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Screening for Yellow Vein Mosaic Virus Resistance and Yield Loss of Okra under Field Conditions in Southern Thailand

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1 SUMMMARY

Fifteen okra varieties (Lucky file 473, KN – OYV – 01, **KN – OYV –** 02, **KN – OYV – 03**, **KN – OYV – 04**, **KN – OYV –** 11, **KN – OYV – 13, KN – OYV –** 14, **KN – OYV – 16, KN – OYV –** 25, **NO** 71, **OP (control accession)**, **PC 52S5, PJ. 03 and TVRC 064) were cultivated in a field trial area of the Department of Agricultural Technology Faculty of Technology and Community Development Thaksin University during June to October 2009 and 2010 to determine their responses to okra yellow vein mosaic virus (OYVMV) and to evaluate of marketable fruit. The results showed that KN – OYV – 03 was moderately resistant, while KN – OYV – 25, PC 52S5, KN – OYV – 01, KN – OYV –13, KN – OYV – 02, KN – OYV – 11, NO 71, KN – OYV – 04 and KN – OYV – 16 were tolerant against OYVMV. TVRC 064 and KN – OYV – 14 were moderate susceptible, Luck file 473 and PJ. 03 varieties were susceptible while OP was highly susceptible to OYVMV. The highest marketable fruit were recorded on Lucky file 473 at 19.78 and 19.76 T ha^{-1} in 2009 and 2010, respectively. Whereas, OP produced the lowest yield (8.96 and 8.54 T ha^{-1}).**

2 INTRODUCTION

Okra (*Abelmoschus esculentas* L. Moench) belongs to the Malvaceae family. It was believed to originate in tropical Africa (Purseglove, 1984; Saifullah and Rabbani, 2009; Akanbi *et al*., 2010). Okra is an important vegetable crop in the tropical and subtropical region of the world (Akinyele and Osekita, 2006; Alam and Hossain, 2008; Kumar *et al*., 2010; Wammanda *et al.,* 2010). Okra has been used for several purposes (Qhureshi, 2007). Its tender fruits are used as boiled vegetable into fried slices for cooking (Lamont, 1999). Its stem is used for paper making in paper mills. The flowers are also edible. Okra dried seeds, nutritious matter that can be used to prepare vegetable curds, or roasted and ground to be used as coffee additive or substitute (Moekchantuk and Kumar, 2004). Okra leaves are considered good cattle feed, but this is seldom compatible with the primary use of the plant. Okra green fruits are also good source of carbohydrate, protein, fats, vitamins and minerals (Haytowitz and Matthews, 1984; Baloch *et al*., 1990; Lamont, 1999; Ali *et al*., 2005a; Arapitsas, 2008; Fajinmi and Fajinmi, 2010). Moreover, okra mucilage is suitable for medicinal and industrial applications (Akinyele and Temikotan, 2007). It has been used as a medicine to replace a plasma and to expand blood volume (Lengsfeld *et al*., 2004). Industrially, okra mucilage is usually used in to glace certain papers and also useful in confectionery among other uses (Savello *et al.,* 1980; Adetuyi *et al*., 2008). The 2004, Thailand exported okra fresh edible pods to

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Japan, Germany, UK, Netherlands, Iran and other countries with an amount greater than 0.79 million US Dollars (Benjawan *et al.,* 2007). Okra planting areas in Thailand have annually increased, particularly in the central, southern and northeastern regions. However, growers in all regions of the country have come across with many problems. A number of viruses, fungi, bacteria, phytoplasma, nematodes and insect pests attack this crop (Ali *et al*., 2000; Petlamul *et al.,* 2009; Prakasha *et al*., 2010). Yield loss of vegetable due to crop pests has been estimated up to 20-30%, and may increase up to 80-90% in case of a severe infestation (Ali *et al.,* 2005b). Okra Yellow Vein Mosaic Virus (OYVMV) transmitted by white fly (*Bemisia tabaci* Gen.) is the most serious disease of okra (Ali *et al*., 2000; Ghanem, 2003; Fajinmi and Fajinmi, 2010). Infection of 100% plants in a field is very usual and yield loss ranges between 50 and 94% depending on the stage of crop growth at which infection occurs (Sastry and Singh, 1974). If plants are infected within 20 days after germination, their growth is retarded; few leaves and fruits are formed and loss may be reach up to 94% (Sastry and Singh, 1974). The extent of damage declines with delay in infection of the pathogens. Plants infected 50 and 65 days after germination suffer a loss of 84 and 49%, respectively (Sastry and Singh, 1974; Ali *et al*., 2005b). The objectives of this study were to evaluate a resistance to OYVMV and a yield loss due to its infection in okra under field conditions. The outcome of the study could be used as a guidance for okra production in Thailand in the future.

