

Original Research Article

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STUDIES ON TRANSMISSION OF PHYTOPLASMA IN SESAME

ABSTRACT

The ~~An~~ experiment was conducted to artificially transmit phytoplasma, the causal organism of sesame phyllody by mechanical sap inoculation and with insect vectors ~~—i.e.,—~~ (*Orosius albicinctus* and *Hishimonus phycitis*). The experimental findings revealed that the phytoplasma could not be transmitted by sap inoculation. The mean transmission rate was found to be 54.67 per-cent, with the highest rate of phyllody transmission (93.33%) observed in both treatments T8 and T9 with 3 insects/plant + 7 Days of Acquisition Feeding (DAF) + 5 Days of Inoculation Feeding (DIF) and 3 insects/plant + 7 DAF+ 7 DIF, respectively, while ~~and~~ the lowest was observed ~~observed~~ in the treatment T1 with 3 insects/plant + 3 DAF+ 3 DIF ~~(with 13.3%) per-cent~~ phyllody transmission from infected to healthy sesame plants. All the treatments were found to be statistically significant over control, however, the treatments T₈ and T₉ with three insects/~~per~~ plant and ~~witha~~n acquisition feeding period of 7 days and inoculation feeding of 5 and 7 days, respectively were found to be at par with each other statistically.

Keywords: Sesame, Leafhoppers, Sap inoculation, Vector transmission

1. Introduction

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Sesame (*Sesamum indicum* L.) commonly known as gingelly (nuvvulu in Telugu; *til* in Hindi, Punjabi, Bengali; tal in Gujarati; ellu in Tamil, Malayalam; rasi in Odia; beeja in Kannada) is one of the important oilseed crops grown worldwide. Sesame yield is relatively low due to non availability of high yielding and resistant varieties (biotic and abiotic stresses), its cultivation in marginal and sub-marginal lands with poor crop management, low harvest index, seed shattering and indeterminate growth habit (Chauhan *et al.*, 2016). Sesame phyllody is one of the major diseases caused by phytoplasma and is transmitted by leafhopper, *Orosius albicinctus* Distant (Thangjam and Vastrad, 2015). The rate of transmission of phyllody disease from infected to healthy seedlings depends on the number of insect population, life stage, gender, flight behavior, quality of the host plant, movement between the plants, time spent on plants and mode of transmission of pathogen which ultimately influence the transmission efficiency of the disease (Bosco and Marzachi, 2016). It is also transmitted from infected to healthy plants *via* dodder (*Cuscuta* sp.), grafting and cuttings but cannot be transmitted through mechanical sap inoculation (Gogoi *et al.*, 2017). Hence, keeping in view the present investigation was carried out to conduct transmission studies of phytoplasma by sap inoculation and insect vector.

Material and methods

Transmission studies of phytoplasma by mechanical sap transmission

Phyllody infected leaf samples collected from the field were used for infectivity studies. Sesame leaves showing clear phyllody symptoms from the infected plants were collected, washed in running water thoroughly to remove dirt and were blot dried. The inoculum was extracted by macerating the infected leaves in the presence of pre-chilled 0.05M phosphate buffer (pH 7.0), (9 ml of potassium phosphate buffer per 1 g of leaf sample) in pre-chilled mortar and pestle. The resultant inoculum was squeezed through two folds of sterile muslin cloth, before using for mechanical transmission. Healthy, well established, actively growing three week old young sesame plants raised in insect proof cages in greenhouse, Insectary were used for mechanical transmission studies. Prior to inoculation, a pinch of celite was added to the filtrate. A sterile cotton pad immersed in the inoculum was gently rubbed over the leaves in single direction to cause mild injury. Immediately after inoculation, the leaves were washed with a jet of sterile distilled water to remove the excess inoculum and abrasive celite. The inoculated plants were labeled and kept in insect proof cages in glasshouse for symptom expression. Healthy seedlings of sesame plants were kept as control.

Transmission studies of phytoplasma by insect vector

The phytoplasmas was artificially transmitted with the help of two leafhopper species that were found in sesame field *i.e.*, *Orosius albicinctus* and *Hishimonus phycitis*. An aspirator comprising a glass tube (10 cm length and 2 cm diameter) and a rubber tube of 15 cm length was used for the collection of leafhoppers. The leafhoppers were collected from sesame field by gently turning the leaves upwards and sucking with an aspirator. The leafhoppers were released on sesame plants maintained in insect proof cages for rearing. Infected sesame twigs showing phyllody symptoms were maintained in acquisition cages. The leafhoppers were collected from the rearing cages using an aspirator and were released into acquisition cages for acquaintance of phytoplasma inoculum. The hoppers were given different acquisition feeding periods (3, 5 and 7 days) as detailed in Table 1. Sesame seeds were sown in pots and seedlings were maintained in insect proof cages for inoculation studies. After giving prescribed acquisition feeding, the leafhoppers were removed carefully from the acquisition cages and transferred to inoculation cages as approved (3, 5 and 7 days) for transferring the inoculum from infected plants to healthy

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seedlings. The cages were kept in greenhouse for symptom expression. After prescribed period of inoculation feeding, the insects were killed using imidacloprid @ 0.3 ml l⁻¹. Data was recorded on rate of per-cent phyllody transmission and number of days taken for development of phyllody symptoms.

Table 1 Treatment details of insect transmission studies

Treatment No	Treatments
T ₁	3 insects/plant + 3 DAF+ 3 DIF
T ₂	3 insects/plant + 3 DAF+ 5 DIF
T ₃	3 insects/plant + 3 DAF+ 7 DIF
T ₄	3 insects/plant + 5 DAF+ 3 DIF
T ₅	3 insects/plant + 5 DAF+ 5 DIF
T ₆	3 insects/plant + 5 DAF+ 7 DIF
T ₇	3 insects/plant + 7 DAF+ 3 DIF
T ₈	3 insects/plant + 7 DAF+ 5 DIF
T ₉	3 insects/plant + 7 DAF+ 7 DIF
T ₁₀	No inoculation (Control)

DAF- Days of Acquisition feeding; DIF- Days of Inoculation feeding

3. Results and discussion

Mechanical Sap Transmission

Mechanical inoculation of sap collected from phyllody infected leaves into the young [healthy sesame \(variety Gowri\)](#) plants ~~of sesame (variety Gowri)~~ at three weeks stage induced no mechanical dissemination of phytoplasma. The plants that were sap inoculated and maintained in insect proof cages did not produce any phyllody symptoms during the period of observation. The results clearly indicated that there was no mechanical transmission of phytoplasma into healthy plants (Table 2).

Transmission with leafhopper, *Orosius albicinctus*

~~The results of artificial transsion of An experiment was designed to artificially transmit sesame phyllody phytoplasma through leafhopper (*O. albicinctus*) are summarized and the results were presented~~ in Table 3. The sesame phyllody disease caused by phytoplasma was

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successfully transmitted by leafhopper, *Orosius albicinctus*. The results revealed that the percentage of phyllody transmission by leafhopper *O. albicinctus* was in the range of 13.3% to 93.3% per cent in the different treatments combination, while and with 0% zero per cent transmission rate was recorded in control. As insects were not released in the control pots, there were no findings of phyllody transmission and symptom expression in control pots that were maintained in insect proof cages.

Treatment T3 recorded the highest percent (46.7%) phyllody transmission in the 3 Days of Acquisition Feeding (DAF) treatment combinations. From the treatments with three insects per plant and acquisition feeding period (DAF) of 3 days, the highest per cent phyllody transmission was achieved in treatment where insects were provided 7 days inoculation feeding period (DIF) (46.7%), and was least in treatment T1 followed by five days inoculation feeding period (26.7%) and three days inoculation feeding period (13.3%). The per cent phyllody transmission was increased as DAF increased, when the acquisition feeding periods were increased to five and seven days when compared to three DAF. The percent phyllody transmission was also observed to increase as the Days of Inoculation Feeding (DIF) increased. At five DAF, the highest per cent phyllody transmission was observed in treatment T6 (3 insects/plant + 5 DAF+ 7 DIF) in pots with 3 insects/plant and acquisition feeding of 5 DAF and inoculation feeding of 7 DIF (86.7%) as compared to percent phyllody transmission recorded in treatment T4 (3 insects/plant + 5 DAF+ 3 DIF) which had the least percent phyllody transmission of 6.0 and 5.3% per cent transmission, respectively. At 7 DAF, the treatment T9 (with 7 DAF+5 DAF and 7 DAF +7 DIF) recorded the highest per cent phyllody transmission of 93.3% per cent, respectively, followed by 7 DAF+3 DAF with 73.3 per cent successful transmission of phyllody to healthy sesame plants. From the transmission study, it was concluded that the mean transmission rate of phyllody transmission was 54.67 per cent. In all the treatments with 3, 5 and 7 days of DAF and DIF, the number of days taken for first appearance of phyllody symptoms in all the treatment combinations (T1-T9) was in the range of 29-41 days. All the treatments were found to be statistically significant over the control, however, the treatments T8 and T9 which recorded the highest with three insects per plant while given an acquisition feeding of 7 days and inoculation feeding of 5 and 7 days, respectively were found to be at par with each other statistically in

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recording highest per cent phyllody transmission ~~were statistically not different from infected to healthy sesame plants.~~

Transmission with leafhopper, *Hishimonus phycitis*

~~The transmission of sesame phyllody disease by insect vector, *Hishimonus phycitis* is presented in Attempts were made to transmit sesame phyllody caused by phytoplasma with the help of another leafhopper, *Hishimonus phycitis* (Table 4). No single plant developed typical phyllody symptoms after introduction of insects during the period of observation. The results from the transmission studies with leafhopper, *H. phycitis* showed/revealed that the leafhopper could not transmit be able to disseminate phytoplasma from infected sesame plants to healthy seedlings. