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Harshal P Patel
Department of Plant Pathology,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

Lalit Mahatma
Department of Plant Pathology,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

Status of *Mungbean yellow mosaic virus* (MYMV) on Mungbean [*Vigna radiata* (L.) Wilczek] in different districts of South Gujarat

Harshal P Patel and Lalit Mahatma

Abstract

To know the status of the *Mungbean yellow mosaic virus*, during the summer 2019 a roving field survey was conducted in different districts of South Gujarat and a fixed plot survey was conducted at the Farm of Pulses and Castor Research Station, Navsari Agricultural University, Navsari. The results of the roving field survey revealed that the percent disease incidence ranges from 0.00 to 99.60. The highest average percent disease incidence of 14.48 percent was recorded in Valsad district, followed by Dangs, Tapi, Surat and Navsari districts with 10.49, 8.38, 6.43 and 1.63 percent, respectively. The recently released varieties of mungbean, GM-6 and GM-7, were found to be resistant in all of the surveyed villages. Among the surveyed villages, Hathuka of Tapi district and Chival of Valsad district had maximum PDiC of 99.60 and 96.0 percent, respectively. The results of the fixed plot survey revealed that the *Mungbean yellow mosaic virus* starts with the emergence of the first trifoliate leaf and constantly increases until it covers the entire field. The percent disease incidence of the fixed plot survey range was from 0.0 to 94.00 percent.

Keywords: *Mungbean yellow mosaic virus*, yellow mosaic disease, roving field survey, fixed plot survey, percent disease incidence

Introduction

The mungbean [*Vigna radiata* (L.) Wilczek] is an important crop in the Fabaceae family from a commercial perspective. Some of its other names are moong, green gram, golden gram, Chickasaw pea, Oregon pea, and chop suey legume. Mungbean is essential to a healthy diet for people because of its high protein, mineral, and vitamin content. Compared to other forms of legumes, mungbean protein is easier to digest. The mungbean is a drought-tolerant, low-input crop with a shortened growing season that excels at conserving moisture. In diverse agroecological zones, it can be cultivated successfully in all three seasons (*Kharif*, *Rabi*, and summer).

Major mungbean-producing states in India include Rajasthan, Maharashtra, Madhya Pradesh, Karnataka, Odisha, Bihar, Tamil Nadu, Gujarat, and Andhra Pradesh. Gujarat produced 1,10,135 metric tonnes of mungbean in 2020–21 over an area of 1,54,692 ha, with a productivity of 711.96 kg/ha. Mungbean is grown in South Gujarat's Surat, Navsari, Bharuch, Tapi, Narmada, Dangs, and Valsad districts.

Viral, fungal, bacterial, and nematode infections drastically reduce mungbean productivity. Mungbean yellow mosaic disease (MYMD), which affects yield both qualitatively and quantitatively, is one of the most serious diseases caused by the *Mungbean yellow mosaic virus* (MYMV). MYMV principally transmitted by its insect vector whitefly, *Bemisia tabaci* (Gennadius, 1889) [6] (Hemiptera: Aleyrodidae). MYMV can be transmitted by grafting but it is not transmitted by seed, soil or sap (Nariani, 1960; Nair, 1971; Nene, 1972) [16, 15, 18]. MYMV belongs to the *begomovirus* genus. In the mungbean field of the Indian Agricultural Research Institute (IARI), New Delhi, MYMV was found in the 1950s (Nariani, 1960) [16]. The visible signs are scattered yellow-colored spots on the young leaves, which eventually transform into a yellow mosaic pattern, resulting in full yellowing, drying and withering of the leaves. The pods on the infected mungbean plant shrink in size and the yellowing of the leaves reduces photosynthetic efficiency, resulting in a substantial yield penalty (Malathi and John, 2009) [11].

Corresponding Author:
Harshal P Patel
Department of Plant Pathology,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari, Gujarat, India

For fitness and reproduction, the whitefly prefers temperatures between 28 °C and 33 °C (Jones, 2016) [8]. This crop is grown in south Gujarat during the three different seasons: *Kharif*, *Rabi* and summer. The whitefly prefers the summer growing season, especially during the early (sowing time) and mid-stages (flowering time), when the temperature is constant at 20–35 °C. South Gujarat thus turns into a significant yellow mosaic disease hotspot zone. Another factor is that the local weed and crop hosts contains viable amounts of the initial source of inoculum. Therefore, the present investigation was planned to find out the status of MYMD on mungbean in the South Gujarat area.

Materials and Methods

Roving field survey

The status of the disease was determined using stratified sampling. Five districts of South Gujarat *viz.*, Navsari, Tapi, Surat, Valsad and Dangs were surveyed during summer 2019. From different Talukas, two villages were selected and from those villages, five fields were selected randomly. The disease was tentatively identified and the virus's symptoms were used to determine the percent disease incidence.

Disease is measured by the researchers through visual observations, either by calculating Plant Disease Incidence (PDIc) or Plant Disease Index (PDIx) based on the type of disease and crop. The abbreviation PDI was interchangeably used for both, Plant Disease Incidence (PDIc) and Plant Disease Index (PDIx); therefore, sometimes it may be confusing. In this study, we have used PDIc to prevent confusion and enable greater clarity (Patel and Mahatma, 2022) [20].

To assess PDIc, each field was observed from all four corners and centers. Around 50 plants were counted on each side. The observation was taken at multiple stages randomly, *viz.*, first

trifoliate, second trifoliate leaf, flowering and maturity. The following formula was used to calculate PDIc (Wheeler, 1969) [33]:

$$\text{PDIc (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of observed plants}} \times 100$$

Fixed plot survey

A fixed plot survey was conducted at the Farm of PCRS, NAU, Navsari during summer 2019 to know the prevalence of MYMV. Before the crop was planted, the entire station was surveyed. Information regarding the field's history and neighboring crops was gathered. The observations were made at four stages of the mungbean crops *viz.*, first trifoliate, second trifoliate leaf, flowering and maturity and accordingly PDIc was calculated.

