

Table 1. Criteria for classification of study areas

Class	TDS (mg/l)	Electrical conductivity ($\mu\text{S}/\text{cm}$)	Impact description
I	<1000	<1500	No detrimental effect on agriculture and acceptable as drinking water source
II	1000–2100	1500–3000	Cause for rejection as source of drinking water at TDS above 1500 mg/l. May have adverse effects on many crops
III	2100–3500	3000–5250	Unfit for drinking and has adverse effect on many crops
IV	3500–4900	5250–7500	Unfit for drinking. Salt-tolerant species may survive on permeable soils with careful management practices
V	>4900	>7500	Unfit for drinking as well as for cultivation of most crops

Source: Ref. 3.

TDS values at locations away from sea, including Kottivakkam beach, Kupparam road, Adyar Krishnamoorthy School and Triplicane showed an increase from May to September 2005. The increase may be due to insufficient rainfall in Chennai as experienced in the last six months till September.

The study area is delineated in Figure 1 based upon TDS values (Table 1)³. The total extent of the study area, covering the sampling points using the polygon attribute table, was found to be 34.882 sq. km.

It is suggested that the areas falling under class I with TDS < 1000 mg/l may be considered as unaffected and those falling under classes II–V may be considered as affected. Figure 1 shows that the southern part of the study area is highly contaminated compared to the northern part. This may be due to higher sea-water intrusion in the southern part (including Besant Nagar, Thiruvananthapuram and Kottivakkam area) as a result of over-exploitation of groundwater. The coastal region in the northern part of the study area, though inundated during the tsunami showed better water quality (class IV) than the coastal regions of the southern part (class V). Locations lying on the northern part of the study area

now falling under class IV were reported to fall almost under the same class during September 2004, i.e. prior to the tsunami.

Poor groundwater quality is evidenced in areas like Kottivakkam beach, Kupparam, Ooruroolkott Kupparam (seashore), Raja Rangasamy Avenue (Thiruvananthapuram), Foreshore Estate, Dhidir Nagar, Nochi-kupparam, Anna-MGR Memorial, which lie in close proximity to the sea and where sea water inundated during the tsunami. Apart from sea-water inundated areas, other areas showing poor water quality include R.A. Puram and Krishnamoorthy School, Adyar. TDS levels observed after the occurrence of the tsunami are within the range as observed during September 2004. Thus the recorded TDS values over time indicate that there is no major impact of the tsunami on water quality. As seepage of sea water is very less due to the short period of transgression during the tsunami, the aquifer has not been affected. Though sea water percolation into the ground through small pockets of waterlogged areas is possible, the effect would be less considering the short period of inundation of sea water during the tsunami. Thus it is clear that the groundwater quality has deteriorated due to lack

of sufficient rainfall leading to sea-water intrusion that is reflected in high TDS and chloride content of the samples.

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Natural occurrence of *Jatropha* mosaic virus disease in India

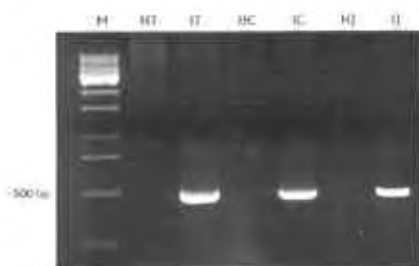
Whitefly-transmitted geminiviruses of the genus *Begomovirus* are important pathogens of a wide range of crop ecosystems. Since the introduction of B biotype *Bemisia tabaci* in Kolar, there has been an increased incidence of begomoviruses on many vegetables and ornamental crops in the southern districts of Karnataka. Mosaic disease caused by begomovirus was one

among such diseases noticed recently on *Jatropha* (*Jatropha curcas* L.), a drought-resistant perennial biodiesel plant in Karnataka¹. The *Jatropha* Mosaic Virus (JMV) was first reported on *Jatropha gossypifolia* from Puerto Rico and identified as begomovirus². Ultrastructural studies of JMV-infected plants indicated the association of cytoplasmic inclusions

such as membrane-bound bodies containing granular or fibrillar material, infection confining to phloem and virus-like particles of 15–18 nm in diameter³. The virus was found to be transmitted by the vector *Bemisia tabaci* Aleyrodidae in a semi-persistent manner, but not through sap inoculation and seed⁴. In this study we attempted a survey of *Jatropha*-growing

Table 1. Incidence of Jatropha mosaic virus disease in different parts of Karnataka during 2005

