TRANSMISSION STUDIES OF CUCUMBER MOSAIC VIRUS CAUSING MOSAIC OF CHILLI (*CAPSICUM ANNUUM* L.)

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Abstract: Chilli is susceptible to a wide variety of diseases caused by fungi, bacteria, viruses and phytoplasmas, out of which viruses cause heavy losses to the crop yields.Survey carried out in farmers' fields in the major chilli growing areas of Krishna – Godavari Zone of Andhra Pradesh revealed that the incidence of cucumber mosaic virus ranged from 0.77 to 71.11 per cent.This virus was transmitted through sap and aphids in non-persistent manner. The virus was sap transmitted to hosts like *Nicotianaglutinosa*L., *N. tabacum*cv.White Burley and *N. tabacum* cv. Samsun while aphid species *Aphis gossypii* and *Myzuspersicae* transmitted it in non-persistent manner. Sodium phosphate-potassium phosphate buffer was found to be the most suitable buffer for the mechanical inoculation of CMV in the laboratory. The virus was successfully extracted from the infected leaves in the presence of sodium phosphate-potassium phosphate buffer of pH 7.0 and the transmission success was 100, 96.67 and 93.33 per cent of 0.1, 0.05 and 0.01 M concentrations, respectively. Insect transmission studies revealed that *Aphis gossypii*and*Myzuspersicae* are the efficient vectors of CMV of chilli isolate.Hundred per cent transmission was obtained by both the insects when the chilli plants were inoculated with 10 insects per plant with a pre-acquisition starving period of 60 min, acquisition feeding period of 10 min and inoculation feeding period of 24 h. The virus under study was not of seed-borne in nature.

Key words: Chilli, transmission, Cucumber mosaic virus.

Introduction: Chilli (*Capsicum annuum* L.) is an important commercial spice and vegetable crop belonging to the family Solanaceae. India's chilli production stood at around 12 lakh tonnes while the global out put was 27.7 lakh tonnes. Chilli is the second largest traded spice in the world with a 22% contribution in the world spice trade. India contributes 25% of the global chilli exports. Chillies are cultivated mainly in the states of Andhra Pradesh, Orissa, Maharashtra, West Bengal, Karnataka, Rajasthan and Tamil Nadu. Andhra Pradesh is the foremost accounting for 50% of the production in the country.

Chilli is susceptible to a wide variety of diseases caused by fungi, bacteria, viruses and phytoplasmas, out of which viruses cause heavy losses to the crop yields (SatyaPrakash, 2001). Over 72 viruses have been reported to infect chilli crop all over the world (SatyaPrakash and Singh, 2004) of which, cucumber mosaic virus (CMV), pepper veinal banding virus (PVBV), potato virus Y (PVY), pepper veinal mottle virus (PVMV), tobacco etch virus (TEV) and tobacco mosaic virus (TMV) has become serious production constraints in Andhra Pradesh. Chilli is infected by cucumber mosaic virus isolate which is transmitted in a non-persistent manner by aphid species causing mosaic disease. Symptoms of CMV are specific to each of its host and vary in their expression. In view of the importance of disease resulting in major losses, attempts were made to study symptomatology and mode of transmission.

Materials and Methods

Survey for the incidence of CMV on chilli: Survey was undertaken in farmers' fields in the major chilli growing areas of Guntur, Prakasam, Krishna, East and West Godavari and parts of Khammam district pertaining to the Krishna – Godavari Zone of Andhra Pradesh to assess the incidence of cucumber mosaic virus. Samplings were made at flowering and podding stages of the crop in two consecutive seasons during *kharif*, 2002-03 and 2003-04. A total of 270 fields pertaining to Guntur, Prakasam, Krishna, West Godavari, East Godavari and Khammam districts were surveyed during both years. In each field, five plots, each of a size of 2.0 x 2.0 m were laid out diagonally with the help of a wooden quadrangle. In each plot, the number of healthy chilli plants and the number of plants showing the typical symptoms of CMV were recorded and the per cent incidence was estimated using the following formula.

$$\text{Per cent incidence of CMV} = \frac{\text{Number of plants infected}}{\text{Total number of plants}} \times 100$$

Diseased samples showing the typical symptoms of CMV were collected from different plants in the field and enclosed in polyethylene bags. Care was taken to make the bag airtight removing the air inside. Labels furnished with the information on place of collection, date of collection and the variety were tagged on to the bags. These samples were carried to the laboratory in ice buckets and transferred immediately to the refrigerator at 4°C for carrying out further studies.

