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Global positioning system based spatial and temporal distribution of new leaf curl begomovirus disease on sunflower in Northern Karnataka

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Abstract: Leaf curl disease on sunflower caused by begomovirus genus of the family geminiviridae. Present investigations on field survey for disease incidence, field diagnostic symptoms and its spatial and temporal distribution in major sunflower growing parts of North Eastern Karnataka through GPS system during 2013-14, revealed that the disease was found to occur at all the stages of sunflower under field condition and exhibited symptoms such as vein thickening (enations) on abaxial surface of the leaves, upward curling and reduction in leaf size and severe discoluration of capitulum (Head) followed by bushy appearance. GPS based survey indicated that the % disease incidence varied from location to location (spatial variation) and also from season to season (temporal variation). The low incidence was noticed during *Kharif* condition which is ranged between 6.34-11.16, with the average incidence of 11.2%, 7.4% and 6.3% in Koppal, Raichur and Ballari districts repectively. Whereas during *Rabi*/ summer season, high magnitude of disease noticed in many of the locations surveyed and is recorded upto 92.9 %. The GPS maps plotted based on PDI scale (0-3) represents high risk areas of the disease in Raichur and adjacent areas of Nort Eastern Karnataka and the result shows that the disease occurrence was more in rabi as compared to Kharif situations irrespective of locations. GPS survey map is an indicator to locate the nature of disease spread so as to conclude the hotspot areas.

Keywords: Begomovirus, GPS survey, Leaf curl disease, Sunflower, Whitefly

INTRODUCTION

Sunflower one of the important edible oilseed crop grown in the world after soybean and groundnut. The oil is also a rich source (64 %) of lenoleic acid which helps in washing out cholesterol deposition in the coronary arteries. Sunflower has gained importance due to its short duration of maturity, excellent quality oil, photo-insensitivity, wide adaptability in different agro-climatic region and drought tolerance (Joshi, 2009; Mündel, 2009).

Although the area under cultivation increased with the adventure of new hybrids and varieties by private and public sectors, the crop being suffer from many fungal and viral diseases (Saharan *et al.,* 2005). Among viral diseases affecting sunflower, very recently leaf curl disease caused by begomovirus of the geminiviridae family was reported for the first time from Main Agricultural Research Station (MARS), University of Agricultural Sciences (UAS) campus, Raichur. Causal agent of the disease was confirmed as ss DNA begomovirus which is clustered next to Tomato Leaf Curl Karnataka Virus isolate Lucknow (ToLCKV-[Luc] (Accession no. EU604297.2). and Tomato Leaf Curl Virus - Bangalore II (ToLCBV-[Ban2]) (Accession no. EU604297.2) and shared 97.5 % nucleotide identities (Govindappa *et al.*, 2011).

The emergence of the whitefly transmitted geminivirus complex around the world depends on various factors, such as exchange of genetic information by recombination plays a role in the evolution of viruses, evolution of variants of the viruses, changes in the biology of vectors, movement of infected planting materials, introduction of new crops and host susceptibility genes through the exchange of germplasm, changes in cropping systems, and climatic factors (Muniyappa and Veeresh, 1984, Saikia and Muniyappa, 1989, Brown, 1994, Ramappa *et al*., 1998, Banks *et al.,* 2001, Varma and Malathi, 2003., Shivalingama *et al*., 2007; Kaur *et al*., 2015).

Although leaf curl disease noticed on sunflower for the first time on sunflower hybrid SB-275 grown in research experimental plots at MARS, Raichur, the incidence level increasing year after year. Further during *Kharif* 2012, highest incidence (72 %) was noticed in many sunflower pipeline hybrids *viz*., KSFH-335, KBSH-70, KSFH-280, KBSH-68, KBSH-1, KBSH-44, KSFH-284, NSSH-1084, DOLLER, NSFH-1001, VSFH-204, SB-275, Morden and BSFH-111 with the incidence range from 30-75 % at Main Agricultural

Research Station at Raichur. In addition, spread of the disease has also been recorded in adjacent areas of Raichur district (Anonymous, 2013), but till date there was no literature available on GPS based distribution and intensity of leaf curl disease incidence of sunflower in potential crop growing areas of Northern Karnataka, spatial and temporal variability of disease have not been studied. Therefor the present study undertaken to investigate spatial and temporal distribution and variability of new leaf curl begomovirus disease on sunflower in Northern Karnataka through global positioning system.

