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Original Research Paper

Epidemiology of ChiVMV and loss assessment in capsicum (*Capsicum annum* var. *grossum* Sendt)

Praful M.V.[1], Reddy B.A.[2], Ramachandra R.K.[2], Reddy M.K.[3] and Anjanappa M.[1]

[1] College of Horticulture, University of Horticultural Sciences, Bengaluru - 560 065, Karnataka, India
[2] Horticulture Research and Extension Center, Hogalagere, Srinivasapura - 563138, Karnataka, India
[3] ICAR- Indian Institute of Horticultural Research, Bengaluru - 560 089, Karnataka India
*Corresponding author Email : arb_agri@yahoo.co.in, ajreddyb007@gmail.com

ABSTRACT

The survey was conducted during *rabi* season (2021) to determine the incidence of mosaic disease of capsicum in major capsicum growing districts namely, Chikkaballapura, Kolar, Bengaluru rural and Ramanagar. The per cent incidence of mosaic disease based on symptoms in field was recorded, highest in Ramanagar (54.85%) and the least incidence of mosaic disease was observed in Chikkaballapura (26.85%). Transmission and host range studies under glasshouse conditions revealed that ChiVMV is transmitted mechanically. Among 16 host plants tested, 7 plant species (*Nicotiana tabacum* cv. Samsun, *N. glutinosa, N. occidentalis, Datura metel, Physalis floridana, S. nigrum, Capsicum annum*) were infected with the Chilli veinal mottle virus disease and the symptom could be seen in 20-25 days. The per cent transmission of ChiVMV by aphid *Aphis gossypii* was studied. The results showed that ChiVMV can be transmitted by *A. gossypii*. However, five aphids per plant showed highest per cent transmission (100%). The effect of different dates of inoculation on different plant growth parameters was also studied, the highest per cent disease transmission was observed in $T_{1:}$ Inoculation 15 days after sowing (100.00%).

Keywords: *Aphis gossypii,* Capsicum, ChiVMV, mosaic

INTRODUCTION

Capsicum (*Capsicum annum* var. grossum sendt) also called as bell pepper is an important vegetable crop. It is known for its nutritional aspects and also for nation's foreign exchange. India contributes one fourth of the world production of capsicum with an average annual production of 1.9 mt from an area of 1.82 mha with the productivity of 1.28 t/ha. Karnataka stands second in area with 89 thousand ha and production of 158 thousand tons (Anon., 2015).

Among the various biotic constraints in the production of bell pepper, viral diseases play a major role. Bell pepper is highly susceptible to natural infection by a large number of viruses in addition to being susceptible to several other diseases. Out of 42 viruses so far reported in bell pepper, 22 are found to occur naturally, while the rest are known to infect on artificial inoculation. Among these, potyviruses *viz.,* potato virus Y (PVY), pepper veinal mottle virus (PVMV), pepper vein banding virus (PVBV), chilli veinal mottle virus (ChiVMV), pepper mottle virus (PMV), tobacco etch virus (TEV) are more prevalent (Caranta *et al.,*1996).

Among these, Chilli veinal mottle virus (ChiVMV) is the major prevalent virus with the incidence of 50 per cent that reduce yield by 50 per cent worldwide (Hussain *et al*., 2008). Further, the ChiVMV is transmitted mechanically and also through aphid vector (*Aphis gossypii*) and found to infect several plant species and induces characteristic systemic mottling symptoms within 7 to 14 days of inoculation.

Several abiotic and biotic stresses affect the productivity of chilli pepper crop worldwide. More than 45-65 viruses have been reported infecting the crop worldwide (Green and Kim, 1994; Anon., 2001). Among pathogenic diseases, viruses are the most devastating agents of chilli pepper, causing serious losses by reducing both fruit quality and quantity (Kang *et al*., 1973; Villalon, 1975; Ong *et al.*, 1980; Yoon *et al.,* 1989; Chew and Ong, 1990). Viruses

produce various types of disease syndrome like mosaic, mottling, leaf distortion, vein etching, yellowing, stunting and narrowing of leaves (Green, 1991; Hameed *et al.*, 1995; Anon., 2001). *Chilli veinal mottle virus* (ChiVMV) is the major virus infecting chilli pepper reducing yield losses up to 50% (Joshi and Dubey, 1973; Ong *et al*., 1980).