Nursery Raising and Maintenance of Experimental Plants: Nurseries for the chilli were raised in earthen pots of 15.0 x 35.0 cm size

containing a mixture of alfisol, sand and farm yard manure (2:1:1). Young seedlings of 30 days old were transplanted in earthen pots of 15.0 x 15.0 cm size containing the soil mixture as mentioned above. Young and actively growing seedlings were used for all experimental purposes. All the experimental plants were maintained under an insect proof polyhouse. The plants were watered regularly. Fertilizers like diammonium phosphate and urea were applied at regular intervals for vigorous growth of experimental plants. Insecticides such as monocrotophos (1.5 ml/1 of water), dimethoate (2.0 ml/l of water) and kelthane (3.0 ml/l of water) were sprayed to the plants occasionally.

Rearing of Aphids: Two species of aphids*viz*., *Myzuspersicae*and *Aphis gossypii*were collected from naturally infested chilli plants at the Agricultural College Farm, Bapatla. Non-winged adults were located on the infested plants and transferred to the healthy chilli leaves in Petri plates with the help of a zero camel brush. The petioles of the leaves were plugged with a swab of wet cotton to maintain the turgidity of leaves till they were brought to the laboratory. The insects brought to the laboratory were transferred to a set of healthy chilli plants enclosed in insect proof cages. The host plants were changed periodically for continuous maintenance of the insect colonies in the laboratory. The insects from the colonies were used for transmission studies. A sample of insects from each colony was transferred to small glass vials containing ethanol (absolute) for identification. The vials were labelled, sealed with wax and identified in the Department of Entomology, AgriculturalCollege, Bapatla at species level.

Isolation and Maintenance of Virus Isolates: The virus isolates sampled from farmers' fields were inoculated on to the chilli cultivar 'Sindhur' (CA-960) and tobacco plants *Nicotianatabacum*cv. Gautham by sap inoculation method adopting the following procedure. ***Sap Inoculation:*** The infected leaves made into small pieces were weighed and ground in the presence of 0.01 M phosphate buffer (pH 7.0) containing 0.2% 2-mercaptoethanol. In the case of tobacco, leaf lamina was separated from the hard veins and made into small pieces. The entire process of grinding was done under cold conditions in an ice bucket with the help of pre-chilled mortar and pestle. The crude extract was filtered through a double layered muslin cloth in a beaker. A pinch of carborundum powder (600 mesh) was added to the filtrate.Young and actively growing chilli plants were used for inoculation purpose. The leaves of the experimental plants to be inoculated were washed with distilled water prior to inoculation to remove the dirt. The extracted sap was rubbed gently over the leaves for 2 to 3 times in one direction followed by rinsing with distilled water. The test plants were labelled and kept under observation for symptom expression.

Transmission tests

Mechanical Transmission of CMV : An experiment was conducted in the laboratory to determine a suitable buffer for the efficient mechanical transmission of CMV. Three buffers viz., sodium phosphate - citrate, sodium phosphate -potassium phosphate and Tris – HCl were used at different concentrations and p^H levels. Sodium phosphate–citrate buffer was tested at 0.1, 0.01 and 0.05 M concentrations and 6.0, 7.0 and 8.0 pH levels. Sodium phosphate - potassium phosphate buffer was tested at 0.1, 0.01 and 0.05 M concentrations and 6.5, 7.0 and 7.5 pH levels. While, Tris – HCl was tested at 0.1and 0.05 M concentrations and at 6.0, 7.0 and 8.0 pH levels. The flasks were labelled and stored in a refrigerator for pre-chilling effect. A set of mortars and pestles were washed thoroughly, sterilized and kept in a refrigerator for a day before extraction. Young leaves showing the typical symptoms of CMV were harvested from a chilli plant maintained in the laboratory. The leaves were made into small pieces and the required quantities of the infected material were ground in the presence of required quantities (2:1) of the test buffer in mortar and pestle. The entire process of extraction was done under cold conditions. The reducing agent such as 0.2 % 2-mercaptoethanol (v/v) was added to the test buffer before grinding. The extract was filtered through a double layered muslin cloth and the filtrate was collected in a beaker. A pinch of carborundum powder (600 mesh) was added to the filtrate. The extract was rubbed over the leaves for 2 to 3 times in one direction. The inoculated leaves were rinsed with distilled water immediately. The same was repeated for all the three test buffers and at the concentrations and pH levels listed above. The experimental plants were labelled and kept under observation for symptom expression.