Results and Discussion

Roving field survey

Total of 25 talukas, 49 villages and 192 fields were surveyed during the summer 2019. 192 fields comprising 71, 57, 25, 21 and 18 fields in Surat, Navsari, Tapi Valsad and Dangs respectively (Table 1). The PDIc ranged from 0.0 to 99.60 percent. A multistage schematic diagram was prepared according to the PDIc (Figure 1). The survey's findings show that MYMV incidence was present in all of the villages except Padgha of Navsari taluka, Navsari district and Charni of Umarpada taluka, Surat district and that there was a significant difference in PDIc depending on the cultivated variety. The highest average PDIc 14.48 percent was recorded in Valsad district, followed by Dangs, Tapi, Surat and Navsari districts with 10.49, 8.38, 6.43 and 1.63 percent, respectively (Figure 2).

Table 1: MYMV incidence in different districts of South Gujarat during summer 2019

Tapi district							
Taluka	Village/Location	Fields	Area (ha)	Variety	Stage of the crop	PDIc (%)	
		2	2.00	GM-7	Maturity stage	10.00	
		3	2.00	GM-6	Maturity stage	10.80	
		4	1.50	GM-6	Maturity stage	8.40	
		5	1.50	GM-4	Maturity stage	99.60	
		1	1.00	GM-6	Maturity stage	8.80	
		2	1.00	GM-7	Maturity stage	9.60	
		3	1.50	GM-6	Maturity stage	8.40	
		4	0.50	Meha	Maturity stage	5.20	
	Vyara	Kelkui	1	1.50	GM-7	First trifoliate leaf	0.00
			2	1.50	GM-6	First trifoliate leaf	0.00
			3	1.00	GM-7	First trifoliate leaf	0.00
			4	0.50	Virat Gold	First trifoliate leaf	2.40
	Umarkui	1	1.00	Meha	First trifoliate leaf	0.40	
		2	1.00	Meha	First trifoliate leaf	0.00	
		3	1.50	Pusa Vishal	First trifoliate leaf	4.00	
		4	1.50	GM-6	First trifoliate leaf	0.00	
Songadh	Amaldi	1	0.50	Virat	Second trifoliate leaf	6.00	
		2	1.00	Virat	Second trifoliate leaf	6.40	
		3	1.50	Virat Gold	Second trifoliate leaf	5.20	
		4	1.50	GM-6	Second trifoliate leaf	0.80	
	Bhanpur	1	0.50	Virat	Second trifoliate leaf	6.00	
		2	0.50	Virat	Second trifoliate leaf	6.80	
		3	1.00	Meha	Second trifoliate leaf	1.20	
		4	1.50	GM-6	Second trifoliate leaf	0.40	
Average PDIc						8.38	

Navsari district						
Taluka	Village/Location	Fields	Area (ha)	Variety	Stage of the crop	PDIC (%)
Navsari	Vejalpur	1	1.20	GM-6	First trifoliate leaf	0.00
		2	1.00	Meha	First trifoliate leaf	0.00
		3	0.50	Meha	First trifoliate leaf	0.00
		4	1.00	GM-6	First trifoliate leaf	0.00
		5	1.00	GM-7	First trifoliate leaf	0.40
	Padgha	1	1.50	GM-7	First trifoliate leaf	0.00
		2	0.70	GM-7	First trifoliate leaf	0.00
		3	0.80	GM-6	First trifoliate leaf	0.00
		4	1.00	GM-6	First trifoliate leaf	0.00
		5	1.30	GM-6	First trifoliate leaf	0.00
Jalalpure	Eru	1	0.50	GM-6	Second trifoliate leaf	0.00
		2	1.00	GM-6	Second trifoliate leaf	0.80
		3	0.50	GM-6	Second trifoliate leaf	0.80
		4	1.50	GM-7	Second trifoliate leaf	1.20
		5	0.70	GM-6	Second trifoliate leaf	0.40
	AAT	1	2.00	GM-7	Second trifoliate leaf	0.00
		2	2.00	GM-6	Second trifoliate leaf	0.40
		3	1.00	GM-6	Second trifoliate leaf	0.40
		4	0.50	GM-6	Second trifoliate leaf	0.80
		5	1.00	GM-6	Second trifoliate leaf	0.40
Gandevi	Endhal	1	0.50	GM-6	First trifoliate leaf	0.40
		2	1.00	GM-6	First trifoliate leaf	0.00
		3	1.20	Meha	First trifoliate leaf	0.00
		4	1.30	GM-6	First trifoliate leaf	0.00
	Changa	1	1.00	GM-6	First trifoliate leaf	0.00
		2	2.00	GM-7	First trifoliate leaf	0.00
		3	1.50	Meha	First trifoliate leaf	0.00
		4	0.50	Virat	First trifoliate leaf	3.20
Khergam	Kakadveri	1	1.50	GM-6	Flowering stage	2.00
		2	1.00	GM-7	Flowering stage	2.40
		3	1.00	Virat	Flowering stage	9.20
		4	0.50	Pusa Vishal	Flowering stage	14.40
	Panikhadak	1	1.50	Pusa Vishal	Flowering stage	17.20
		2	1.00	GM-6	Flowering stage	2.00
		3	0.70	GM-6	Flowering stage	2.40
		4	1.30	GM-7	Flowering stage	2.80
Chikhli	Sadadvel	1	1.50	GM-6	Flowering stage	2.40
		2	1.50	GM-7	Flowering stage	2.00
		3	1.00	GM-6	Flowering stage	2.40
		4	1.00	GM-7	Flowering stage	1.20
		5	1.50	GM-7	Flowering stage	2.80
	Zari	1	1.50	GM-7	Flowering stage	2.80
		2	1.50	GM-6	Flowering stage	2.40
		3	1.00	GM-6	Flowering stage	2.00
		4	0.50	GM-7	Flowering stage	2.40
Vansada	Dholumber	1	1.00	GM-6	Second trifoliate leaf	0.80
		2	1.00	GM-6	Second trifoliate leaf	0.80
		3	0.50	Meha	Second trifoliate leaf	0.80
		4	0.50	Meha	Second trifoliate leaf	0.80
		5	1.00	Meha	Second trifoliate leaf	1.20
	Limzar	1	1.50	GM-6	Second trifoliate leaf	0.80
		2	2.00	GM-7	Second trifoliate leaf	0.80
		3	2.50	GM-7	Second trifoliate leaf	1.20
		4	2.00	GM-7	Second trifoliate leaf	0.80
		5	1.50	GM-6	Second trifoliate leaf	0.40
Average PDIC						1.63
Dang district						
Taluka	Village/Location	Fields	Area (ha)	Variety	Stage of the crop	PDIC (%)
		2	0.08	GM-6	Maturity stage	10.40
		3	0.08	GM-6	Maturity stage	10.40
		1	0.08	GM-6	Maturity stage	11.20
	UGA	2	0.08	GM-6	Maturity stage	11.20
		3	0.08	GM-6	Maturity stage	10.40