MATERIALS AND METHODS

Survey

A roving survey was conducted during rabis season to determine the incidence of mosaic disease in major capsicum growing districts of Southern Karnataka (Chikkaballapura, Kolar, Bengaluru rural and Ramnagar). Plants were observed for the typical symptoms *viz.,* yellowing, mosaic symptoms, mottling *etc.* During the survey, type of symptoms was recorded at different fields and samples were collected. For each one acre of field five sites were randomly selected (10m x 10m) and the average disease incidence was calculated using the following formula.

Per cent disease incidence (PDI) =

$$\frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$

Serological survey

The samples brought from the field were subjected to serological assay using CMV and ChiVMV antiserum adopting the DAC-ELISA procedure (Hobes *et al*., 1987).

Host range

To identify the natural reservoirs of the virus different hosts *viz.,* tomato, brinjal, chilli, potato, *Nicotiana tabacum cv. Samsun, Nicotiana glutinosa, Nicotiana occidentalis, Solanum nigrum,* and others like *Chenopodium quinoa, Datura metel, D. stromanium, Physalis minima, Physalis floridana* and *Gomphrena globosa* and also the other weed hosts were sown in polythene bags of 3 X 6" size and seedlings were raised with standard agronomic practices and seedlings of 25-30 days old were used for sap inoculation. The host plants were inoculated by following the procedure described by (Noordam, 1973) and the inoculated plants were observed for symptom expression under insect proof cages for upto 30 days.

Vector transmission

The experiment was carried out to know the aphid transmissibility of ChiVMV using *Aphis gossypii*, as per the procedure explained by *Damiri et al.* (2013). The healthy aphid (*A. gossypii*) colony was first raised on the cotton host plant under greenhouse conditions (25-27OC). The vector aphids were carefully collected in plastic Petri plates and starved for 60 min. in Petri plates lined with black paper on both sides. Later allowed for 5 min. acquisition feeding on ChiVMV infected capsicum leaves, followed by brief inoculation feeding period of 1-3 min. on healthy capsicum plants. After that aphids were killed by spraying with systemic insecticide and the plants were then placed in insect proof conditions in greenhouse at 25-27°C and observed for symptom expression upto 30 days and a set of uninoculated plants were maintained as control.

Loss estimation

To know the impact of ChiVMV on per cent transmission, plant growth and yield. The experiment on loss estimation was carried out using the susceptible capsicum var. Indra. The experiment was conducted in green house conditions using CRD design with nine treatments and three replications with standard agronomic practices using the pots of 9 x 12" cement pots. The artificial sap inoculation was done at fifteen days intervals *viz.,* $T_{1:}$ Inoculation 15 days after sowing, T_2: Inoculation immediately after planting, T_3: Inoculation 15 days after planting, T_4: Inoculation 30 days after planting, T_5: Inoculation 45 days after planting, T_6: Inoculation 60 days after planting, T_7: Inoculation 75 days after planting, T_8: Inoculation 90 days after planting, T_9: Control. The observations on per cent transmission growth and yield parameters *viz.,* plant height (cm), number of branches, number of fruits, fruit weight and per cent disease transmission were recorded at the time of harvest, the data was analyzed statistically.