Insect Transmission: Insect transmission tests were carried out in the laboratory by using two aphid species of viz., *Aphis gossypii* and *Myzuspersicae* to determine the virus-vector relationship.

Virus- vector relationship

Determination of minimum number of aphids required for transmission of CMV: The adult apterous*Aphis gossypii* and*Myzuspersicae* were transferred to empty Petri plates from the aphid colonies maintained on healthy plants with the help of a brush. The insects were allowed to starve for 60 min as pre-fasting period. These insects were again transferred to the leaves infected with CMV in a Petri plate and allowed to feed for 10 min. After an acquisition of 10 min, the aphids were transferred to healthy chilli plants at 1, 2, 4, 6, 8, 10 and 15 insects

per plant and allowed to feed for 24 h. After 24 h of inoculation the test plants were sprayed with monocrotophos (1.6 ml/l of water). Ten plants were inoculated for each treatment. The test plants were labelled and kept under observation for symptom expression.

Determination of pre-acquisition starving period: Both the adult apterousAphis gossypii andMyzuspersicae from the colonies maintained on healthy plants were transferred to empty Petri plates with the help of a brush. Then these insects were allowed to starve for different periods of 0, 10,15, 30 and 60 min. In the case of 0 period the insects were not given any fasting period. These insects were immediately transferred to the leaves infected with CMV in a Petri plate and allowed to feed for 10 min (Plate 4 –5). Later, viruliferous aphids were inoculated to healthy chilli plants and allowed to feed for 24 h. Ten plants were inoculated for each treatment. After 24 h of inoculation the test plants were sprayed with monocrotophos (1.6 ml/l of water). The experimental plants were labelled and kept under observation for symptom expression.

Determination of acquisition feeding period: Both the adult apterous*Aphis gossypii* and*Myzuspersicae*were transferred to empty Petri plates from the colonies maintained on healthy plants with the help of a brush and allowed to starve for 60 min. These insects in batches of ten were transferred to the leaves infected with CMV in a Petri plate and allowed to feed for different periods of 30 sec, 1, 2, 5, 10,15, 30, 60 and 120 min. Later, the insects were inoculated to healthy chilli plants and allowed to feed for 24 h. Ten plants were inoculated for each treatment. After 24 h of inoculation the test plants were sprayed with monocrotophos (1.6 ml/l of water). The experimental plants were labelled and kept under observation for symptom expression.

Determination of post-acquisition starving period: Both the adult apterous*Aphis gossypii* and*Myzuspersicae*were transferred to empty Petri plates from the aphid colonies maintained on healthy plants with the help of a brush. The insects were fed on detached chilli leaves showing typical symptoms of CMV for 10 min. Later these insects in batches of ten were allowed to starve for different periods of 0, 10, 15, 30 and 60 min. Later, the insects were transferred to healthy chilli plants and allowed to feed for 24 h. Ten plants were inoculated for each treatment. After 24 h of inoculation the test plants were sprayed with monocrotophos (1.6 ml/l of water). The experimental plants were labelled and kept under observation for symptom expression.

Determination of inoculation feeding period: Both the adult apterous*Aphis gossypii* and*Myzuspersicae* were transferred to empty Petri plates from the aphid colonies maintained on healthy plants with the help of a brush and allowed to starve for 60 min. The insects were fed on detached chilli leaves showing the typical symptoms of CMV for 10 min. Later, the aphids were transferred to healthy chilli plants and allowed to feed for different periods of 30 sec, 1, 5, 10, 15, 30, 60 min and 6, 12 and 24 h. Ten plants were inoculated for each treatment. After 24 h of inoculation the test plants were sprayed with monocrotophos (1.6 ml/l of water). The experimental plants were labelled and kept under observation for symptom expression.

Seed Transmission: Transmission studies were carried out in the laboratory to determine the transmission of the virus through seed. Ripened pods from the chilli plants showing the symptoms of CMV were collected from farmers' fields during *Kharif,* 2002. These pods were dried for seven days under sun and the seeds were collected in a cloth bag. Twenty seeds were sampled from the seed lot and sown at different periods in earthen pots of 15.0 x 15.0 cm size containing a mixture of soil, sand and farmyard manure in the ratio of 2:1:1. The pots were kept in insect proof cages in polyhouse and the seedlings were watered regularly. The plants were observed for 60 days for symptom expression.