MATERIALS AND METHODS

A roving survey was conducted to understand spatial and temporal variation of Sunflower Leaf Curl Virus (SuLCV) disease incidence in major sunflower growing areas of Northern Karnataka which included Raichur, Ballari and Koppal districts during *Kharif* and *Rabi* 2013 -14. Roving survey was adopted wherein three taluks from each district and two villages from each taluk and two locations of 100 sq meter area were selected as sampling point. Each site was geo referenced in the Universal Transverse Mercator (UTM) co-ordinate system with a Global Positioning System (GPS). By using global positioning system (GPS) (Trimble MAK – Geo XH), where the co-ordinates (latitudes and longitudes) were collected at each sampling point to map the spatial variation of SuLCV disease. Further, the survey was extended to record the incidence of disease in selected points during *Rabi* 2013-14 to know the temporal variation of disease. The per cent incidence of the viral disease in each location was calculated. Further, the incidence of the disease from each location of the above districts was designated based on disease rating scale 0-3 (0: No incidence; 1: 1-10 %; 2: 11-25 %; 3 :> 25 % and above) for the convenience to develop GIS maps to understand the spatial and temporal variation of disease.

GPS data import: The collected data from each location using GPS were imported using path finder software. Since the projection system of collected locations were pre-defined in the GPS, the imported sample points were found within the respective villages administrative boundary (having similar projection and datum *i.e.*, UTM, WGS 84), when imported in the GIS environment.

Data attachment and mapping: The field observations on leaf curl disease incidence of the respective sampling point were fed in excel sheet with proper labelling for each observations. The unique *id* was added and the physical *id* was created along with the sample locations imported in the Arc GIS environment. Further the collected field data were attached to the respective GPS location points using unique *id* 121 relationships in Arc GIS 2010. The disease incidence was displayed through unique symbology to understand the spatial and temporal variability of leaf curl disease. The Differential Global Positioning System (DGPS) used in this study is the latest version (GeoXH) from Trimble, which is enabled to receive the satellite signals from *Global Navigation Satellite System* **(***GNSS***)** which will give more accurate location reading.

Computer software: ArcGIS 10 software from Department of Plant Pathology, College of Agriculture, Raichur was used for the processing and analysis of the data. During the survey, symptoms of leaf curl disease on sunflower were also observed on different stages of crop growth in order to understandthe susceptible stage of crop.

RESULTS AND DISCUSSION

The investigations on leaf curl disease of sunflower with respect to GPS based spatial and temporal distribution and variability in major sunflower growing areas of Northern Karnataka were carried out at Department of Plant Pathology and MARS, University of Agricultural Sciences, Raichur. Present study revealed that the leaf curl caused by geminivirus disease found to occur at all the stages of sunflower with characteristic symptoms of vein thickening (enations) on abaxial surface of the leaves, upward curling and reduction in leaf size and severe discoluration of capitulum (Head) followed by stunted growth and poor head formation in many of the locations surveyed (Fig. 1). Similar the infection of gemini viruses found to occur at all the growth stages of crop such as tomato, cassava, tobacco and Okra (Saikia and Muniyappa, 1989, Mathew and Muniyappa, 1991, Valand and Muniyappa, 1992, Venkataravanappa, 2008). However the symptoms caused by these viruses in many vegetable and commercial crops were closely resembles to each other. The GPS based survey of leaf curl disease on sunflower indicated that the per cent incidence of leaf curl disease varied from season to season (temporal variation) across the locations surveyed. During *Kharif* 2013 the lowest average incidence was observed in many of the locations surveyed with the mean incidence of 11.16 %, 7.41 % and 6.34 % in Koppal followed by Raichur and Ballari (districts) respectively. Whereas during *Rabi*/summer 2013-14, higher magnitude of disease incidence noticed in many of the locations surveyed and is ranged from 0.00 to 92.85 %. However, Raichur district has recorded highest average incidence (17.16 %), while in Koppal and Ballari district, incidences of 16.11 and 7.99 % were recorded respectively.