District	Place	Incidence (%)
Kolar	Sugatur, Kolar (tq)	46.66
	Chintamani, Chintamani (tq)	17.50
	Chikkadibburahalli, Sidlaghatta (tq)	44.61
Bangalore	Kanakapura, Kanakapura (tq)	35.20
	Jalige, Doddaballapura (tq)	30.30
	Marasandra, Doddaballapura (tq)	32.60
	Hesarghatta, Bangalore North (tq)	26.50
Tumkur	Kuchhangi, Tumkur (tq)	36.80
	Katharighatta, Kunigal (tq)	28.22
	Yadiure, Kunigal (tq)	31.11
	Thippur, Kunigal (tq)	26.66
Mandya	Manthanahalli, Nagamangala (tq)	38.88
Hassan	Bookanabetta, Channarayapattana (tq)	27.77
	Ayarahalli, Channarayapattana (tq)	38.81
	Irisave, Channarayapattana (tq)	46.19
Chitradurga	Hiriyur, Hiriyur (tq)	26.00
	Chitradurga, Chitradurga (tq)	18.13
Bellary	Kudligi, Kudligi (tq)	12.50
	Sandur, Sandur (tq)	29.70
Uttar Kannada	Yekkambi, Sirsi (tq)	18.20
	Sirsi, Sirsi (tq)	23.33
Coorg	Kutta, Virajpet (tq)	20.35
	Panjarpet, Virajpet (tq)	22.50

**Figure 1.** Jatropha plant exhibiting mosaic symptoms.**Figure 2.** Products obtained by amplification of nucleic acids from healthy and ToLCV, ICMV and mosaic virus-infected Jatropha plants. Lane M, Marker; lane HT, Healthy tomato; lane IT, Infected tomato; lane HC, Healthy cassava; lane IC, Infected cassava; lane HJ, Healthy Jatropha and lane IJ, Infected Jatropha.

areas for natural occurrence of the disease, transmission and PCR detection of the geminivirus from mosaic virus-infected Jatropha plants using Deng primers⁵.

The surveys were carried out in different parts of Karnataka to assess the incidence of mosaic virus infecting naturally grown Jatropha plants. The disease incidence was assessed by counting the number of plants infected out of total plants present at each location. The virus culture was established by grafting healthy plants using scions made from naturally infected Jatropha plants. Insect transmission studies were carried out using a healthy colony of *B. tabaci* maintained on cotton plants. The whitefly adults were given 24 h acquisition on JMV-infected foliage and allowed to feed on healthy seedlings at first leaf stage for 24 h as inoculation feeding period. The inoculated seedlings were kept in insect-proof cages and carefully observed for symptom development at regular intervals. PCR detection of the virus was carried out by amplifying the total DNA extracted by C-TAB method⁶ from JMV-infected plant samples using degenerate oligonucleotide primers (Deng primers)⁵, designed for amplification of specific DNA

fragment of DNA A of whitefly-transmitted geminiviruses.

During field survey, mosaic symptoms on naturally grown Jatropha were observed during September 2004 for the first time in Kolar and Bangalore districts. The disease incidence was observed in all districts surveyed. The disease incidence ranged from 12.50 to 46.66%, with highest incidence in Kolar (46.66%) followed by Hassan (46.19%), Tumkur (36.80%) and Bangalore (35.20%) districts and least in Bellary district (12.50%; Table 1). Symptoms observed on naturally infected plants include mosaic, reduced leaf size, leaf distortion, blistering and stunting of diseased plants (Figure 1). The disease was successfully established in healthy plants through grafting using scions made from infected cuttings. Graft-inoculated plants produced typical mosaic symptoms within 25 days after graft inoculation. The disease was transmitted to healthy plants through whiteflies up to 40%. Whitefly inoculated plants developed typical symptoms such as veinal netting, chlorotic specks, leaf distortion and stunting of seedlings within 30 days of inoculation.

A band of approximately 500 bp was consistently amplified from total DNA extracted from infected *Jatropha* samples (Figure 2). PCR has been employed to detect and establish association of begomoviruses through amplification of approximately 500 bp fragment of DNA-A of begomoviruses using Deng primers⁵, viz. Primer A (forward) and Primer B (reverse) corresponding to the nucleotide sequences 146–165 and 650–672 respectively, were used in PCR to amplify DNA fragment of DNA-A to yield a product size ranging from 500 to 527 bp. This clearly indicates the association of a whitefly-transmitted geminivirus with the mosaic disease on *Jatropha*. The association of JMV was confirmed through amplification of approximately 575 bp fragment of begomoviral coat protein gene using degenerate primers V324 and C889 (core CP) capable of universally amplifying begomoviruses⁷. There are already reports on occurrence of JMV (JMV-PR) on *Jatropha gossypifolia* and *Jatropha multifida* from Puerto Rico (USA)^{2,4}. Wyatt and Brown⁸ detected JMV isolate from Puerto Rico using another set of degenerate primers (AV494 and AC1048) directed to amplify the core region of coat protein DNA fragment of approximately 550 bp.

The B biotype whitefly is known to alter the epidemics, as there are reports of increased epidemics of JMV in Puerto Rico after the introduction of B biotype². The disease assumes special significance in view of the recent introduction of B biotype into southern Karnataka and the proposed large-scale promotion of *Jatropha* cultivation in the country for its oil to use as biofuel. Investigations on epidemiology and development of specific diagnostic techniques help to develop suitable management strategies to combat the disease, which is likely to become a serious threat for *Jatropha* cultivation in the country.

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