RESULTS AND DISCUSSION

Survey

In random survey carried out in south Karnataka**,** in Kolar district of 32.99 average per cent disease incidence was recorded, and it ranged from 14.85 to 47.42 per cent. In Chikkaballapura district the average per cent disease incidence was 20.25 and it ranged from 7.99 to 26.85 per cent and in Ramanagar district the average per cent disease incidence was 27.42 and

it ranged from 26.28 to 54.85 per cent and in Bengaluru rural district the average per cent disease incidence was 29.24 and it ranged from 27.42 to 36.56 (Table 1). This difference may be attributed to different climatic factors, vectors activity, different cultivars and different cultivation practices followed. It may also be due to variation in plant protection practices followed by the farmers, low quality seeds (Hameed *et al*., 1995), and similar work carried Laxminarayana Reddy (2006), conducted survey and reported the ChiVMV incidence ranged from 5.3 to 81.5 per cent in Karnataka, 7.6 to 31.7 per cent in Andhra Pradesh, 5.7 to 47.6 per cent in Tamil Nadu, 5.9 to 25.3 per cent in Kerala and 7.5 to 37.8 per cent in Maharashtra. Therefore, the natural incidence of Chilli veinal mottle virus disease would vary from field to field in the surveyed area.

Host range

To identify the natural reservoirs and those susceptible to virus, the host range study of the virus was conducted. Out of sixteen different plant species used in the study (Table 2). Seven plant species *viz., Nicotiana tabacum* cv. Samsun*, Nicotiana glutinosa, Nicotiana occidentalis, Daturametel, Physalis floridana, Solanum nigrum, Capsicum annum* were infected with the ChiVMV and the symptoms could be seen in 20-25 days (Table 2). The infection was confirmed by DAC-ELISA. Similar work was conducted by Siriwong *et al*. (1995) reported that host range of ChiVMV is restricted to Solanaceae family. The present results are in accordance to those reported by Moury *et al*. (2005) *i.e.,* three isolates of ChiVMV induced systemic mosaic symptoms on *N. occidentalis*, *N. glutinosa* but none infected *Solanum melongena*. Brunt *et al*. (1996) reported that *N. glutinosa* is diagnostically not a susceptible host but our findings show that this host species was susceptible and developed mosaic symptoms and was found positive in DAC-ELISA. Similar results have also been reported by Ong *et al*. (1979). Brunt (1996) reported that *Gomphrena globosa* and *Nicotiana glutinosa* is diagnostically not a susceptible host but in our case *Nicotiana glutinosa* became susceptible and developed mosaic symptoms and was DAC-ELISA positive.

Vector transmission

To find out the vector transmissibility and per cent transmission of ChiVMV by aphid *A. gossypii* was used for the transmission of Chilli veinal mottle virus using susceptible capsicum cultivar Indra. The results showed that ChiVMV could be transmitted by *A. gossypii*. Further, five aphids per plant showed highest per cent transmission (100 %) followed by four aphids per plant (80 %), three and two aphids per plant (60 %) and one aphid per plant (40 %) (Table 3). The chilli veinal mottle virus was readily transmitted by sap inoculation and also by aphid vector namely *A. gossypii*, which resembled potyvirus, reported by Mariyappan *et al*. (1973) and Bidari (1982). Jeyarajan and Ramkrishnan (1969) reported *A. gossypii*as the sole vector of potyvirus on bell pepper and chilli. This virus, on young leaves of capsicum produced green vein-banding, leaves are smaller and distorted, stunted and have dark-green streaks on their stems and branches. The symptoms were similar to those produced by potyvirus on chilli and bell pepper as reported by earlier workers (Prasad Rao, 1979; Bidari, 1982 and Pandurangegowda, 1989). The ChiVMV was readily transmitted by sap inoculation to chilli and other herbaceous hosts. The virus was also transmitted in a non persistent manner by the aphids namely, *A. gossypii*, *A. craccivora* and *Myzus persicae* and no seed transmission was observed (Satyaprakash and Singh, 2006).