Further, GPS maps also helps in indicating the spatial variability (Location to location) of leaf curl disease across the surveyed areas and results are represented in GIS maps. Far instances, In Raichur district, during *Kharif* season maximum disease incidence was noticed to the extent of 46.66 % in University campus of Raichur taluk and while least disease incidence was noticed in Harvi (5.68 %) village of Manvi taluk. During *Rabi* season, the incidence recorded in Raichur taluk was 92.85 % and lowest disease incidence was noticed in Venketapur (5.83 %) village of Lingasugur taluk (Table 1: Fig. 2). In Bellary district, during kharif condi-

Table 1. Spatial and temporal distribution of leaf curl virus disease incidence on sunflower in Raichur district of North Karnataka during *Kharif* and *Rabi* 2013-14.

District	Taluk	Location	Longitude	Lattitude	% disease incidence during *Kharif*	% disease incidence during *Rabi*
Raichur	Raichur	MARS, Raichur	77.333003	16.204984	46.66	92.85
		MARS, Raichur	77.333264	16.204869	31.11	71.42
		Askihal	77.325768	16.203002	0.00	7.14
		Askihal	77.324835	16.204249	0.00	12.50
		Eklaspur	77.291879	16.223926	0.00	0.00
		Eklaspur	77.280299	16.211488	0.00	0.00
	Lingsugur	Maski	76.656123	15.955682	5.68	17.14
		Maski	76.656397	15.961840	7.14	11.57
		Venketapur	76.619172	15.962151	0.00	8.33
		Venketapur	76.619643	15.974040	0.00	5.83
	Manvi	Harvi	77.045010	16.070353	7.5	0.00
		Harvi	77.062850	16.064410	5.71	0.00
		Nirmanvi	77.099760	16.044320	0.00	0.00
		Nirmanvi	77.098250	16.045740	0.00	12.64

Table 2. Spatial and temporal distribution of leaf curl virus disease incidence on sunflower in Ballari district of North Karnataka during *Kharif* and *Rabi* 2013-14.

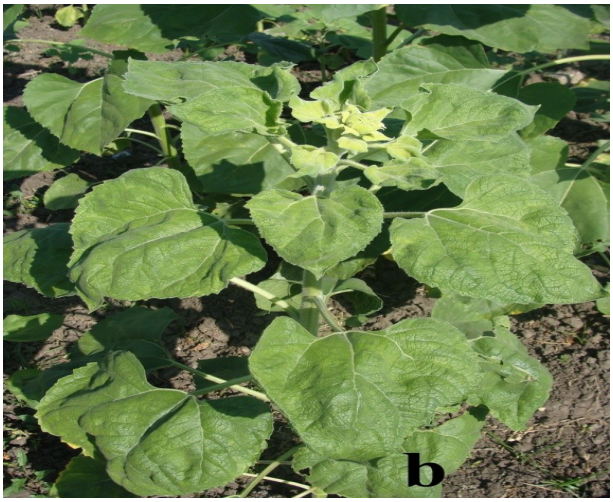
District	Taluk	Location	Longitude	Lattitude	% disease incidence during *Kharif*	% disease incidence during *Rabi*
Bellary	Hadagali	Hoovinahadagali	75.935426	15.016796	11.66	20.22
		Hoovinahadagali	75.941539	15.017482	15.15	11.11
		Uttangi	76.017286	15.003401	12.85	9.56
		Uttangi	76.041785	14.974892	8.97	10.22
	Kudligi	Kudligi	76.388834	14.902060	10.52	13.63
		Kudligi	76.383819	14.901290	0.00	13.26
		Kuppinakeri	76.361220	14.913580	0.00	0.00
		Kuppinakeri	76.351360	14.888374	0.00	0.00
		Gajapur	76.310928	14.874355	0.00	0.00
		Gajapur	76.309179	14.873478	0.00	0.00
	Hagaribommanahalli	Hagari bommanahalli	76.199760	15.050987	10.34	14.44
		Hagari bommanahalli	76.204870	15.057544	7.69	2.98
		Kadalabalu	76.218590	15.095692	0.00	16.45
		Kadalabalu	76.183250	15.098702	11.66	0.00

Table 3. Spatial and temporal distribution of leaf curl virus disease incidence on sunflower in Koppal district of North Karnataka during *Kharif* and *Rabi* 2013-14.

