Use of agro-insecticide, plant extracts and resistance inducers to manage yellow vein mosaic of okra

ABSTRACT

Production of okra is under threat due to certain biotic and abiotic factors. Okra yellow vein mosaic virus (OYVMV) is a devastating disease of okra, caused by monopartite and bipartite begomovirus and transmitted by whiteflies (*Bemisia tabaci* Gen.). Yield loss due to this virus is quite high, up to 80-94 percent is reported under heavy infection. The field experiment was carried out to evaluate the effect of insecticide (malathion 50 EC) alone or with plant extracts (Faba bean seed extract and Sarpagandha leaves extract) and resistance inducers were used for the effective management of yellow vein mosaic disease of okra in Hisar condition. The result revealed that among all the treatments malathion 50 EC (2 ml/litre) in combination with sarpagandha leaves extract (10%) had recorded the lowest terminal per cent disease index **(**PDI) (15.55%) during all the observation periods as compared to untreated check plot (71.68%). The fruit yield was also recorded highest (3833.20 kg/ha) in this treatment as compared to control (1811.15 kg/ha) and other treatments. For the evaluation of resistance inducers, the seeds were soaked in salicylic acid with concentrations of 50, 100 and 150 mg/litre water and *Trichoderma viride* @ 5 g/litre water at the time of sowing and later sprayed with the same doses at 15 days interval. Amongst different treatments, salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water recorded significantly less terminal PDI (28.89%) as well as the highest fruit yield as compared to other treatments and untreated check plot (73.33%). The treatment with bioagent *Trichoderma viride* @ 5 g/litre as seed priming and spray @ 5 g/litre water also effective in reducing the disease severity and increasing fruit yield significantly as compared to control.

Keywords: *Okra, OYVMV, PDI, Insecticide, Plant extracts, Resistance inducers, Seed priming*

INTRODUCTION

Okra (*Abelmoschus esculentus* (L) Moench) is extensively grown around the world in tropical, subtropical, and warm climates. Due to its ease of cultivation and tolerance to different moisture levels, it is a popular crop in India. In England, it's known as lady's finger; in the United States, it's known as gumbo; and in India, it's known as okra. The cultivated okra containing chromosome number 2n=130 is an amphidiploid vegetable of *Abelmoschus tuberculatus* (2n=58) and an unknown species with chromosome number 2n= 72 (Datta and Naug, 1968). It's regarded as super-vegetable with several nutritional and therapeutic properties. It accounts for 60% of total fresh vegetable exports. Okra is mostly exported from India to West Asia, Western Europe, and the United States. Okra is mostly imported by Kuwait, the United Arab Emirates, Saudi Arabia, and Qatar. It is grown on 0.528 million hectares in India, with a yield of 6.15 million metric tonnes and productivity of 11.63 metric tonnes per hectare. Among the states, West Bengal has the highest area (77,400 hectares) and production (0.91 million metric tonnes) followed by Gujarat, Odisha, Bihar and Madhya Pradesh. Productivity is highest in Andhra Pradesh (17.45 metric tonnes per hectare) followed by Jammu & Kashmir, Assam and Jharkhand (Ministry of Agriculture, 2018). Okra is rich in vitamins, minerals, carbohydrate fibre, protein, fat and phenols (Lengsfeld *et. al.*, 2004).

Viruses, fungus, bacteria, and nematodes are among the biotic agents that cause disease in the okra crop. Viruses such as Okra yellow vein mosaic virus (OYVMV), Okra mosaic virus (OMV), and Okra leaf curl virus (OLCV) are among the potential factors for production limitations in the okra crop (Kucharek, 2004). Okra yellow vein mosaic virus disease (OYVMV) is a deadly and extensively spread disease seen in okra farms all over the world, including India. Okra yellow vein mosaic virus (OYVMV), a member of the Begomovirus family Geminiviridae, causes this illness. It is spread in a persistent circulative way by whiteflies (*Bemisia tabaci* Gen.) (Ghanem, 2003). OYVMV was found on plants, exhibiting symptoms such as mosaic patterns on leaves, vein clearing, tiny fruit development, and stunting in extreme instances (Ali *et. al.*, 2014). In India, substantial yield losses of up to 75% were seen, coupled with the typical chlorosis yellowing of leaves, deformity, and small fruit size (Solankey et. al.,2014). For effective management of OYVMV disease through agro-insecticide alone or in combination with different plant extracts and by using resistance inducers this study was undertaken.