Table 1 : Average per cent disease incidence of capsicum mosaic disease in different districts in Southern Karnataka

District	Per cent disease incidence	
	Average	Range
Kolar	32.99	14.85-47.42
Chikkaballapura	20.25	7.99-26.85
Ramanagar	27.42	26.28-54.85
Bengaluru rural	29.24	27.42-36.56

Table 2 : Host range of mosaic disease caused by ChiVMV under laboratory conditions

Host	No of plants inoculated	Symptoms	ELISA Absorbance	ELISA reaction (+/-)
Nicotiana tobacum cv. Samsun	5	Necrotic lesion	3.08	+
Nicotiana glutinosa	5	Severe Mosaic	3.40	+
Nicotiana occidentalis	5	Mild Mosaic & vein banding	2.87	+
Datura metel	5	Severe Mottling & rat tail	3.51	+
Physalis floridana	5	Sever Mottling	3.02	+
Solanum nigrum	5	Mild Mosaic	2.45	+
Capsicum annum	5	Mild mosaic	2.32	+
Solanum melongina	5	Nil	0.42	-
Solanum tuberosum	5	Nil	0.38	-
Solanum lycopercicum	5	Nil	0.23	-
Chenopodium quinoa	5	Nil	0.25	-
Datura stromonium	5	Nil	0.52	-
Physalis minima	5	Nil	0.34	-
Gomphrena globosa	5	Nil	0.65	-
Stachy terpeta	5	Nil	0.42	-
Passiflora foetida	5	Nil	0.53	-
ChiVMV (Positive check)	-	-	1.53	-
Healthy	-	-	0.56	-

Table 3 : Vector transmission of ChiVMV by using the aphid- *Aphis gossypii*

No. of aphids per plant	No. of plants inoculated	No. of plants infected	Per cent transmission	Days required for symptom expression
1	10	4	40	20-21
2	10	6	60	19-20
3	10	6	60	19-20
4	10	8	80	19-20
5	10	10	100	19-20
Control (uninoculated)	10	0	0	0

Loss estimation

To know the impact of stage of inoculation on per cent transmission and on plant growth and yield, the plants were inoculated artificially as explained in the material and methods. It revealed that the dates of inoculation on plant growth parameters such as plant height and number of branches and per cent transmission differed significantly over different dates of inoculation (Table 4). The maximum reduction of plant height was observed in T_1 (22.06 cm) and maximum height was

Table 4 : Loss estimation in capsicum due to ChiVMV under polyhouse conditions

Treatment	Plant height (cm)	No. of branches/ plants	No. of fruits/ plants	Average fruit weight (g)	Per cent disease incidence
T_1- 15DAS	22.06	0.66	0.00	0.00	100.00
T_2- 30DAS	25.83	1.73	1.66	7.93	99.00
T_3- 15 DAT	33.56	2.60	1.86	22.93	99.00
T_4- 30 DAT	51.10	3.46	2.37	45.83	98.66
T_5- 45 DAT	49.87	3.60	2.60	61.63	91.33
T_6- 60 DAT	50.37	3.40	4.13	79.67	72.00
T_7- 75 DAT	52.64	3.53	4.27	100.43	71.33
T_8- 90 DAT	54.06	4.13	6.06	101.26	44.66
T_9- Uninoculated (Control)	55.22	4.23	8.04	133.13	0
S.Em ±	0.74	0.08	0.16	0.62	1.05
CD @ 5%	2.21	0.26	0.48	1.86	3.14

Note: DAS- Days after sowing, DAT- Days after transplanting

found in T_9 (55.22). Similarly, maximum reduction in number of branches found in T_1 (0.66) maximum number of branches was found in T_9 (4.23) (Table 4 and Fig.1).

There was significant difference with respect to number of fruits per plant observed among the treatments (Table 4). Maximum reduction of fruits per plant were noticed in T_1 (0.00) and maximum number of fruits per plant was found in T_9 (8.04) (Table 4 and Fig.1). Data pertaining to average fruit weight differed significantly over different dates of inoculation and similar trend was observed in T_9 (133.13) (Table 4 and Fig.1).