3 METHODOLOGY

3.1 Plant material: Fifteen varieties of okra (Lucky file 473, KN-OYV-01, KN-OYV-02, KN-OYV-03, KN -OYV-04, KN-OYV-11, KN-OYV-13, KN-OYV-14, KN-OYV-16, KN-OYV-25, NO 71, OP (control accession), PC 52S5, PJ. 03 and TVRC 064) were collected from research centers in Thailand and other countries (Table 1).

3.2 Planting, experimental design and cultural practices : All varieties of okra were planted under the field conditions at the Department of Agricultural Technology Faculty of Technology and Community Development, Thaksin University, Phatthalung Province, Thailand (Latitude: 7° 34' 50" N, Longitude: 100° 9' 58" E). Okras were planted in a growing season during June to October of two separate years in 2009 and 2010. Before planting, soil was prepared by ploughing thoroughly, and left it at rest for a week. Afterwards, a vegetable plot size 2 x 5 m (10 m^2) was done, dividing into two rows with a pairs of hole. Each variety was replicated four times. Spacing range between plants and rows were maintained at 75 cm and 75 cm, respectively. A Randomized Complete Block Design (RCBD) was performed. Okra seeds were put into 12 shallow holes (3 seeds/hole) of each plot. Seven days after planting, seedlings were tilled remaining one seedling/hole. Two times of fertilization were done throughout a planting season. The first time, an organic based fertilizers (manure) was added in the bottom of the holes (12,500 T·ha^{-1}) after the soil had been prepared. The second time, the full rate of NPK 15-15-15 (chemical fertilizer) at 0.65 T ha^{-1}, was put around the holes was applied about 28 days after planting. The conventional agronomic practices were followed to keep the crop in good condition.

3.3 Data sampling : Eight weeks (56 days) after planting we counted the number of okra yellow vein mosaic virus present on 10 randomly chosen plants per plot. Counting was done early in the morning between 7 and 10 am. The disease on each test entry was assessed in according to Prakasha *et al.* (2010), following self made disease rating scale by Ali *et al.* (2005a, b) (Table 2). Fresh fruits were harvested from 8 plants in the plot at weekly intervals over one month period and were sorted out into marketable and unmarketable fruits per hectare. In addition, color of flower, stem and pod as well as shape of leaf were recorded.

3.4 Statistical analysis : Data collected was subjected to the analysis of variance using the mixed model procedure. Mean separation were done where there is significant differences using Duncan

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Multiple Range Test. Significance was accepted at $P \leq 0.01$.

Table 1: Sources of okra plant varieties

Serial No.	Varieties	Sources	Original sources
1	KN – OYV – 01	Phichit Horticulture Research Center	India
2	KN – OYV – 02	Phichit Horticulture Research Center	India
3	KN – OYV – 03	Phichit Horticulture Research Center	India
4	KN – OYV – 04	Phichit Horticulture Research Center	India
5	KN – OYV – 11	Phichit Horticulture Research Center	India
6	KN – OYV – 13	Phichit Horticulture Research Center	India
7	KN – OYV – 14	Phichit Horticulture Research Center	India
8	KN – OYV – 16	Phichit Horticulture Research Center	India
9	KN – OYV – 25	Phichit Horticulture Research Center	India
10	Lucky file 473	Bangkok Province	Japan
11	NO 71	Phichit Horticulture Research Center	India
12	OP (control variety)	Phatthalung Province	Thailand
13	PC 52S5	Phichit Horticulture Research Center	Thailand
14	PJ. 03	Phichit Horticulture Research Center	Thailand
15	TVRC 064	Bangkok Province	Thailand

Table 2: Disease rating scale of OYVMV.