MATERIALS AND METHODS

To study the effect of agro-insecticide alone or in combination with different plant extracts and resistance inducers on PDI and yield of okra, a field experiment was conducted at the research farm Department of Plant Pathology, CCS Haryana Agricultural University. The experiment was laid out in randomized block design having six treatments with three replications. The sowing was done on 15th June, 2018 using the seeds of Pusa Sawani cultivar. Three sprays of agro-insecticide and plant extracts were taken at 15 days interval. First spray was done on 30 days after sowing. For evaluation of resistance inducers, the seeds were soaked in salicylic acid and *Trichoderma viride* solutions at different concentrations at the time of sowing and later sprayed with the same doses at 15 days interval from 30 days after sowing i.e. 30, 45 and 60 days. Detail of the experiments given below;

Chart 1: Treatment details of agro-insecticide and plant extracts

Treatments	Details
T_1	Malathion 50 EC @ 2ml/litre of water
T_2	Malathion 50 EC @ 2ml/litre of water + Faba bean seed extract @ 10%
T_3	Malathion 50 EC @ 2ml/litre of water + Sarpagandha leaves extract @10%
T_4	Faba bean seed extract @ 10%

T_5	Sarpagandha leaves extract @10%
T_6	Untreated check

Chart 2: Treatment details of resistance inducers

Treatments	Details
T_1:	Salicylic acid @ 50 mg/litre as seed priming* and spray @ 50 mg/litre water
T_2:	Salicylic acid @ 100 mg/litre as seed priming and spray @ 100 mg/litre water
T_3:	Salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water
T_4:	*Trichoderma viride* @ 5g / litre as seed priming and spray @ 5g/litre water
T_5:	Check (Seed dipping in water & Water Spray)

* For priming, seeds were soaked in different solutions for 6 h at 30^0C.

Disease assessment:

Data were recorded on percent disease severity at 15 days after the interval and extended up to the last picking. The disease severity was calculated at 7 days interval by using a 0-6 scale (Ali *et al.*, 2005). Per cent disease index (PDI) was calculated with the method of McKinney, 1923.

Chart 3: Disease severity scale

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

The percentage disease index (PDI) was calculated by McKinney's, 1923 formula:

$$\text{Per cent disease index} = \frac{\text{Sum of all numerical ratings}}{\text{No. of plant examined} \times \text{maximum disease rating}} \times 100$$

Per cent disease control:

The per cent disease control (PDC) was determined by using the following formula:

$$\text{Per cent disease control} = \frac{\text{Disease severity in control} - \text{Disease severity in treatment}}{\text{Disease severity in control}} \times 100$$

Fruit yield

The immature fruits were harvested at regular intervals and the yield of fruits was recorded in g/plot. Later on, fruit yield was calculated in kg/ha and per cent increase in fruit yield was calculated by using the following formula:

$$\text{Per cent increase in yield} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