Results and Discussion

Survey for the incidence of CMV on chilli: Survey was undertaken in farmers' fields in the major chilli growing areas of Guntur, Prakasam, Krishna, West and East Godavari and parts of Khammam districts pertaining to the Krishna – Godavari (KG) zone of the Andhra Pradesh to assess the incidence of cucumber mosaic virus. The data presented in Table 1 revealed that the incidence of CMV ranged from 0.77 to 71.11 per cent. Of the total 270 fields surveyed in both the consecutive seasons 2002-'03 and 2003-'04, 175 fields recorded less than 5.0 per cent, 64 fields recorded 5.0-15.0 per cent, 22 fields recorded 15.0-25.0 per cent, seven fields recorded 25.0-50.0 per cent and two fields recorded more than 50.0 per cent incidence of CMV.Under field conditions, the disease was characterized by the visual symptoms such as mosaic mottling, puckering, yellow discoloration, vein-clearing, curling, inward rolling, distortion, filiform, rat tailing and reduction in inter nodal length, leaf and fruit size and stunted growth.The virus isolates collected from farmers' fields inoculated to a set of differential hosts and the result of their reaction revealed that chilli isolates of CMV induced characteristic chlorotic local lesions followed by necrosis on *Chenopodiumamaranticolor;*chlorotic local lesions followed by systemic mosaic symptoms on *Cucumissativus*; necrotic local lesions on *Vignasinensis;* characteristic mosaic symptoms on

Nicotianaglutinosa; systemic mosaic symptoms and blistering on *Nicotianatabacum* cv. White Burley; systemic mosaic, vein clearing and reduction in leaf size on *Capsicum annuum*cv. California Wonder and necrotic local lesions on *Daturastramonium*.

Transmission tests

Mechanical Transmission of CMV: Effect of different buffers such as sodium phosphate-citrate, sodium phosphate-potassium phosphate and Tris-Hcl were tested at different pH levels and at different concentrations by mechanical transmission and the data is presented in Table 2 revealed that the highest transmission was obtained from sodium phosphate – potassium phosphate buffer at pH 7.0 of 0.1 M (100%), 0.05 M (96.67%) and 0.01 M (93.33%) which are at par with each other. While, the success was less than 73.33 per cent in the rest of the treatments.These findings are in accordance with those of Nagaraju and Reddy (1982), Narayan Rishi and PoonamDhawan (1989) and Kiranmai*et al*. (1997).

Insect Transmission: A preliminary trial was conducted on the efficacy in transmission of cucumber mosaic virus to both chilli and tobacco plants by three aphid species viz., *Aphis gossypii, A. craccivora* and*Myzuspersicae*. Results presented in Table 3 revealed that 80.0, 70.0 and 10.0 per cent of transmission success was achieved by *A. gossypii*, *M. persicae* and *A. craccivora* respectively on to chilli plants. While, the transmission success was 90.0, 80.0 and 20.0 per cent by *A. gossypii*, *M. persicae* and *A. craccivora* respectively on to tobacco plants. With the results achieved a detailed investigation was carried out on the virus-vector relationship using *A. gossypii* and *M. persicae*.These findings are in accordance with that of PrasadaRao (1976), Nagaraju and Reddy (1982), Gomez Pinar and Blanco Sanchez (1985) who reported that *A. gossypii*and *M. persicae* are the efficient vectors of cucumber mosaic virus.