Rating Scale		Severity Range (%)
0	Immune	0 %
1	Highly resistant	1-10 %
2	Moderate resistant	11-25 %
3	Tolerant	26-50 %
4	Moderate susceptibility	51-60 %
5	Susceptibility	61-70 %
6	High susceptibility	71-100 %

Source: Ali *et al.* (2005a, b)

4 RESULTS AND DISCUSSION

Morphological characteristics in term of color of flower, stem, pod and leaf shape of different variety okra were recorded and shown in Table 3. There were no difference in flower color and shape of leaf among okra varieties. Varieties were grouped into 3 on the basis of their of stem and pod. There were light green, dark green and reddish green**.** The flower color and leaf shape observed from our studies (Table 3) were similar to the results reported by Alam and Hossain (2008). The leaves' arrangement was alternative. There was a single leaf in one section. Lines on the leaves were palmate.

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The tip of the leave was acute and its' rim was serrate (Lamont, 1999; Rashwan, 2011). Almost varieties (13 of 15 varieties) were grouped into light and dark green, whereas the rest 2 varieties were categorized into reddish green (Table 3). The response of fifteen okra varieties against OYVMV was observed under field conditions. The resistant levels found only 22.58 and 24.24% OYVMV infection was found on KN – OYV – 03 in 2009 were similar to those found in 2010.

Table 3: Morphological characteristics of various varieties of okra plants

Varieties	Flower color	Stem color	Pod color	Leaf shape
KN – OYV – 01	Light yellow	Light green	Light green	Palmate
KN – OYV – 02	Light yellow	Reddish green	Reddish green	Palmate
KN – OYV – 03	Light yellow	Dark green	Dark green	Palmate
KN – OYV – 04	Light yellow	Light green	Light green	Palmate
KN – OYV – 11	Light yellow	Dark green	Dark green	Palmate
KN – OYV – 13	Light yellow	Dark green	Dark green	Palmate
KN – OYV – 14	Light yellow	Dark green	Dark green	Palmate
KN – OYV – 16	Light yellow	Dark green	Dark green	Palmate
KN – OYV – 25	Light yellow	Dark green	Dark green	Palmate
Luck file 473	Light yellow	Reddish green	Reddish green	Palmate
NO 71	Light yellow	Dark green	Dark green	Palmate
OP (control variety)	Light yellow	Light green	Light green	Palmate
PC 52S5	Light yellow	Light green	Light green	Palmate
PJ. 03	Light yellow	Light green	Light green	Palmate
TVRC 064	Light yellow	Dark green	Dark green	Palmate

However, mean percentages of disease rating were higher in 2010 than in 2009 (Table 4). Based on disease rating scale of OYVMV shown in Table 2, there was no resistant variety found in this study. Most okra varieties (9 of 15 varieties) were categorized into tolerant level, only one variety (KN – OYV – 03) was moderately resistant. Two varieties were classified to each of moderate and slight susceptibility, whereas the OP was highly susceptible. KN – OYV – 03 potential of resistance against OYVMV, only 22.58 and 24.24% plant infection was found on this varieties between 2009 and 2010, respectively. KN – OYV – 25, PC 52S5, KN – OYV – 01, KN – OYV –02, KN – OYV – 13, KN – OYV – 04, KN – OYV – 11, NO 71 and KN – OYV – 16 showed 32.26, 35.48, 36.36, 38.71, 38.71, 40.63, 40.63, 40.63 and 41.94% OYVMV infection, respectively and were graded as tolerant (Table 4). TVRC 064 and KN – OYV – 14 were moderate susceptibility, Luck file 473 and PJ. 03 were slight susceptibility, and OP was highly susceptibility to OYVMV in the first seasons (2009). The results of the second season (2010) showed that were similar data level of resistance. Chaudhury *et al.* (1992) has reported the incidence of yellow vein mosaic virus in okra. In case of hybrids disease incidence ranged between 19.26 and 69.13% whereas, on parent plants, it ranged from 19.95 to 51.16%. Batra and Singh (2000) screened eight okra varieties against OYVMV, Okra No.6, LORM-1, VRO-3 and P-7 were found free from disease whereas VRO-4 showed mild reaction. Ali *et al.* (2005b) reported Safal, Subz Pari and Surkh Bhindi varieties against OYVMV in a field trial (3.36-24.40%). Moreover, OYVMV resistance among different okra cultivars has also been