RESULTS AND DISCUSSION

Effect of agro-insecticide and plant extracts on OYVMV PDI and fruit yield

Chemical management is commonly used by farmers to increase fruit yield, but its injudicious use has resulted in a slew of issues in the field, including insect resistance, pesticide residues, the extinction of beneficial fauna, and pollution. In such conditions, the employment of both chemical and botanical insecticides in pest management is seen as an environmentally feasible option for addressing the aforementioned issues. Considering the importance of eco-friendly approaches to the pest's management the present investigation was undertaken using agro-insecticide *i.e*. malathion 50 EC alone or in combination with two plant extracts *i.e*. Faba bean seed extract and Sarpagandha leaves extract. The result in Table 1 revealed that all the treatments alone or in combination had a significant effect in reducing OYVMV PDI and also increased the yield as compared to control. In all the treated plots significantly lower PDI was recorded during all the periods of observations. Among all the treatments malathion 50 EC (2 ml/litre) + sarpagandha leaves extract (10%) had recorded significantly less terminal PDI (15.55%) which was followed by malathion 50 EC (2 ml/litre) + faba bean seed extract 10 percent (22.22%) and the fruit yield was also recorded highest (3833.20 kg/ha) in treatment malathion 50 EC (2 ml/litre) + sarpagandha leaves extract (10%) as compared to control (1811.15 kg/ha) and other treatments. Srivastava *et al.* (2010) found that medicinal plant extracts were inhibitory for all three strains, with the leaf extracts of *Rauvolfia serpentine* showing the greatest decrease in disease incidence for all three strains for up to 75 days. Tiwari *et al.* (2010) also found that *Rauwolfia serpentine* leaf extracts reduced disease incidence the most and were also extremely efficient for plant growth indices. In Haryana, *Rauwolfia serpentine* is particularly useful in managing a variety of fungal diseases (Malik *et al.*, 2008; Malik *et al.*, 2018). At 25 DAS minimum PDI (0.55%) was observed in treatment malathion 50 EC (2 ml/litre) + sarpagandha leaves extract (10%), followed by treatment malathion 50 EC (2 ml/litre) + faba bean seed extract 10 percent. At 25 DAS malathion 50 EC (2 ml/litre) + faba bean seed extract (10%) recorded a PDI of 3.33 percent which was significantly lower than faba bean seed extract (9.98%) alone, but statistically at par to malathion 50 EC (3.88%) and sarpagandha leaves extract (5.00%). Amongst both plant extracts alone the sarpagandha leaves extract (10%), had lower PDI (31.11) and more fruit yield (2608.50 kg/ha). The maximum percent disease control (78.30 %) and percent increase in fruit yield (111.64) was in treatment malathion 50 EC (2 ml/litre) + sarpagandha leaves extract (10%) followed by treatment malathion 50 EC (2 ml/litre) + faba bean seed extract (10%). The spray of malathion 50 EC (2 ml/litre) alone was also effective in lowering the PDI and in increasing fruit yield as compared to control. Mali and Kachhawa (2014) found that foliar spraying malathion 50 EC resulted in an 18.6% PDI. Borah and Nath (1995) observed that plots treated with dimethoate (0.03 percent) had a 9.4% incidence of OYVMV disease at 15 days after germination (DAG), followed by malathion (0.05 percent) at 25 and 30 DAG, which was significantly lower than control plots (20.3 percent).

Table 1: **Effect of agro-insecticide and plant extracts on OYVMV PDI and fruit yield of okra**

Tr. No.	Treatments	Per cent disease index at different time periods (DAS)						Per cent disease control	Fruit yield (Kg/ha)	Per cent increase in fruit yield
		25	40	55	70	85	100			
T1	Malathion 50 EC @ 2ml/litre of water	3.88 (10.95)	7.22 (15.56)	10.55 (18.87)	15.55 (23.19)	20.55 (26.92)	24.44 (29.57)	65.90	3,156.10	74.25
T2	Malathion 50 EC @ 2ml/litre of water + Faba bean seed extract @ 10 %	3.33 (9.92)	6.66 (14.88)	8.89 (17.32)	13.88 (21.82)	18.89 (25.74)	22.22 (28.10)	69.00	3,307.80	82.63
T3	Malathion 50 EC @ 2ml/litre of water + Sarpagandha leaves extract @10%	0.55 (2.47)	3.33 (10.28)	5.55 (13.47)	8.88 (17.32)	12.22 (20.32)	15.55 (23.19)	78.30	3,833.20	111.64
T4	Faba bean seed extract @ 10 %	9.98 (18.39)	14.99 (22.71)	20.00 (26.50)	26.66 (31.05)	32.22 (34.56)	38.33 (38.23)	46.52	2,260.70	24.82
T5	Sarpagandha leaves extract @10%	5.00 (12.60)	11.66 (19.93)	15.00 (22.69)	20.55 (26.92)	26.66 (31.05)	31.11 (33.86)	56.59	2,608.50	44.02
T6	Untreated check	17.28 (24.50)	25.00 (29.98)	31.11 (33.88)	36.66 (37.24)	51.07 (45.60)	71.68 (57.84)	-	1,811.15	-
CD(p=0.05)		(5.61)	(3.68)	(3.73)	(3.05)	(3.66)	(3.87)		288.79	
SE(m)±		(2.07)	(1.15)	(1.17)	(0.96)	(1.15)	(1.21)		90.48	