Virus – Vector relationship

Determination of minimum number of aphids required for transmission of CMV: The trial was conducted to determine the minimum number of aphids required for transmission of CMV using two species of aphids viz., *A. gossypii* and *M. persicae*. The adult insects given a pre-starving period of 1 h, an acquisition feeding period of 10 min and inoculation access period of 24 h were inoculated on to chilli plants at the rate of 1, 2, 4, 6, 8, 10 and 15 insects per plant and the results are presented in Table 4.A single adult aphid of A. gossypii was able to transmit CMV of chilli isolate and the success was 20.0 per cent. The transmission success was 30.0, 50.0, 60.0 and 80.0 per cent with 2, 4, 6 and 8 insects inoculated per seedling respectively. The transmission success increased with the increase in number of insects per seedling. A minimum of 10 insects per seedling could get 100 per cent success in transmission of the virus.Similarly a single adult aphid of *M. persicae* was able to transmit CMV isolate of chilli and the success was 10.0 per cent. The transmission success was 20.0, 40.0, 50.0 and 70.0 per cent with 2, 4, 6 and 8 insects inoculated per seedling respectively. The transmission success has increased with the increase in number of insects per seedling to a minimum of 10 insects per seedling achieved 100 per cent of success in transmission of the virus.Dubey and Joshi (1974) also reported that a single aphid of *A. gossypii* was able to transmit CMV to chilli with a pre-acquisition fasting period of 4 h, acquisition feeding of 2 min and inoculation feeding of 30 min. Lockhart and Fischer (1976) also reported that a single aphid of *M. persicae* transmitted CMV to pepper, when the aphids were given 60 min of pre-acquisition starvation period, 5 min of acquisition feeding period and 24 h of inoculation feeding period.

Determination of pre-acquisition starving period: The trial was conducted to determine the efficacy of pre-acquisition starving period for the transmission of CMV of chilli isolate. The insects were allowed to starve for a period of 0, 10, 15, 30 and 60 min before acquisition of the virus. In the case of 0 period, the insects were not given any fasting period. After the pre-acquisition fasting period, the insects were allowed to feed for 10 min (AFP) over the leaves infected with CMV. The viruliferous insects at the rate of 10 insects per plant were inoculated on to healthy chilli plants with an inoculation feeding period of 24 h (IFP) and the results are presented in Table 5.The insects were able to transmit the virus to the extent of 10.0 per cent success with out any pre-acquisition starving. The success of transmission has increased to 30.0, 40.0 and 60.0 per cent with the increase in starving period of 10, 15 and 30 min respectively. While, the success of transmission was 100 per cent when the insects were given a starving period of 60 min prior to the acquisition of the virus. The insects were able to transmit the virus to the extent of 10.0 per cent success with out any pre-acquisition starving. The success of transmission has increased to 20.0, 30.0 and 60.0 per cent with the increase in starving period of 10, 15 and 30 min respectively. While, the success of transmission was 100 per cent when the insects were given a starving period of 60 min prior to the acquisition of the virus.While, PandurangeGowda (1979) and Nagaraju and Reddy (1982) reported that pre-acquisition fasting period of one hour is required for transmission of CMV to chilli. Dubey and Joshi (1974) reported that pre-acquisition fasting period of 4 h is required for transmission of CMV to chilli. The variation in transmission success might be due to the variability in aphid species and the test plants used

for conducting the experiments.

Determination of acquisition feeding period: The trial was conducted to determine the minimum acquisition feeding period required for transmission of CMV of chilli isolate. The insects were allowed for starving for a period of 1 h. These insects were then transferred to the leaves infected with CMV and allowed to feed for different periods of acquisition such as 30 sec, 1, 2, 5, 10, 15, 30 min, 1 h and 2 h. Later the insects at the rate of ten per plant were inoculated to healthy chilli plants and allowed to feed for 24 h. The per cent success of transmission was presented in Table 6.In case of *A. gossipii*, the results revealed that the minimum acquisition feeding period was 1 min however, the transmission success was only 20.0 per cent. When the acquisition feeding period increased to 2 and 5 min the transmission success was 20.0 and 50.0 per cent respectively. The transmission success was 100 per cent when the acquisition feeding period was 10 and also for 15 min. Further increase in acquisition feeding period of 30 min, 1 h and 2 h the success of transmission was decreased to 70.0, 60.0 and 40.0 per cent respectively.Where as when *M. persicae* was used the results revealed that when the minimum acquisition feeding period was 1 min however, the transmission success was only 10.0 per cent. When the acquisition feeding period has increased to 2 and 5 min the transmission success was 40.0 and 60.0 per cent respectively. The transmission success was 100 per cent when the acquisition feeding period was 10 and also for 15 min. Further increase in acquisition feeding period to 30 min, 1 h and 2 h the success of transmission was decreased to 60.0, 40.0 and 40.0 per cent respectively. Earlier reports revealed that both *A. gossypii* and *M. persicae* transmits the CMV of chilli isolate with an acquisition access period 20 min (PrasadaRao 1976) and 15-20 min (Nagaraju and Reddy 1982). Simons (1957) from Everglade's area of South Florida reported that a single aphid of both *A. gossypii* and *M. persicae* transmitted CMV to bell pepper with an acquisition-feeding period of 20 sec. Dubey and Joshi (1974) reported that a single aphid of *A. gossypii* transmitted CMV to chilli with an acquisition-feeding period of two min. As per the studies made by PandurangeGowda (1979), the acquisition feeding period for *A. gossypii* was 20 min.