Ahwa	Jamlapada	1	0.08	GM-6	Maturity stage	8.80
		2	0.08	GM-6	Maturity stage	9.60
	Gundiya	1	0.08	GM-6	Maturity stage	9.60
		2	0.08	GM-6	Maturity stage	10.40
		3	0.08	GM-6	Maturity stage	11.20
	Subir	Vahutiya	1	0.08	GM-6	Maturity stage
2			0.08	GM-6	Maturity stage	11.20
3			0.08	GM-6	Maturity stage	10.40
4			0.08	GM-6	Maturity stage	10.40
Sajupada		1	0.08	GM-6	Maturity stage	9.60
		2	0.08	GM-6	Maturity stage	10.40
	3	0.08	GM-6	Maturity stage	11.20	
Average PDIC						10.49

Surat district						
Taluka	Village/Location	Fields	Area (ha)	Variety	Stage of the crop	PDIC (%)
		2	2.50	GM-7	Maturity stage	11.20
		3	2.50	GM-7	Maturity stage	9.20
		4	1.00	GM-6	Maturity stage	8.80
		5	2.00	GM-6	Maturity stage	8.40
	Narthan	1	1.00	Meha	Maturity stage	7.20
		2	2.00	Meha	Maturity stage	6.80
		3	2.00	GM-6	Maturity stage	9.20
		4	0.50	GM-6	Maturity stage	9.60
Bardoli	Vankaner	1	0.50	Virat	Second trifoliolate leaf	6.40
		2	0.50	Virat	Second trifoliolate leaf	6.00
		3	1.00	GM-7	Second trifoliolate leaf	0.80
		4	2.00	GM-6	Second trifoliolate leaf	0.80
		5	2.00	GM-6	Second trifoliolate leaf	0.80
	Vanesha	1	2.00	GM-7	Second trifoliolate leaf	0.80
		2	2.00	GM-6	Second trifoliolate leaf	0.40
		3	1.00	Meha	Second trifoliolate leaf	1.60
4	2.00	Virat	Second trifoliolate leaf	8.00		
Kamrej	Digas	1	2.00	GM-7	Maturity stage	9.20
		2	2.00	GM-7	Maturity stage	9.60
		3	1.00	GM-6	Maturity stage	9.60
		4	2.00	GM-6	Maturity stage	10.00
		5	1.00	GM-7	Maturity stage	10.80
	Orna	1	2.00	Meha	Maturity stage	6.40
		2	2.00	GM-6	Maturity stage	9.60
		3	1.50	Meha	Maturity stage	6.80
		4	2.00	GM-6	Maturity stage	9.20
		5	2.00	GM-6	Maturity stage	10.00
Chorasi	Bhesan	1	2.00	GM-6	Maturity stage	9.60
		2	1.00	GM-6	Maturity stage	9.20
		3	0.50	Meha	Maturity stage	6.80
		4	0.50	PUSA Vishal	Maturity stage	23.60
	Bhatha	1	1.00	Meha	Maturity stage	6.80
		2	0.50	Pusa Vishal	Maturity stage	22.80
		3	1.50	GM-6	Maturity stage	10.40
		4	1.50	GM-7	Maturity stage	11.20
Mahuva	Karcheliya	1	1.50	Pusa Vishal	Second trifoliolate leaf	9.60
		2	1.00	Pusa Vishal	Second trifoliolate leaf	10.00
		3	1.50	GM-7	Second trifoliolate leaf	0.80
		4	1.50	Virat	Second trifoliolate leaf	5.60
	Ondach	1	1.50	GM-6	Second trifoliolate leaf	0.80
		2	2.00	GM-6	Second trifoliolate leaf	0.80
		3	1.00	Virat	Second trifoliolate leaf	6.80
		4	1.00	Meha	Second trifoliolate leaf	1.20
Mandvi	Balethi	1	2.00	GM-6	Maturity stage	11.20
		2	1.50	Pusa Vishal	Maturity stage	25.60
		3	1.00	Meha	Maturity stage	6.40
	Isar	1	1.00	GM-6	Maturity stage	10.40
		2	0.50	Virat	Maturity stage	20.40
		3	1.00	Meha	Maturity stage	6.80
Mangrol	Kantvav	1	1.5	GM-6	Second trifoliolate leaf	0.80
		2	1.50	GM-6	Second trifoliolate leaf	0.80
		3	1.00	Virat	Second trifoliolate leaf	7.20
	Isanpor	1	1.00	Meha	Second trifoliolate leaf	0.80

		2	0.50	Virat	Second trifoliolate leaf	7.20
		3	1.00	GM-6	Second trifoliolate leaf	0.80
		4	2.00	Virat	Second trifoliolate leaf	7.20
Palsana	Kanav	1	1.50	GM-6	First trifoliolate leaf	0.00
		2	2.00	GM-6	First trifoliolate leaf	0.00
		3	0.50	Virat Gold	First trifoliolate leaf	2.00
		4	1.00	Virat	First trifoliolate leaf	4.00
	Vanasa	1	2.00	Virat	First trifoliolate leaf	3.60
		2	2.00	Virat Gold	First trifoliolate leaf	2.00
3		2.00	GM-6	First trifoliolate leaf	0.00	
Umarpada	Kevdi	1	2.00	GM-6	First trifoliolate leaf	0.00
		2	2.00	GM-6	First trifoliolate leaf	0.00
		3	1.50	Virat	First trifoliolate leaf	3.60
		4	0.50	Virat Gold	First trifoliolate leaf	2.80
	Charni	1	2.00	GM-6	First trifoliolate leaf	0.00
		2	1.00	GM-7	First trifoliolate leaf	0.00
		3	1.00	Meha	First trifoliolate leaf	0.00
Average PDIC						6.43