reported by other researchers such as Arora *et al.* (1992) 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 OYVMV. Sharma *et al.* (1993) reported that Punjab, Padmini and Punjab-7 varieties of okra were found high yielding and resistant to OYVMV.

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Table 4: Response to OYVMV under natural conditions between 2009 and 2010.

Varieties	2009			2010		
	No. of infected plants/test pants	**Mean of disease rating (%)**	**Level of resistance**	**No. of infected plants/test plants**	**Mean of disease rating (%)**	**Level of resistance.**
KN – OYV – 01	12/33	36.36	Tolerant	13/32	40.63	Tolerant
KN – OYV – 02	12/31	38.71	Tolerant	14/34	41.18	Tolerant
KN – OYV – 03	7/31	22.58	moderately resistant	8/33	24.24	moderately resistant
KN – OYV – 04	13/32	40.63	Tolerant	16/36	44.44	Tolerant
KN – OYV – 11	13/32	40.63	Tolerant	14/32	43.75	Tolerant
KN – OYV – 13	12/31	38.71	Tolerant	13/32	40.63	Tolerant
KN – OYV – 14	17/32	53.13	Moderately susceptibility	20/34	58.82	Moderately susceptibility
KN – OYV – 16	13/31	41.94	Tolerant	13/28	46.43	Tolerant
KN – OYV – 25	10/31	32.26	Tolerant	11/31	35.48	Tolerant
Luck file 473	20/32	62.50	Susceptibility	28/34	67.65	Susceptibility
NO 71	13/32	40.63	Tolerant	14/32	43.75	Tolerant
OP(control variety)	30/30	100.00	highly susceptibility	26/26	100.00	highly susceptibility
PC 52S5	11/31	35.48	Tolerant	12/33	36.36	Tolerant
PJ. 03	21/32	65.63	Susceptibility	20/29	68.97	Susceptibility
TVRC 064	16/31	51.61	Moderately susceptibility	17/32	53.13	Moderately susceptibility

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As the data regarding green pod yield tons per hectare was derived from green pod yields per plant and number of plants in a hectare, therefore, the data per hectare presented the same picture. The difference in pod yield among different variety was found significantly in two seasons. The highest marketable pod yields per hectare in 2009 and 2010 were recorded in Lucky file 473 (19.78 and 19.76 T ha^{-1}), followed by KN – OYV – 25, KN – OYV – 01, KN – OYV – 02, KN – OYV – 14, TVRC 064, KN – OYV – 11, KN – OYV – 13, PJ. 03, KN – OYV – 03, KN – OYV – 16, KN – OYV – 04, PC 52S5 and NO 71 which were recorded to be 19.10, 18.39, 17.90, 17.48, 17.37, 16.33, 15.30, 14.01, 13.85, 13.34, 13.32, 12.54 and 10.80 $T{\cdot}ha^{-1}$, respectively. The lowest marketable yield per hectare was recorded in control variety (OP) at 8.96 $T{\cdot}ha^{-1}$ (first season) and 8.54 $T{\cdot}ha^{-1}$ (second season) (Table 5). Variation in yield among different okra cultivars has also been reported by other workers (Baloch *et al*., 1990; Amjad *et al*., 2001; Halim *et al*., 2009; Saifullah and Rabbani, 2009). When considering the results of an initial experiment concluded that KN – OYV – 03, KN – OYV – 25, PC 52S5, KN – OYV – 01, KN – OYV –02, KN – OYV – 13, KN – OYV – 04, KN – OYV – 11, NO 71 and KN – OYV – 16 varieties were quite suitable for improving to good okra varieties, because their average yielding higher were than an average of all over the world 6.6 $T{\cdot}ha^{-1}$ (Varmudy, 2011). Besides, they were also highly virus tolerant to OYVMV.