Determination of post-acquisition starving period: The trial was conducted to determine the influence of post-acquisition starving period for the efficient transmission of CMV of chilli isolate by both the species of aphids viz., *A. gossypii* and *M. persicae.* The insects were allowed for fasting for 1 h prior to the acquisition of the virus for 10 min on to the detached chilli leaves showing typical symptoms of CMV. After acquisition, the insects were again allowed to starve for different periods of 0, 10, 15, 30 and 60 min. These insects were transferred to healthy chilli plants at the rate of ten insects per plant and allowed to feed for 24 h. The results are presented in Table 7 on transmission of *A. gossypii* revealed that the transmission success was 100 per cent when the insects were transferred immediately after acquisition without any post-acquisition starving period. With the increase in starving period for 10, 15, 30 and 60 min the success of transmission was reduced to 80.0, 50.0, 30.0 and 10.0 per cent respectively prior to the inoculation of the virus. Results in transmission of *M. persicae* revealed that the transmission success was 100 per cent when the insects were transferred immediately after acquisition without any post-acquisition starving period. With the increase in starving period for 10, 15, 30 and 60 min the success of transmission has reduced to 70.0, 40.0, 20.0 and 10.0 per cent respectively prior to the inoculation of the virus.The present findings are in accordance with the statements made by PandurangeGowda (1979) and Nagaraju and Reddy (1982) that an immediate transfer of aphid would be better for a successful transmission of CMV to chilli.

Determination of inoculation feeding period: The trial was conducted to determine the minimum inoculation feeding period required for the efficient transmission of CMV of chilli isolate by both the species of aphids viz., *A. gossypii* and *M. persicae.* The insects were given a pre-starving period of 1 h prior to the acquisition of the virus for 10 min on to the detached chilli leaves showing typical symptoms of CMV. Later the insects at the rate of ten per plant were transferred to healthy chilli plants and allowed to feed for different periods of 30 sec, 1, 5, 10, 15, 30, 60 min and 6, 12 and 24 h and the results are presented in Table 8.The results of *A. gossypii* indicated that the minimum inoculation feeding period for transmission of CMV of chilli isolate was 10 min however, the transmission success was 20.0 per cent. The transmission rate was remained the same for 15 min of inoculation feeding period. With further increase of 30 and 60 min, 6 h and 12 h of inoculation period, the success of transmission was 30.0, 40.0, 60.0 and 80.0 per cent respectively. The transmission success was 100 per cent at 24 h of inoculation feeding period.The results of *M. persicae* indicated that the minimum inoculation feeding period for transmission of CMV of chilli isolate was 15 min however, the transmission success was 20.0 per cent. With further increase of 30 and 60 min, 6 h and 12 h of inoculation period, the success of transmission was 40.0, 40.0, 50.0 and 70.0 per cent respectively. The transmission success was 100 per cent at 24 h of inoculation feeding period.These findings are in accordance with that of Nagaraju and Reddy (1982)

who has made similar study and reported that *A. gossypii*could able to transmit the CMV to chilli plants with 24 h of inoculation feeding period. However, Dubey and Joshi, (1974) and PandurangeGowda (1979) reported that 30 and 60 min of inoculation are adequate for the transmission of CMV by *A. gossypii* and *M. persicae*.

Seed Transmission: Transmission studies were carried out in the laboratory to determine the transmission of the virus through seed. The seeds collected from the ripened pods of the chilli plants infected with CMV were dried and sown at different intervals in earthen pots. Data presented in Table 9 indicated that none of the seedlings showed the disease symptoms indicating that the virus is not seed-borne in nature.These results are in conformity with the findings of the earlier workers who reported that CMV is not seed transmitted in chilli (Gahukar and Nariani, 1982; Nagaraju and Reddy, 1982 and Sharma et. al. 1993).