Valsad district						
Taluka	Village/Location	Fields	Area (ha)	Variety	Stage of the crop	PDIC (%)
Valsad	Bhomapardi	1	0.08	GM-6	Maturity stage	9.60
		2	0.08	GM-6	Maturity stage	10.40
		3	0.08	GM-6	Maturity stage	11.20
	Navera	1	0.08	GM-7	Maturity stage	10.40
		2	0.08	GM-7	Maturity stage	10.40
		3	0.08	GM-7	Maturity stage	11.20
Vapi	Koparli	1	0.08	GM-6	Maturity stage	11.20
		2	0.08	GM-6	Maturity stage	10.40
		3	0.08	GM-6	Maturity stage	9.60
		4	0.08	GM-6	Maturity stage	8.80
	Degam	1	0.08	GM-6	Maturity stage	9.60
		2	0.08	GM-6	Maturity stage	10.40
Pardi	Panchlai	1	0.08	GM-6	Maturity stage	10.40
		2	0.08	GM-6	Maturity stage	10.40
		3	0.08	GM-6	Maturity stage	9.60
		4	0.08	GM-6	Maturity stage	11.20
	Chival	1	0.08	GM-4	Maturity stage	96.00
		2	0.08	GM-7	Maturity stage	11.20
		3	0.08	GM-7	Maturity stage	11.20
Umargam	Manekpor	1	0.08	GM-7	Maturity stage	10.40
		2	0.08	GM-7	Maturity stage	10.40
Average PDIC						14.48