District	Taluk	Location	Longitude	Lattitude	% disease incidence during *Kharif*	% disease incidence during *Rabi*
Koppal	Koppal	Ginigera	76.244760	15.352285	17.85	20.20
		Ginigera	76.247770	15.348448	16.88	16.92
		Kanakapur	76.253540	15.342423	14.94	15.33
		Kanakapur	76.266839	15.330831	9.37	22.47
	Kushtagi	Byalihal	76.137854	15.755988	12.22	15.83
		Byalihal	76.142582	15.757263	0.00	9.23
		Madalgatti	76.156504	15.738224	0.00	18.57
		Madalgatti	76.162341	15.748468	15.55	11.66
	Yelburga	Kudri kottagi	76.041128	15.617779	7.59	21.11
		Kudri kottagi	76.038654	15.618231	0.00	13.33
		Gedigera	76.073798	15.612712	22.66	12.22
		Gedigera	76.065811	15.604864	16.92	16.47

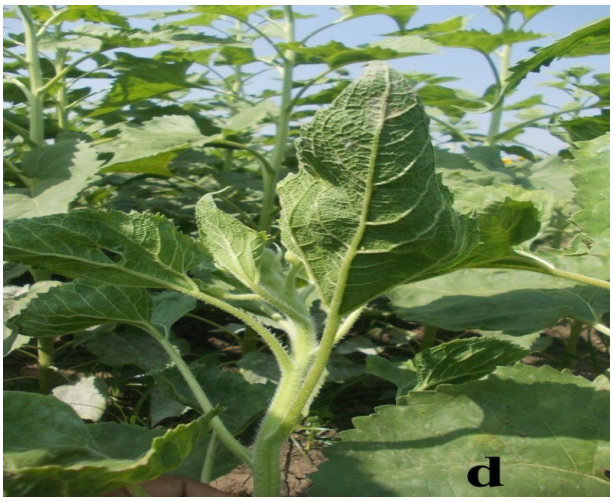
tion, the disease incidence noticed upto 15.2 % from Uttangi village whileduring *Rabi*, 2013-14 situations the prevalence of disease was highest and recorded upto 20.22 % in Huvinahadagali (Table 2; Fig. 3).

(a) Prominent upward leaf curling



(b) Reduced leaf size and ear head

(c) Vein thickenings and leathery Appearance of leaves



(d) Vein thickening coupled with enations on abaxial surface

Fig. 1. *Field symptoms of leaf curl virus disease on sunflower plants.*

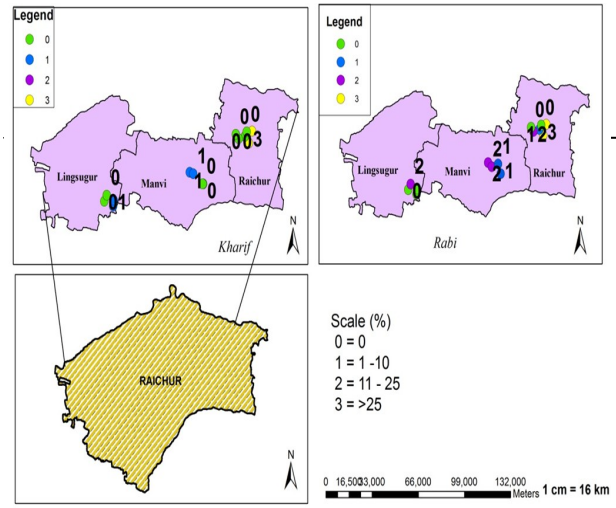


Fig. 2. *GIS Map showing spatial and temporal distribution of leaf curl disease during Kharif and Rabi 2013-14 in Raichur district.*

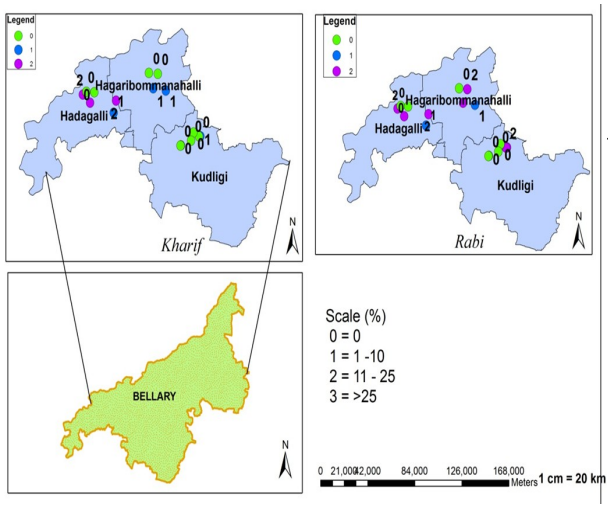


Fig. 3. *GIS Map showing spatial and temporal distribution of leaf curl disease during Kharif and Rabi 2013-14 in Ballari district.*

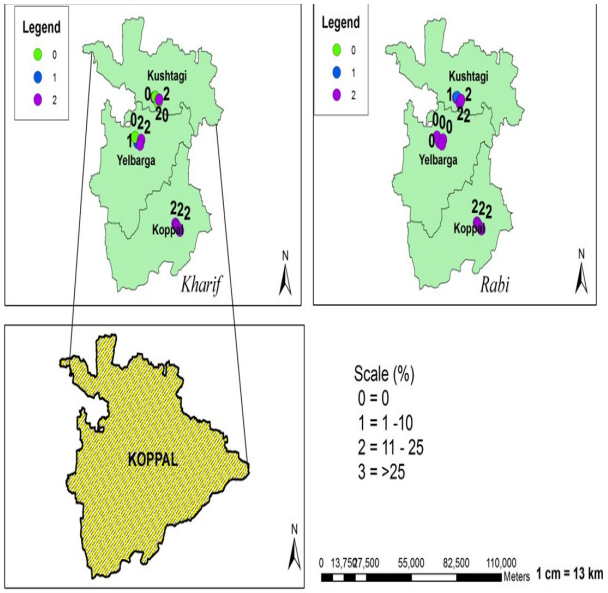


Fig. 4. *GIS Map showing spatial and temporal distribution of leaf curl disease during Kharif and Rabi 2013-14 in Koppal district.*

In Koppal district, the incidence of leaf curl disease during *Kharif* reveals that the highest disease incidence (22.66 %) in Gedigera village of Yelburga taluk and lowest disease incidence was noticed in Kudrikotgi (7.59 %) village of Yelburga taluk. Whereas during *Rabi* 2013 -14 the disease incidence was highest (22.47 %) in Kanakapur village of Koppal taluk and lowest disease incidence was noticed in Byalihal (9.23 %) village of Kushtagi taluk (Table 3; Fig. 4).

The survey on leaf curl disease across sunflower growing regions of North East Karnataka revealed that the % disease incidence varied from location to location and also from season to season, which indicates the leaf curl disease is highly sporadic and varying across the locations.

The differences in the incidence of disease in areas surveyed might be due to the variation in the source of virus inoculum (ToLCV Karnataka clone IKH12) (Vanitha, 2012), vector population, climatic conditions and the susceptibility of sunflower genotypes. Interestingly, in the areas where maximum disease incidence was recorded, the vector population was apparently high with a favourable temperature conditions during *Rabi*/summer periods. *B. tabaci* is readily capable of establishing to extreme population levels with higher temperature, particularly crops grown under irrigated and arid field conditions and greenhouse systems. In addition to this, whitefly has the potential to colonize a wide range of dicotyledonous species, among which are primarily vegetable and fiber species. Recent studies indicated that there are numerous populations of *B. tabaci* that, vary in their capacity to develop high population densities and cause direct feeding damage, in the extent of their host ranges, and in the efficacy with which they can transmit geminiviruses (Bedford *et al*., 1994). Some of them are also known to be source of infections for other Begomoviruses. In addition introduction of B-biotype whitefly has been attributed for epidemics and emergence of new viruses in Southern parts of Karnataka (Banks *et al*., 2001). In recent years there have been wide spread occurrence of Begomoviruses on many crop plants as well as ornamental plant species Hibiscus (Rajeshwari *et al*., 2005), Zinnia (Shivakumar, 2010) and Croton (Mahesh *et al*., 2010). Further investigations on cotton leaf curl virus (CLCuV) incidence in North India, also coincided with variation in virus strains across the locations. Until 2004, CLCuRV (Rajasthan strain) was predominant in North West India but during 2005- 06, CLCuBuV (Burewala strain) appeared to be a new Begomovirus and in the recent years of 2009-10 onwards CLCuBuV emerged as dominant resistance breaking strain in NW India. A survey for viruses causing CLCuD was conducted by Rajagopalan *et al.* (2012) during the 2009 and 2010 cropping seasons in the northwestern Indian cotton-growing belt in the states of Punjab, Haryana and Rajasthan. Partial sequences of 258 and full-length sequences of 22 virus genomes were determined. This study showed that the resistance-breaking cotton leaf curl Burewala virus (CLCuBuV) is now the dominant virus in many fields. Hence further detail investigations is need of an hour to understand the diversity pattern of leaf curl strain infecting sunflower in Karnataka.

The maps showed that a different colour in legends represents high and low risk areas of the disease with % disease incidence and based on severity scale (0-3). This result shows the various steps to move from overall scenario of disease to pin pointing the disease incidence in a location specific or hotspot analysis. The variability of associations is likely due to the fact that various environmental factors and biotic factors such as sources of disease inoculum, temperature, rainfall, relative humidity, host susceptibility, *etc.,* and their spatial heterogeneity affect the incidence and epidemic development of viral disease.

Govindappa *et al*. (2011) reported leaf curl virus disease on sunflower to the extent of 40 % at Main Agricultural Research Station, University of Agricultural Sciences, Raichur. Further, Vanitha (2012) made a survey in five districts of northern and southern Karnataka and the studies revealed that the incidence in sunflower ranged from 0-58 % and highest incidence of 58 % was recorded at Main Agriculture Research Station, University of Agricultural Sciences, Raichur, However there was no incidence in Tumkur and Bengaluru rural district. Further Deepa (2013) conducted a survey in five districts of northern Karnataka and during the study the mean disease incidence of 11.68 % in Raichur district followed by Koppal (7.59 %), and Yadgiri (3.22 %). From the above studies, it is clear that Raichur recorded highest incidence among the districts surveyed and it is occurring repeatedly in Raichur locations hence,

Raichur can be one of the "hot spot" for leaf curl virus incidence which recorded 57.9 and 65.25 % disease incidence in *Kharif* 2012 and *Rabi*/summer 2012-2013, respectively. Further, the present investigation also reveals that the incidence of leaf curl disease on sunflower at MARS, Raichur is highest of 46.66 and 92.85 % during *Kharif* 2013 and *Rabi*/summer 2013-14, respectively.

Conclusion

Present investigations on Leaf curl disease of sunflower caused by begomovirus revealed that the disease was found to occur at all the stages of sunflower under field condition across the locations surveyed. GPS based survey indicated that the % disease incidence varied from location to location (spatial variation) and also from season to season (temporal variation). The low incidence was noticed during *Kharif* condition Whereas during *Rabi*/summer season, high magnitude of disease noticed in many of the locations surveyed and is recorded upto 92.9 %. The GPS maps plotted based on PDI scale (0-3) represents high risk areas of the disease in Raichur and adjacent areas of North Eastern Karnataka and the result further shows that the disease occurrence was more in rabi as compared to Kharif situations irrespective of locations.

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REFERENCES

Anonymous, 2013, Annual Sunflower report, 2013, Directorate of Oilseed Research, Hyderbad, 254.

Banks, G.K., Colvin, J., Chowda Reddy, R.V., Maruthi, M. N., Muniyappa, V., Venkatesh, H.M., Kiran Kumar, M., Padmaja, A.S., Beitia, F.J. and Seal, S.E. (2001). First report of the *Bemisia tabaci* B-biotype in India and an associated *Tomato leaf curl virus* disease epidemic. *Plant Disease*, 85: 231.

Bedford, I.D., Briddon, R.W., Jones, P., Alkaff, N. and Markham, P.G. (1994). Differentiation of three whitefly transmitted geminiviruses from the Republic of Yemen. *European J. Pl. Pathol.,* 100: 243-257.

Brown, J.K. (1994). Current status of *Bemisia tabaci* as a plant pest and virus vector in agro-ecosystems worldwide. FAO *Plant Prot. Bull*., 42: 3-32.