References:

1. **Dubey L N and Joshi R D 1974.** Transmission studies on chilli mosaic (CMV) by its vector *A. gossypii*Glove. *Bangladesh Journal of Botany* 3: 93-97.
2. **Gahukar K B and Nariani T K 1982.**Studies on aphid borne mosaic disease of chilli.*Indian Phytopathology* 35: 73-79.
3. **Gomez Pinar J and Blanco Sanchez N 1985.**Differences in aphid transmission of two strains of cucumber mosaic virus.*Ciencieas De La Agricultura* 25: 132-133.
4. **Kiranmai G, Sreenivasulu P and Nayudu M V 1997.** Characterization of cucumber mosaic cucumo virus isolates naturally infecting three solanaceous vegetable crops in Andhra Pradesh. *Indian Phytopathology* 50: 416-425.
5. **Lockhart B E L and Fischer H U 1976.**Cucumber mosaic virus infection of pepper in Morocco.*Plant Disease Reporter* 60: 262-264.
6. **Nagaraju and Reddy H R 1982.**Occurrence of cucumber mosaic virus in bell pepper.*Indian Journal of Mycology and Plant Pathology* 12: 217-219.
7. **Narayan Rishi and PoonamDhawan 1989.** Characterization and identification of viruses causing mosaic diseases of capsicum in nature. *Indian Phytopathology* 42: 221-226.
8. **PandurangeGowda K T 1979.** Studies on chilli (*C. annuum*Linn.) mosaic virus occurring in some parts of Kolar district. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Bangalore, India.
9. **Prasada Rao R D V J 1976.**Characterization and identification of some chilli mosaic viruses. Ph.D Thesis, University of Agricultural Sciences, Hebbal, Bangalore.
10. **SatyaPrakash 2001.**Studies on virus diseases of chilli (*C. annunm*Linn.).Ph. D. Thesis, Department of Botany, D.D.U. Gorakhpur Univ. Gorakhpur, Uttar Pradesh, India, p. 283.
11. **SatyaPrakash and Singh S J 2004.** Viral diseases of chilli/capsicum in India, their management and future research needs. *Vegetable Science* (In Press).
12. **Simons J N 1957.** Three strains of cucumber mosaic virus affecting bell pepper in the Everglades area of South Florida. *Phytopathology* 47: 145-150.

Table1. Incidence of CMV district wise in KG Zone of Andhra Pradesh

District	Disease incidence (%)				
	<5	5-15	15-25	25-50	>50
Guntur (50)	31	14	4	1	-
Prakasam (50)	34	11	2	2	1
Krishna (50)	26	18	6	-	-
West Godavari (50)	32	10	6	1	1
East Godavari (50)	32	11	4	3	-
Khammam (20)	20	-	-	-	-
Total (270)	175	64	22	7	2

Figures in parenthesis indicate the number of chilli fields surveyed

Table2. Effect of buffers in transmission of CMV of chilli isolate			
Buffer	**pH**	**Concentration**	***Per cent Transmission**
Sodium phosphate - citrate buffer	6	0.1 M	23.33 (28.78)
		0.05 M	20.00 (26.56)
		0.01 M	16.67 (23.85)
	7	0.1 M	60.00 (50.77)
		0.05 M	56.67 (48.85)
		0.01 M	53.33 (46.92)
	8	0.1 M	40.00 (39.23)
		0.05 M	33.33 (35.22)
		0.01 M	30.00 (33.21)
Sodium phosphate - potassium phosphate buffer	6.5	0.1 M	56.67 (48.85)
		0.05 M	53.33 (46.92)
		0.01 M	50.00 (45.00)
	7	0.1 M	100.0 (89.19)
		0.05 M	96.67 (83.31)
		0.01 M	93.33 (77.44)
	7.5	0.1 M	60.00 (50.77)
		0.05 M	56.67 (48.85)
		0.01 M	53.33 (46.92)
Tris - HCl buffer	6	0.1 M	30.00 (33.21)
		0.05 M	26.67 (30.99)
	7	0.1 M	73.33 (59.01)
		0.05 M	70.00 (56.79)
	8	0.1 M	50.00 (45.00)
		0.05 M	43.33 (41.15)
SEm+/-			2.25
C.D (0.05%)			6.42
* Mean of three replications			
Figures in parenthesis are arc sin transformed values			