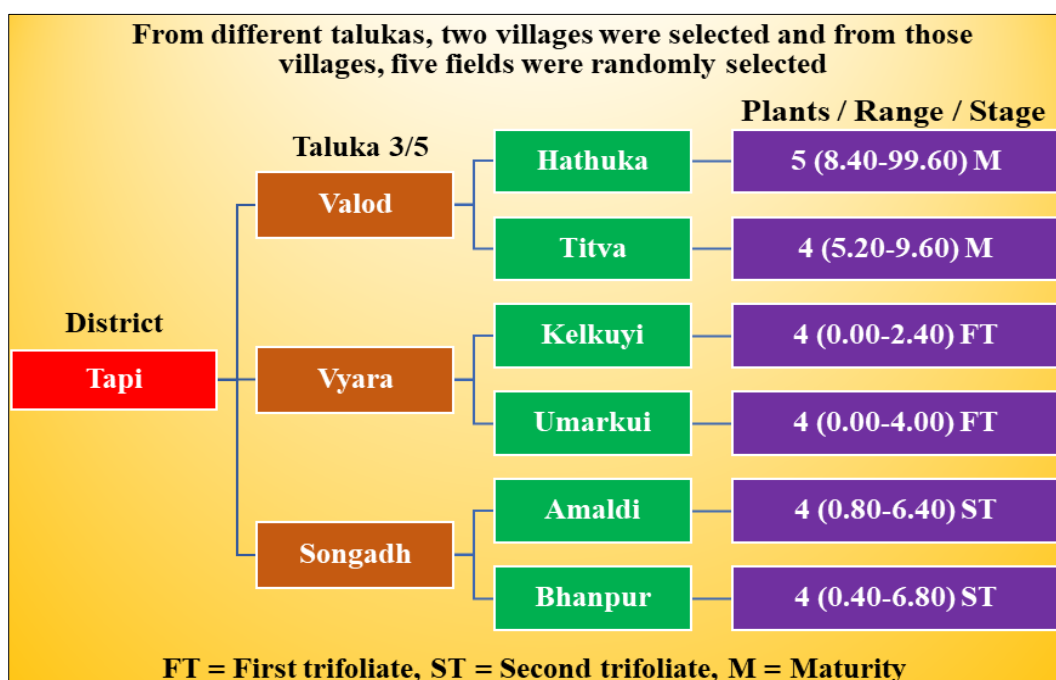


Fig 1A: Tapi district

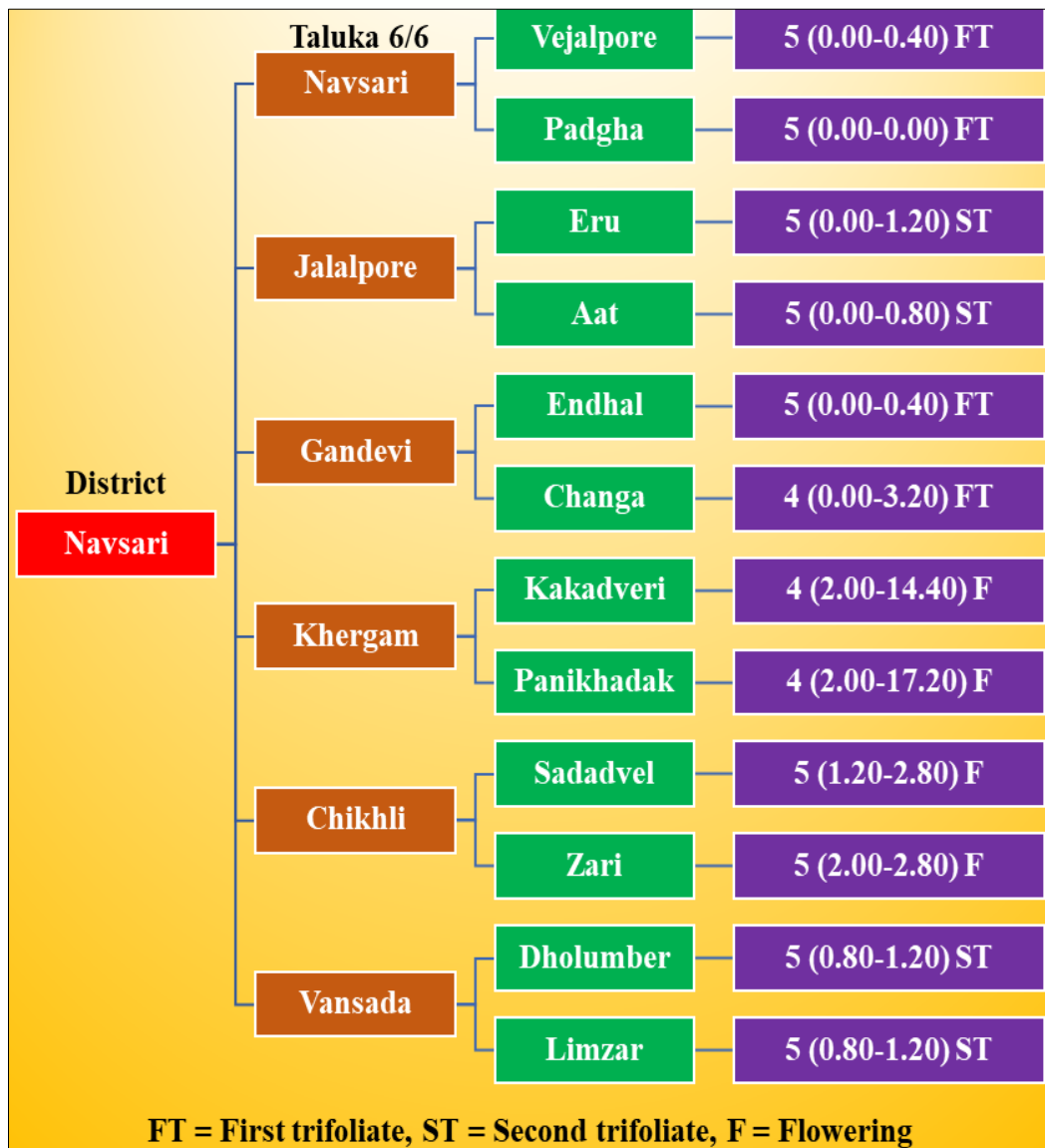


Fig 1B: Navsari district

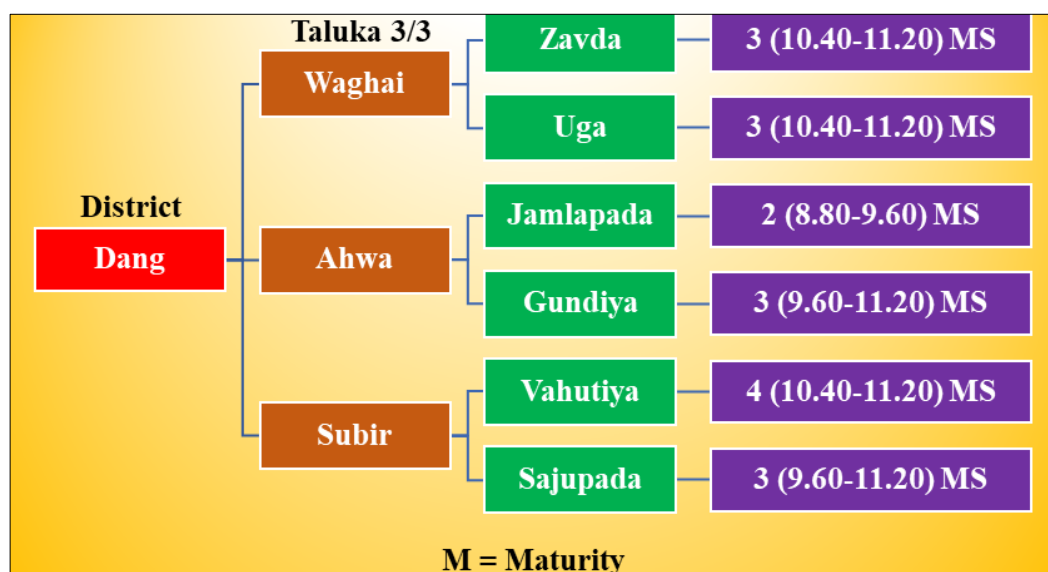


Fig 1C: Dang district

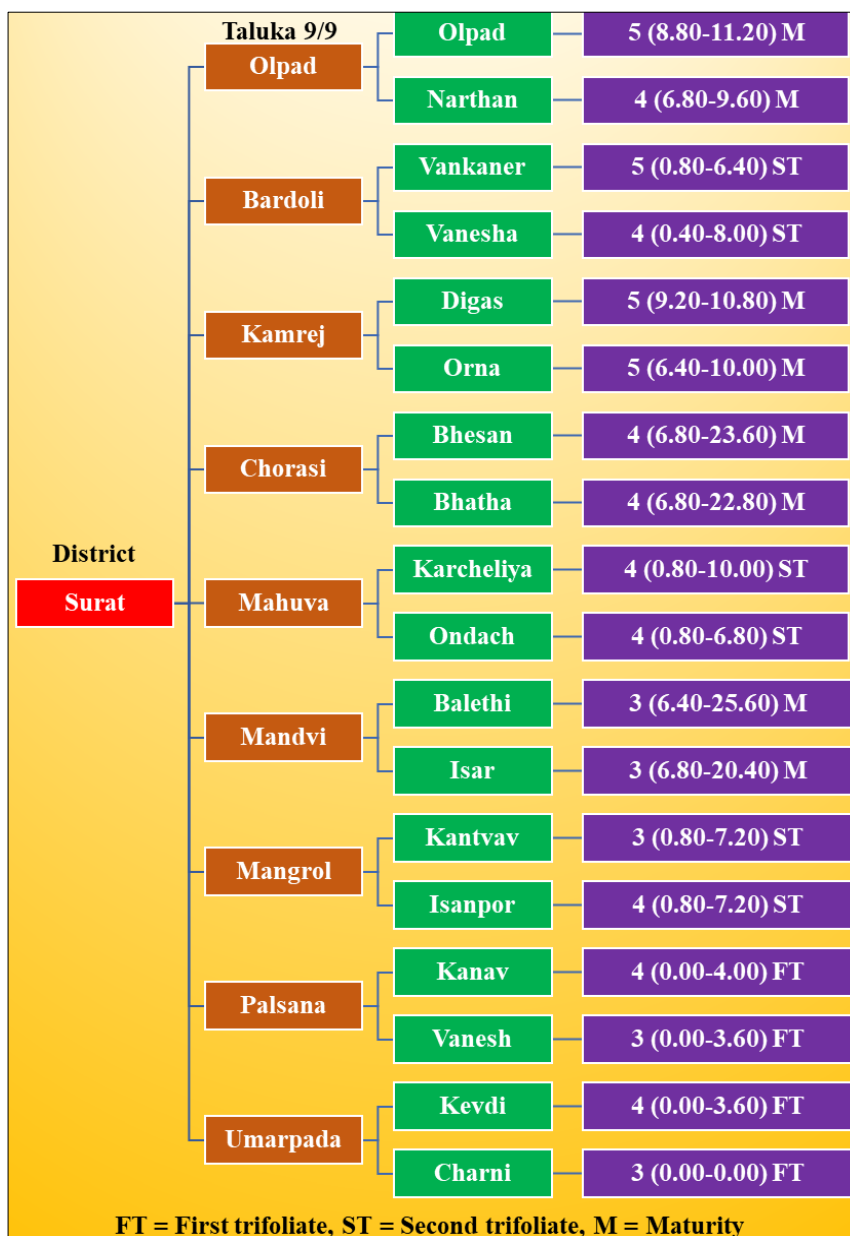


Fig 1D: Surat district

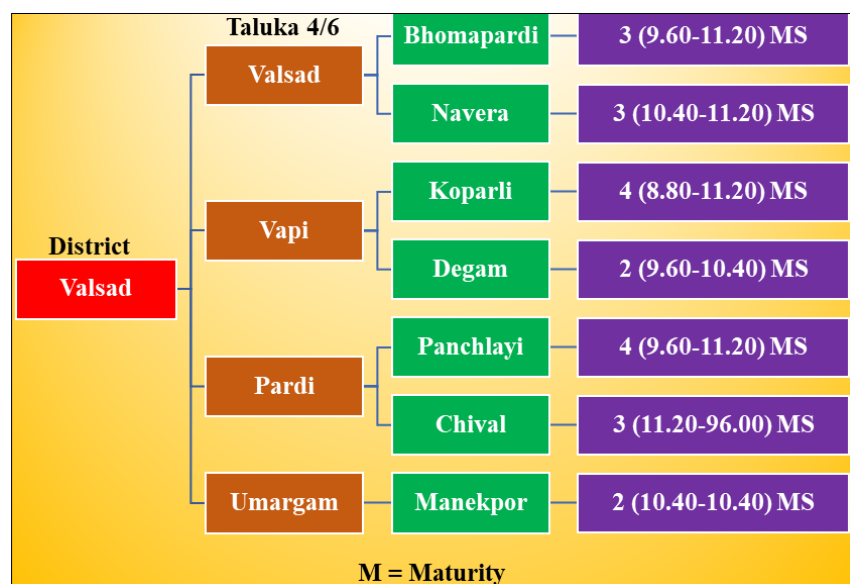


Fig 1E: Valsad district

Fig 1: Districts wise multistage schematic diagram according to the PDIC A) Tapi, B) Navsari, C) Dang, D), Surat and E) Valsad

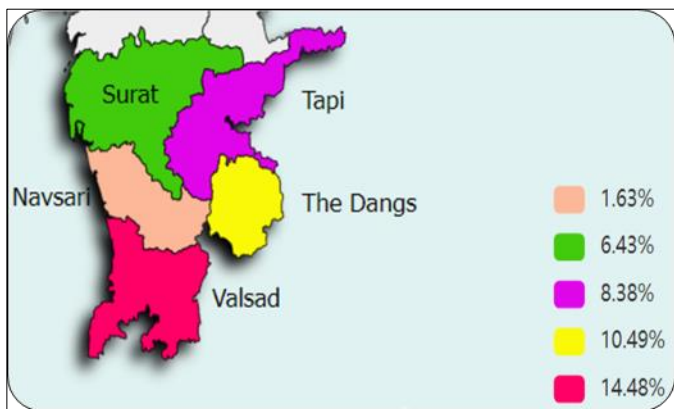


Fig 2: Map shows the PDIC of MYMV in different district of South Gujarat during summer-2019

Among the surveyed village, Hathuka of Valod taluka, Tapi district (Photo 1) and Chival of Pardi taluka, Valsad district (Photo 2) had maximum PDIC of 99.60 and 96.0 percent, respectively. The reason might be the growing of highly susceptible variety GM-4. This was followed by the 25.60 percent in Balethi village of Mandvi taluka 23.60 and 22.80 percent in Bhesan and Bhatha village of Chorasi taluka. The results of the roving survey show that, except these two villages (Hathuka and Chival), MYMV incidence remained below 30 percent.

During the survey, it was observed that mainly seven mungbean varieties viz., GM-6, GM-7, Meha, Virat, Virat Gold, Pusa Vishal and GM-4 were grown by various farmers (Table 2). GM-6 showed 0.02, 0.64, 7.38 and 10.09 PDIC at the first, second trifoliate, flowering and maturity stages respectively. GM-7 showed 0.11, 0.80, 5.73 and 10.25 PDIC at the first, second trifoliate, flowering and