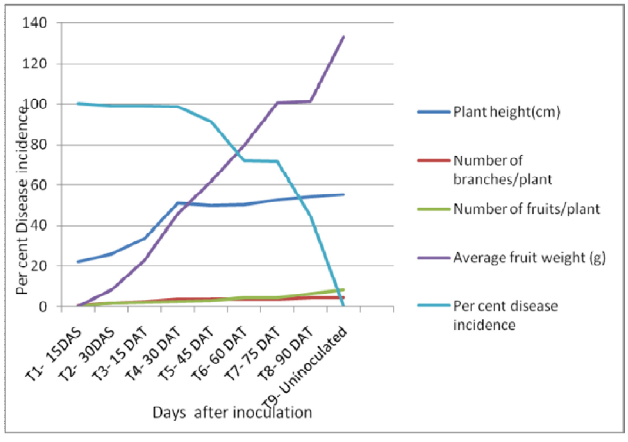

Fig. 1 : Effect of different dates of inoculation on growth and other characters

Per cent transmission

Highest per cent disease transmission was observed in T_1 (100.00 per cent) followed by T_2 and T_3 (99 per cent each), T_4 (98.66 per cent), T_5 (91.33 per cent), T_6 (72 per cent), T_7 (71.33 per cent) and T_8 (44.66 per cent) and the rate of transmission and the impact was decreased with the increase in age of the plant and they differ significantly (Fig.1).

The infection occurs at later stages, the extent of reduction in yield and plant height was less. Sastry and Singh (1976) reported that ToLCV infected plants produced very few fruits when infected within 20 days after planting and resulting up to 92.30 per cent yield loss. While plants infected at 35 and 50 days after transplanting resulted in 82.9 and 74.0 per cent yield loss, respectively. Similar results were reported by Reddy *et al.* (2010).

CONCLUSION

It is concluded that since the infected plants cannot be cured and the early infection leads to severe reduction both in yield and quality, early-stage protection of the crop both in nursery and in the main field is important in order to reap the better yields.

REFERENCES

Reddy, B.A., Patil, M.S. and Rajasekaram, T. 2010.Effect of tomato leaf curl virus infection

on plant growth and yield in tomato. *K. J. Agric. Sci.,* **23**(5): 806

Anonymous.2001. *Proceedings of the South Asia Vegetable Research Network* (SAVERNET-II) Final Workshop 3-8 June 2001, Bangkok, Thailand. Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan.

Bidari, V. B. 1982. Distribution and epidemiology of chilli viruses in Karnataka. *Ph. D. Thesis*, *Uni. Agric. Sci*., Bangalore.

Brunt, A. A., Crabtree, K., Gibbs, M. J., Watson L. and Zurcher, E. J. 1996. Plant Viruses online: Description and lists from VIDE. http://biology.anu.edu. Au/Group/MES/vide.

Caranta, C. and Palloix, A. 1996. Both common and specific genetic factors are involved in phylogenic resistance of pepper to several potyviruses. *Theor. Appl. Genet*., **92**: 15-20.

Chew, B.H. and Ong, C.A., 1990. *Genetics and Breeding for chilli veinal mottle and cucumber mosaic virus resistances in hot pepper*. Malaysian Plant Protection Society.

Damiri, B. V., Al-Shahwan, I. M., Al-Saleh, M. A., Abdalla, O. A. and Amer, M. A. 2013. Identification and characterization of cowpea aphid-borne mosaic virus isolates in Saudi Arabia. *J. Pl. Pathol.,* **95**(1): 79-85.

Green, S.K. 1991. *Guidelines for diagnostic work in Plant virology*. Asian Vegetable Research and Development Center. *Tech. Bulletin*, No. **15**, Second Edition.

Green, S.K. and Kim.J.S.1994. Source of resistance to viruses of pepper (*Capsicum* spp.): Acatalog. AVRDC *Tech. Bulletin*, p. 20-64.

Hameed, S., Shah, H., Ali, H., and Khalid, S. 1995. Prevalence of chilli viruses in Pakistan. *Fifth National Congress of Pl. Sci*., 28-30 March, NARC, Islamabad.

Hussain, S., Tahira, Y.Fahim, M., Shahid, H., and Haque, M.I. 2008. Transmission and host range studies of Pakistani isolate of C*hilli veinal mottle virus*. *Pak. J. Bot*., **40**(6): 2669-2681.