Govindappa, M.R., Shankergoud, I., Shankarappa, K.S., Wickramaarachchi, W.A.R.T., Anjeneya Reddy, B. and Rangaswamy, K.T. (2011). Molecular detection and partial characterization of begomovirus associated with leaf curl disease of sunflower (*Helianthus annuus*) in Southren India. *Plant Pathol. J.*, 10 (1): 29-35.

Joshi, D.B. (2009). Developing Statistical Models to Study the Growth and Instability in Oilseed Production of Karnataka. Unpublished thesis of Master of Science (Agriculture) in Agricultural Statistics, submitted to the University of Agricultural Sciences, Dharwad, Karnataka (India).

Kaur S.I., 1 Kang, S.S and Sharma, A. (2015). Occurrence of begomoviruses in cotton-vegetable agro ecosystem in India, *African Journal of Microbiology Research*., 9 (30), 1798-1805.

Mahesh, Y.S., Shankarappa, K.S., Rangaswamy, K.T., Prameela, H.A., Aswathanarayana, D.S., Divya, B.L., Nagesha, N., and Maruthi, M.N. (2010). Detection and characterization of a Begomovirus associated with leaf curl disease of ornamental croton (*Codiaeum variegatum*). *J. Hort. Sci. Biotech*., 85: 101-105.

Mathew, A.V. and Muniyappa, V. (1991). Transmission of Indian cassava mosaic virus by *Bemisia tabaci*. *Fitopatologia Brasileira*, 16: 46-49.

Mündel, H.H. (2009). Sunflowers: An Important Part of the Tool kit for Dry-land Farming. Australian Grain, January-February 2009:30-33.

Muniyappa, V. and Veeresh, G.K. (1984). Plant virus diseases transmitted by whiteflies in Karnataka. *Indian Acad. Sci.* (Anim. Sci.), 93: 397-406.

Rajagopalan, P.A., Naik, A., Katturi., P. and Kurulekar, M. (2012). Dominance of resistance breaking cotton leaf curl Burewala virus (CLCuBuV) in north western India. *Arch. Virol.,* 157:855- 868.

Rajeshwari, R., Reddy, R.V.C., Maruthi, M.N., Colvin, J., Seal, S.E. and Muniyappa, V. (2005). Host range, vector relationships and sequence comparison of a begomovirus infecting hibiscus in India. *Ann. Appl. Biol.,* 147: 15-25.

Ramappa, H.K., Muniyappa, V and Colvin, J. (1998). The contribution of tomato and alternative host plants to tomato leaf curl virus inoculums pressure in different areas of south India. *Annals of Applied Biology*, 88: 369 -387.

Saharan, G.S., Naresh Mehta and Sangwan, M. S. (2005). *Diseases of Oil Seed Crops*, ISBN-81-7387-176-0, Indus publishing company, New Delhi, pp.38.

Saikia, A.K., and Muniyappa, V. (1989). Epidemiology and control of tomato leaf curl virus in southern India. *Trop. Agri.*, 66: 350-354.

Shivakumar (2010). Studies on Zinnia leaf curl virus disease, *M.Sc. (Agri.) Thesis.,* Univ. Agri. Sci., Bangalore, India, 78 pp.

Shivalingam, P.N., Padmalatha. K.V., Mandal. B., Monga. D., Ajemra, B.D and Malathi VG (2007). Detection of begomoviruses by PCR in weeds and crop plants in and around cotton field infected with cotton leaf curl disease. Indian Phytopathol, 60: 360-361.

Valand, G.B. and Muniyappa, V. (1992). Epidemiology of tobacco leaf curl virus in India. *Ann. Appl. Biol.,* 120: 257-267.

Vanitha, L.S. (2012). Molecular characterization of begomovirus causing leaf curl disease in sunflower. *Ph.D Thesis*, Univ. Agri. Sci., Bangalore.

Varma, A. and Malathi, V.G. (2003). Emerging geminivirus problems: A serious threat to crop production. *Ann. Appl. Biol*. 142: 145-164.

Venkataravanappa (2008). Molecular characterization of bhendi yellow vein mosaic virus. *Ph.D Thesis*, Univ. Agri. Sci., Bangalore.

Zhang, N., Wang, M. and Wang, N. (2002). Precision agriculture - a worldwide overview. *Computers and Electronics in Agriculture*, 36: 113–132.