Effect of resistance inducers on OYVMV PDI and fruit yield

The effect of resistance inducers, i.e., salicylic acid at different doses and bioagent *Trichoderma viride* were evaluated against OYVMV disease. Salicylic acid which is natural messenger has been used to control tobacco mosaic virus (TMV) (Murphy and Carr, 2002). The PDI and yield results are presented in Table 2. The results revealed that all the treatments had a significant effect in reducing OYVMV PDI and increased the yield as compared to control. Amongst different treatments, salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water recorded significantly less terminal PDI (28.89%) as compared to other treatments and untreated check plot (73.33%). Similar findings were also reported by Nabila (1999) in squash plants (*Cucurbita pepo*) that gained resistance against CMV infection after seed treatment with oxalic acid, salicylic acid or hot water. At 10 mM, salicylic acid and oxalic acid-induced resistance by reducing infective virus particles by 83.3 percent and 37.5 percent, respectively. At 25 DAS minimum percent disease index (1.11%) was observed in treatment salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water which was significantly lower than other treatments, followed by salicylic acid @ 100 mg/litre as seed priming and spray @ 100 mg/litre water and *Trichoderma viride* @ 5g / litre as seed priming and spray @ 5g/litre water which was statistically at par. At 40 DAS statistically at par PDI was recorded for treatment salicylic acid @ 100 mg/litre as seed priming and spray @ 100 mg/litre water and salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water. Among the treatments salicylic acid @ 50 mg/litre as seed priming and spray @ 50 mg/litre water recorded the highest (48.88%) PDI at 100 DAS. Karthikeyan *et al.* (2009) observed that pre-inoculation spraying of black gram plants with resistance-inducing chemicals, namely salicylic acid and benzothiadiazole at 100 ppm concentration was found effective in reducing urdbean leaf crinkle virus ULCV infection.

The fruit yield was also recorded highest in treatment with salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water (2807.09 kg/ha) as compared to control (1723.66 kg/ha) and all other treatments. This was followed by treatment with salicylic acid @ 100 mg/litre as seed priming and spray @ 100 mg/litre water registering yield of 2479.34 kg/ha.

The treatment with bio agent *Trichoderma viride* @ 5g / litre as seed priming and spray @ 5g/ litre water also enhanced fruit yield significantly as compared to control. Earlier, Kolase and Sawant (2007) found that culture filtrate of individual *Trichoderma harzianum*, *T. viride* and *T. longisporum* as well as the combination of culture filtrate of *T. harzianum* and *T. viride* induced systemic resistance on tomato plants and reduced the Tobacco mosaic virus (TMV) symptoms and also TMV local lesions produced on *Nicotiana glutinosa*. The maximum percent disease control (60.60%) and percent increase in fruit yield (62.85) was in salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water followed by treatment by salicylic acid @ 100 mg/litre as seed priming and spray @ 100 mg/litre water.

Table 2: Effect of resistance inducers on OYVMV disease severity of okra and fruit yield

Tr. No.	Treatments	Per cent disease index at different time periods (DAS)						Per cent disease control	Fruit yield (Kg/ha)	Per cent increase in fruit yield
		25	40	55	70	85	100			
T1	Salicylic acid @ 50 mg/litre as seed priming* and spray @ 50 mg/litre water	8.88 (17.23)	16.11 (23.63)	21.66 (27.72)	29.44 (32.84)	36.67 (37.24)	48.88 (44.34)	33.34	1,983.10	15.05
T2	Salicylic acid @ 100 mg/litre as seed priming and spray @ 100 mg/litre water	5.00 (12.79)	9.44 (17.83)	16.11 (23.63)	20.55 (26.95)	29.44 (32.82)	38.33 (38.23)	47.73	2,479.34	43.84
T3	Salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water	1.11 (3.5)	6.11 (14.08)	10.55 (18.89)	16.11 (23.63)	22.22 (28.11)	28.89 (32.50)	60.60	2,807.09	62.85
T4	*Trichoderma viride* @ 5g / litre as seed priming and spray @ 5g/litre water	4.44 (11.99)	11.11 (19.38)	15.00 (22.78)	22.77 (28.49)	30.00 (33.18)	46.66 (43.07)	36.37	2,371.95	37.61
T5	Check (Seed dipping in water & Water Spray)	14.44 (22.32)	21.66 (27.72)	31.11 (33.87)	44.44 (41.78)	55.55 (48.17)	73.33 (58.90)	-	1,723.66	-
CD(p=0.05)		(4.81)	(4.19)	(2.46)	(2.51)	(2.57)	(3.13)		173.09	
SE(m)±		(1.45)	(1.27)	(0.74)	(0.76)	(0.78)	(0.94)		52.27	

CONCLUSION

The treatment malathion 50EC in combination with sarpagandha leaves extract were found to be most effective in controlling OYVMV disease and enhancing fruit yield followed by the treatment malathion 50EC in combination with faba bean seed extract. The non-convention resistance inducers and bioagents also affect in reducing OYVMV disease. Amongst different treatments, salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre water had recorded significantly less terminal PDI as compared to untreated check plot and other treatments. The fruit yield was also recorded highest in treatment with salicylic acid @ 150 mg/litre as seed priming and spray @ 150 mg/litre.

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