Jeyarajan, R. and Ramakrishnan, K.1969. *Potato virus Y* on chilli (*Capsicum annuum* L.) in Tamil Nadu. *Madras Agric. J.*, **56**: 761-766.

Joshi, R.D. and Dubey, L.N. 1973. Assessment of losses due to CMV on chilli. *Sci. Cult.*, **39**: 521-522.

Kang, K.Y., Choi, J.I. and La, Y.J. 1973. Isolation and identification of viruses affecting pepper (*Capsicum annuum*) in Korea. *J. Kor. Soc. Horti. Sci.*, **13**: 35-43.

Laxminarayana Reddy, C.N.2006. Molecular characterization of *Chilli veinal mottle virus* infecting chilli (*Capsicum annum* L.), *Ph. D.(Agri.) thesis, UAS, Bengaluru,* p. 136.

Mariappan, V., Govindaswamy, C.V. and Ramakrishnan, S. 1973. Studies on the role of weed plants in spread virus diseases. II Role of *Solanum nigrum* in spreading chilli mosaic virus a strain of potato virus-y. *Madras Agric. J.,* **60**: 120-122.

Moury, B., Palloix, A., Caranta, C., Gagnalons, P., Souche, S., Gebre, S. K. and Marchoux, G. 2005. Serological, molecular and pathotype diversity of *Pepper veinal mottle virus* and *Chilli veinal mottle virus*. *Phytopathol.*, **95**: 227-232.

Noordam, D.,1973. Dilution end-point determination In: *Identification of Plant viruses: Methods and Experiments*. Published by PUDOC, Center for Agricultural Publishing and Documentation, Wageningen, Netherlands.

Ong, C. A., Varghese, G. and Poh, T. W. 1979. An etiological investigation on a *veinal mottle virus* of chilli (*Capsicum annuum* L.), newly recorded from Peninsular Malaysia. *Malaysian Agric. Res. Dev. Inst. (MARDI) Res. Bull*., **7**: 78-88.

Ong, C.A.,Varghese, G. and Poh, T.W.1980. The effect of chilli veinal mottle virus on yield of chilli (*Capsicum annuum* L.). *MARDI Res. Bulletin*, **8**: 74-79.

Ong, C.A., Varghese, G. and Tingwen, P.1979. Aetiological investigation on a veinal mottle virus of chilli (*Capsicum annuum* L.) newly recorded from peninsular Malaysia, *MARDI Res. Bulletin.*, **7**: 278-288.

Pandurangegowda, K. T. and Reddy, H. R. 1989. Aphid transmitted viruses infesting chilli. *Curr. Res.,* **18**: 71-72.

Prasad Rao, R. D. V. J. and Yaraguntaiah, R. C. 1979. A key for diagnosis of some *chilli mosaic viruses*. *Mysuru J. Agric. Sci.,* **13**: 442-445.

Sastry, K. M. S. and Singh, S. J. 1976. Assessment of losses in tomato caused by *Tomato leaf curl virus*. *Indian J. Mycol. Pl. Pathol.,* **3**: 50-54.

Satya Prakash and Singh, S. J. 2006. Insect transmitted viruses of peppers. *Veg. Sci.* **33**(2): 109-116.

Siriwong, P., Kittipakam, K. and Lkegaru, M. 1995. Characterization of *chilli vein banding mottle virus* isolated from pepper in Thailand. *Pl. Pathol.,* **49**: 710-727.

Villalon, B.1975. Virus diseases of bell pepper in South Texas. *Pl. Dis. Rep.*, **59**: 858-862.

Yoon, J.Y., Green, S.K., Tschanz, A. T., Tsou, S.C.S. and Chang, L.C.1989. Pepper improvement for the tropics, problems and the AVRDC approach. In: *Tomato and pepper production in the tropics*. (Eds.) S.K. Green, T.D. Griggs and B.T. Mclean, B.T.: Proceeding of the international symposium on integrated management practices 21-26 March 1998, Tanian, Taiwan, pp. 86-98.

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