Table 5: Marketable and unmarketable of 15 okra varieties

Varieties	Pod yield in 2009 (T ha^{-1})		Pod yield in 2010 (T ha^{-1})	
	Marketable	Unmarketable	Marketable	Unmarketable
KN – OYV – 01	18.39B*	3.37B	18.14AB	3.39C
KN – OYV – 02	17.90B	2.97C	17.55ABC	3.18D
KN – OYV – 03	13.85C	3.21BC	13.23DEF	3.34C
KN – OYV – 04	13.32CD	3.27BC	12.91EF	3.42C
KN – OYV – 11	16.33BC	2.88C	16.31BCD	3.02D
KN – OYV – 13	15.30BC	3.42B	15.09BCDE	3.74B
KN – OYV – 14	17.48B	2.78C	17.17ABCD	3.12D
KN – OYV – 16	13.34C	3.51B	13.22DEF	3.62B
KN – OYV – 25	19.10AB	3.25BC	18.98AB	3.39C
Lucky file 473	19.78A	2.91C	19.76A	3.23CD
NO 71	10.80D	3.33B	10.46FG	3.56B
OP (control variety)	8.96E	5.56A	8.54G	5.37A
PC 52S5	12.54CD	2.71D	12.20FG	2.94D
PJ. 03	14.01BC	3.27BC	13.98CDE	3.58B
TVRC 064	17.37B	2.71D	17.16BCD	2.93D

*Mean within the same column followed by different characters showed significantly different between treatments Duncan's New Multiple's Range Test (DMRT) at $p \leq 0.01$

The influence of temperature and the level of relative humidity and raining on the experimental period from June to October in 2009 and 2010, it was found that in 2009 the highest average temperature in June was at 28.79°C, whereas the highest humidity in October was 77.00%. The 2010, the temperature level, relative humidity and raining were higher than in 2009 season every month (except raining in October 2009). The temperature levels were recorded between 28.40

and 29.40 °C and the humidity was obtained between 77 and 80% (Table 6).

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Table 6: Temperate and relative humidity between June and October in 2009 and 2010.

Months (2009)	Temperature/Month (°C)			Relative Humidity (RH)/Month (%)			Rain (mm.) /Month
	Maximum	Minimum	Averages	Maximum	Minimum	Averages	
June	29.78	26.86	28.79	85.00	71.00	75.00	31.60
July	29.92	26.91	28.05	89.00	69.00	76.00	80.50
August	29.36	26.51	28.30	86.00	67.00	75.00	70.00
September	29.49	26.66	28.05	84.00	70.00	76.00	45.40
October	30.20	25.05	27.58	97.00	65.00	77.00	732.40
Months (2010)	**Temperature/Month (°C)**			**Relative Humidity (RH)/Month (%)**			**Rain(mm.) /Month**
	Maximum	**Minimum**	**Averages**	**Maximum**	**Minimum**	**Averages**	
June	33.80	25.00	29.40	93.00	61.00	77.00	49.70
July	33.20	24.30	28.80	94.00	62.00	78.00	118.50
August	33.20	24.40	28.80	95.00	62.00	78.00	101.50
September	33.10	24.40	28.40	95.00	64.00	79.00	87.40
October	32.20	24.40	28.40	94.00	66.00	80.00	255.20

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5 CONCLUSION

In conclusion the easiest and cheapest method of reducing yellow vein mosaic disease of okra is the cultivation of resistant varieties KN – OYV – 03. Moreover, KN – OYV – 25, PC 52S5, KN – OYV – 01, KN – OYV –13, KN – OYV – 02, KN – OYV – 11, No71, KN – OYV – 04 and KN – OYV – 16 were also used because of their tolerance against OYVMV. However, researchers should test okra field trial against OYVMV in other seasons and locations should be done to assure that the seed of suitable varieties are distributed to farmers.

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