Table 3. Transmission of CMV by different species of aphids						
Aphid species*	Chilli			Tobacco		
	No. of plants inoculated **	No. infected	Per cent Transmission	No. of plants inoculated **	No. infected	Per cent Transmission
A. gossypii	10	8	80.00	10	9	90.00
A. craccivora	10	1	10.00	10	2	20.00
M. persicae	10	7	70.00	10	8	80.00

Acquisition feeding period was 10 min; ** 10 adults per plant were inoculated

Table4. Determination of minimum number of aphids required for transmission of CMV			
Aphid Species*	No. of plants		Per cent Transmission
	Inoculated	Infected	
A. gossypii			
1	10	2	20.00
2	10	3	30.00
4	10	5	50.00
6	10	6	60.00
8	10	8	80.00
10	10	10	100.00
15	10	10	100.00
M. persicae			
1	10	1	10.00
2	10	2	20.00
4	10	4	40.00
6	10	5	50.00
8	10	7	70.00
10	10	10	100.00
15	10	10	100.00

* Acquisition feeding period was 10 min and inoculation feeding period of 24 h

Table5. Determination of pre-acquisition starving period on the transmission of CMV of chilli isolate			
Pre-starvation period*	*No. of plants*		Per cent Transmission
	Inoculated**	Infected	
A. gossypii			
0 min	10	1	10.00
10 min	10	3	30.00
15 min	10	4	40.00
30 min	10	6	60.00
60 min	10	10	100.00
M. persicae			
0 min	10	1	10.00
10 min	10	2	20.00
15 min	10	3	30.00
30 min	10	6	60.00
60 min	10	10	100.00

* 10 adults per plant were inoculated; ** Acquisition feeding period was 10 min and inoculation feeding period of 24 h

Table6. Determination of acquisition feeding period for transmission of CMV

Acquisiton feeding period*	No. of plants		Per cent Transmission
	Inoculated**	Infected	
A. gossypii			
30 sec	10	0	0.00
1 min	10	2	20.00
2 min	10	2	20.00
5 min	10	5	50.00
10 min	10	10	100.00
15 min	10	10	100.00
30 min	10	7	70.00
1 h	10	6	60.00
2 h	10	4	40.00
M. persicae			
30 sec	10	0	0.00
1 min	10	1	10.00
2 min	10	4	40.00
5 min	10	6	60.00
10 min	10	10	100.00
15 min	10	10	100.00
30 min	10	6	60.00
1 h	10	4	40.00
2 h	10	4	40.00

* 10 adults per plant were inoculated; ** Inoculation feeding period was 24 h

Table7. Determination of post-acquisition starving period for the transmission of CMV

Post acquisition starving period*	No. of plants		Per cent Transmission
	Inoculated**	Infected	
A. gossypii			
0 min	10	10	100.00
10 min	10	8	80.00
15 min	10	5	50.00
30 min	10	3	30.00
60 min	10	1	10.00
M. persicae			
0 min	10	10	100.00
10 min	10	7	70.00
15 min	10	4	40.00
30 min	10	2	20.00
60 min	10	1	10.00

* 10 adults per plant were inoculated; ** Acquisition feeding period was 10 min and inoculation feeding period of 24 h

Table8. Determination of inoculation feeding period of aphids for transmission of CMV of chilli			
Inoculation feeding period*	**No. of plants**		**Per cent Transmission**
	Inoculated**	**Infected**	
A. gossypii			
30 sec	10	0	0.00
1 min	10	0	0.00
5 min	10	0	0.00
10 min	10	0	20.00
15 min	10	2	20.00
30 min	10	3	30.00
60 min	10	4	40.00
6 h	10	6	60.00
12 h	10	8	80.00
24 h	10	10	100.00
M. persicae			
30 sec	10	0	0.00
1 min	10	0	0.00
5 min	10	0	0.00
10 min	10	0	0.00
15 min	10	2	20.00
30 min	10	4	40.00
60 min	10	4	40.00
6 h	10	5	50.00
12 h	10	7	70.00
24 h	10	10	100.00

* 10 adults per plant were inoculated; ** Acquisition feeding period was 10 min\

Table 9. Transmission of CMV through seed			
Time of sowing	**No. of seeds sown**	**No. of plants showing symptoms**	**Per cent Transmission**
Immediately after drying	20	0	0.00
15 days after drying	20	0	0.00
1 month after drying	20	0	0.00
2 months after storage	20	0	0.00
4 months after storage	20	0	0.00
8 months after storage	20	0	0.00
12 months after storage	20	0	0.00

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