maturity stages respectively. Meha showed 0.06, 1.09, and 6.58 percent PDIC at the first, second trifoliate and maturity stages respectively. Virat showed 2.88, 6.63, 9.20 and 20.4 percent PDIC at the first, second trifoliate, flowering and maturity stages respectively. Virat gold showed 2.3 and 2.88 percent PDIC at the first and second trifoliate stages respectively. Pusa vishal showed 4.00, 9.80, 15.80 and 24.00 percent PDIC at the first, second trifoliate, flowering and maturity stages respectively. Out of 49 villages, cv. GM-4 was sown only in two villages (Hathuka and Chival) and showed 97.8 percent PDIC.

Table 2: Variety wise PDIC

Sr. No.	Variety	PDIC at different stage of crop (%)			
		First trifoliate	Second trifoliate	Flowering stage	Maturity stage
1	GM-6	0.02	0.64	7.38	10.09
2	GM-7	0.11	0.80	5.73	10.25
3	Meha	0.06	1.09	-	6.58
4	Virat	2.88	6.63	9.20	20.40
5	Virat gold	2.30	2.88	-	-
6	GM-4	-	-	-	97.80
7	Pusa Vishal	4.00	9.80	15.80	24.00

The variation in the PDIC may result from the varying whitefly population which simultaneously depends on the planting locations and season (Laosatit *et al.*, 2020) [9]. More whitefly built-up were reported at a higher temperature; whereas, high-rainfall and high-humidity results in a negative impact on the whitefly population (Rahman *et al.*, 2006; Islam *et al.*, 2008) [25, 7]. Although PDIC was also affected by the

crop stage at the time of infection, variety of the crop and favorable environmental factors for the vector's growth (Gautam *et al.*, 2021) [5].

