Gangopadhyay *et al.* (2016). High level of resistance to shoot and fruit borer in *A. tuberculatus* might be due to tubercles on the surface of the fruit wall. Singh *et al.* (2007) also opined the same regarding *A. tuberculatus* resistance to fruit borers. While the presence of dense trichomes on the stem and fruit surfaces of *A. manihot* var. *tetraphyllus* and *A. moschatus* provided them resistance to fruit borer. Negative correlation between trichome density and borer infestation in okra was observed by Sharma and Singh (2010). Lengthy fruits were found more suitable for damage by *Earias* as they harbored more larvae per fruit in okra (Muthukumaran and Ganesan, 2017). In the present investigation highest fruit length was observed in Pusa Sawani (14.09 cm) and among the wild accessions it varied from 1.5 to 7.5 cm. Accordingly, highest fruit borer infestation was observed in Pusa Sawani and none of wild *Abelmoschus* accessions were recorded under the susceptibility category.

The results obtained indicate that one wild accession IC141055 (*A. moschatus*) was found resistant to Jassids, whiteflies and fruit borer along with resistance to BYVMV which in turn indicated its possible importance as multiple biotic stress resistance source. So far no attempts have been made to exploit the biotic stress tolerance from *A. moschatus* which might be due to scarce information available about its crossability with cultivated *Abelmoschus esculentus*. Thus, *A. moschatus* can be further studied at different hotspots for confirmation.

REFERENCES

- Anonymous, 2018. Indian Horticultural Database 2018. Retrieved from <http://www.nhb.gov.in>.
- Bag M K, Gautam N, Prasad T, Pandey S, Dutta M and Roy A. 2014. Evaluation of an Indian collection of black gram germplasm and identification of resistance sources to Mungbean yellow mosaic virus. *Crop Protection* **61**: 92–101.
- Borad V K, Puri S N, Brown J K and Butler G D. 1993. Relationship of *Bemisia tabaci* population density and yellow vein mosaic disease incidence in okra. *Pest Management and Economic Zoology* **1**(1):1–14.
- Chakraborty S, Pandey P K and Singh B. 1997. Okra enation leaf curl disease-a threat to cultivation of okra (*Abelmoschus esculentus* (L.) Moench). *Vegetable Science* **24**: 52–4.
- Dhankar S K, Dhankar B S and Yadava R K. 2005. Inheritance of resistance to yellow vein mosaic virus in an interspecific cross of okra. *Indian Journal of Agricultural Science* **75**: 287–90.
- Dharavath S, Sharma R K and Sinha S R. 2016. Wild, exotic and indigenous okra for resistance to insect pests. *Indian Journal of Entomology* **78**(3): 205–10.
- Gangopadhyay K K, Singh A, Bag M K, Ranjan P, Prasad T V, Roy A and Dutta M. 2016. Diversity analysis and evaluation of wild *Abelmoschus* species for agro-morphological traits and major biotic stresses under the north western agro-climatic condition of India. *Genetic Resources and Crop Evolution* **64**(4): 775–90.
- Hooda V A and Dhankhar B S. 1992. Evaluation of Wild taxa of okra against the leaf hopper, *Amrasca biguttula biguttula* Ishida. *Test of Agrochemicals and Cultivars* **13**: 108–9.
- Iqbal J, Mansoor H, Muhammad A, Shahbaz T and Amjad A. 2008. Screening of okra genotypes against jassid, *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae). *Pakistan Journal of Agricultural Sciences* **45**(4): 448–51.
- Jambhale N D and Nerkar Y S. 1985. An unstable gene controlling developmental variation in okra. *Theoretical and Applied Genetics* **71**(1): 122–5.
- Kumar K K and Urs K C D. 1988. Population fluctuation of *Earias vittella* (Fab.) on okra in relation to abiotic factors. *Journal of Plant Protection* **16**: 137–42.
- Moaward F G, Abdelwhab B M, Abdelnahun F M, Shehaya F W. 1984. *Annals of Agricultural Science* **21**: 603–13.
- Mudgalkar A B, Sonalkar V U and Gaikwad B B. 2014. Performance of some Okra genotypes against leaf hopper and whitefly. *Journal of Entomological Research* **38**(4): 291–4.
- Muthukumaran N and Ganesan P. 2017. Antixenosis resistance in okra and their hybrid derivatives against shoot and fruit borer *Earias vitella* (Fab.). *Journal of Entomology and Zoology Studies* **5**(4):1884–7.
- Narayanan U S, Muthiah C, Chinniah C and Balakrishnan K. 2017. In vivo screening of okra (*Abelmoschus esculentus* L.) germplasm collections against sucking pests. *Electronic Journal of Plant Breeding* **8**(1):187–92.
- Nene Y, Srivastava S and Nareh J. 1972. Evaluation of black-gram (*Phaseolus mungo* Roxb.) and greengram (*Phaseolus aureus* Roxb.) varieties and germplasms for resistance to yellow-mosaic virus of green-gram. *Indian Journal of Agricultural Sciences* **42**:251–4.
- Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*, 3rd Edn. ICAR, New Delhi.
- Prabhu T, Warade S D, Mehdiv S and Baheti H S. 2009. Screening wild and cultivated okra species for resistance to important pests. *Indian Journal of Plant Protection*. **37**(1&2): 87–91.
- Pun K B and Doraiswamy S and Jeyarajan R. 2005. Management of Okra yellow vein mosaic virus disease and its whitefly vector. *Indian Journal of Virology* **16**(1/2): 32–5.
- Rajmony L, Jessykutty P C and Mohankumaran N. 1995. Resistance to YVMV of bhindi in Kerala. *Vegetable Science*. **22**(2):116–9.
- Sanwal S K, Singh M, Singh B, and Naik P S. 2014. Resistance to yellow vein mosaic virus and okra enation leaf curl virus: challenges and future strategies. *Current Science* **106**: 470–1.
- Sharma B N and Singh S. 2010. Biophysical and biochemical, factors of resistance in okra against shoot and fruit borer. *Indian Journal of Entomology* **72**(3): 212–6.
- Singh B, Rai M, Kalloo G, Satpathy S and Pandey K K. 2007. Wild taxa of okra (*Abelmoschus* species): reservoir of genes for resistance to biotic stresses. (In) International Conference on Indigenous Vegetables and Legumes. *Prospectus for Fighting Poverty, Hunger and Malnutrition* **752**: 323–8.
- Singh B, Singh P M, Sanwal S K and Pal A. K. 2014. Standardization of cost effective hybridization technique for hybrid seed production in okra (*Abelmoschus esculentus*). *Indian Journal Agricultural Sciences* **84**:1111–4.
- Thakur M R. 1976. Inheritance of resistance to yellow vein mosaic in a cross of okra species *Abelmoschus esculentus* × *A. manihot* sub sp. *manihot*. *SABRAO Journal* **8**: 69–73.