The survey also indicated that Meha had even higher tolerance than GM-6 and GM-7. Recently released varieties of mungbean GM-6 (Photo 3) and GM-7 (Photo 4) from NAU, Navsari, were found to grow in 75 percent of the fields surveyed and contributed significantly to the reduction of MYMV incidence.



Photo 1: Severe MYMV incidence at Hathuka village of Valod taluka, Tapi district

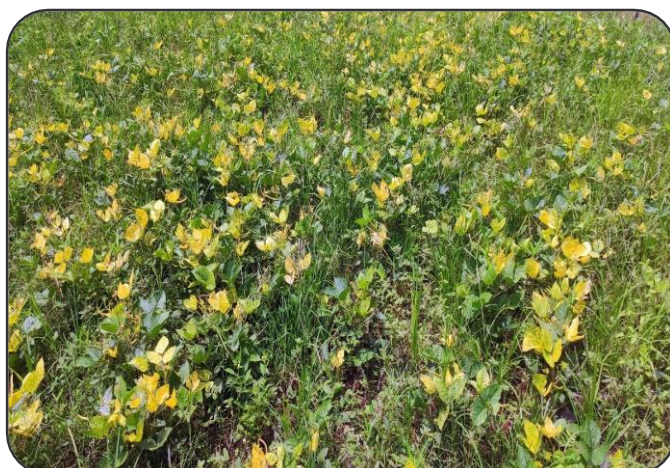


Photo 2: Severe MYMV incidence at Chival of Pardi taluka, Valsad district



Photo 3: Resistance variety GM-6 at farmer's field



Photo 4: Resistance variety GM-7 at farmer’s field

During survey it was noticed that, at early-stage infected crop suffered more and showed severe symptoms. This includes severe mosaic, complete yellowing, reduction in leaf area and higher PDIC. In the severely infected leaves, the green areas become thick, leathery and showed puckering. The plants

showed late maturity giving few flowers and pods. The flower stalk and pods were reduced in size; pods were yellowish in color, turned upwards and produced under developed, immature seeds (Photo 5).



Photo 5: Symptoms of MYMV

There have been numerous field studies conducted by experts to determine the prevalence of the MYMV, including those by Nariani (1960) [16], Nene (1972) [18], Singh (1979) [31], Bansal *et al.* (1984) [2], Nath and Saikia (1995) [17], Singh *et al.* (2000) [30], Pathak and Jhamaria (2004) [22], Bashir *et al.* (2006) [3], Pawar (2010) [24], Patel (2011) [21], Salam *et al.* (2011) [27], Mugisa (2012) [14], Panduranga *et al.* (2012) [19], Srivastava and Prajapati (2012) [32], Manjunath *et al.* (2013) [12], Paul *et al.* (2013) [23], Pawar and Mahatma (2013) [25], Archith *et al.* (2017) [1], Deepa *et al.* (2017) [4], Jayappa *et al.* (2017) [8], Meti *et al.* (2017) [13], Gautam *et al.* (2021) [5], Sheoran *et al.* (2021) [28].

Fixed plot survey

A fixed plot survey was carried out at the Farm of PCRS, NAU, Navsari at four different stages of crop *viz.*, first trifoliolate, second trifoliolate leaf, flowering and maturity stages. The PCRS farm is situated in the South Gujarat Heavy Rainfall Zone AES-III at 10 meters above mean sea level, 20.93 latitude and 72.89 longitudes.

In 2018, mungbean and pigeonpea were grown in *Kharif*, while mungbean, Indian bean and chickpea were grown in *Rabi*. MYMV also made an appearance in both seasons (*Rabi* and *Kharif*), but the PDiC was low as compared to the summer season. Mungbean, Urdbean and cowpea were grown over the summer 2019. Thus, over the season, the mungbean shared a border with the crops Urdbean and cowpea, both of which serve as the MYMV's hosts. Therefore, the source of the inoculum was available throughout the year.

In and around fields, many weed plants have been found to show typical yellow mosaic type symptoms, as shown in mungbean (Photo 6). However, whether they serve as sources of primary inoculum has not been fully explored.

MYMV incidence ranged from 0 to 94.00 percent (Table 3)

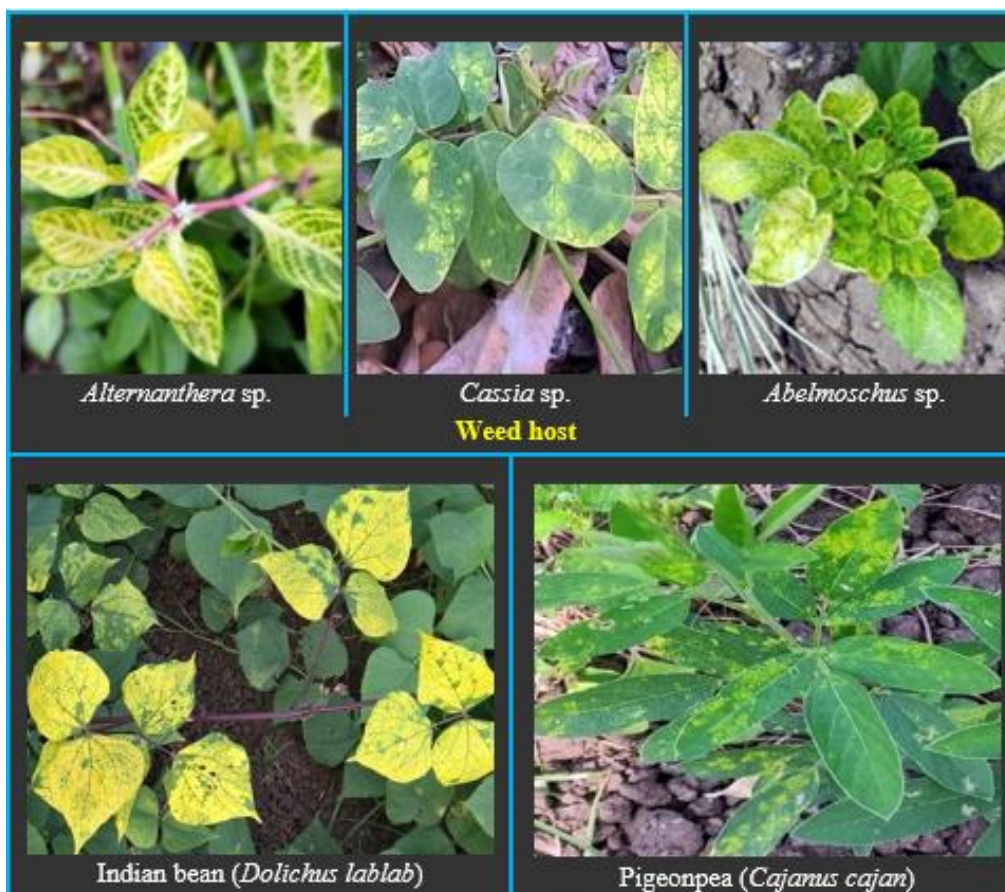
due to the availability of the initial source of inoculum, susceptible varieties and whitefly populations. The plots selected for the fixed plot survey were having GM-4, GAM-5, Meha, GM-6 and GM-7.

Table 3: MYMV incidence at farm of PCRS, NAU, Navsari during summer 2019

Sr. No.	Variety	Area (ha)	PDiC at different stage of crop (%)			
			First trifoliolate	Second trifoliolate	Flowering stage	Maturity stage
1	GM-4	1	11.50	14.50	50.50	94.00
2	GAM-5	0.5	1.20	2.80	5.60	14.80
3	Meha	0.5	0.00	0.67	1.67	6.00
4	GM-6	1.5	0.00	0.57	7.14	10.86
5	GM-7	1.5	0.00	0.50	5.50	12.00

GM-4 showed 11.50, 14.50, 50.50 and 94.00 percent PDiC at the first, second trifoliolate, flowering and maturity stages respectively. Meha and GAM-5 were especially sown as a resistant check for the breeding trials. Meha showed 0.00, 0.67, 1.67 and 6.00 percent PDiC at the first, second trifoliolate, flowering and maturity stages respectively. GAM-5 showed 1.20, 2.80, 5.60 and 14.80 percent PDiC at the first, second trifoliolate, flowering and maturity stages respectively. GM-6 showed 0.00, 0.57, 7.14 and 10.86 percent PDiC at the first, second trifoliolate, flowering and maturity stages respectively. GM-7 showed 0.00, 0.50, 5.50 and 12.00 percent PDiC at the first, second trifoliolate, flowering and maturity stages respectively.

The fixed plot survey revealed that the MYMV starts with the emergence of the first trifoliolate leaf (Photo 7) and constantly increases until it covers the entire field (Photo 8, 9). The spreading rate was more rapid, especially in the susceptible varieties.



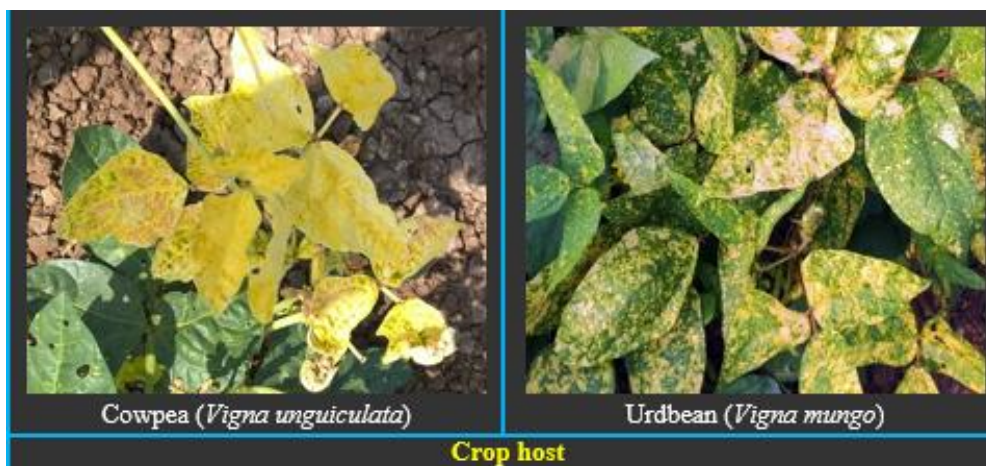


Photo 6: Symptoms of yellow mosaic disease found in different crop and weed plant



Photo 7: Appearance of the MYMV on the first trifoliate leaf



Photo 8: Appearance of the MYMV on the second trifoliate leaf



Photo 9: MYMV covering the entire field

In all the mungbean that has been surveyed during this study, infected plants exhibited the same symptom that has been characterized by Nariani (1960) [16]. There has been fixed plot survey were conducted by Silodia *et al.* (2017) [29] and Srivastava and Prajapati (2012) [32] to determine the prevalence of the MYMV.

Conclusion

Roving field survey conducted in 192 fields across different districts in South Gujarat revealed that none of the villages were MYMD free except two villages (Padgha and Charni). The range of the PDIC was 0.0 to 99.60 percent. Among the surveyed districts, the highest average PDIC of 14.48 percent

was recorded in Valsad district, followed by Dangs, Tapi, Surat and Navsari districts with 10.49, 8.38, 6.43 and 1.63 percent, respectively. Among the surveyed villages, Hathuka of Valod taluka, Tapi district and Chival of Pardi taluka, Valsad district had maximum PDIC of 99.60 and 96.0 percent, respectively. The recently released mungbean varieties, GM-6 and GM-7, were shown to be resistant in every village. It was found after completing a fixed plot survey that the MYMV begins within the first trifoliate leaf and constantly increases until it covers the entire field. The PDIC of the fixed plot survey range was from 0.0 to 94.00 percent. The spreading rate was higher, especially in the susceptible varieties.

Acknowledgment

Navsari Agricultural University, Navsari 396 450 Gujarat (India)

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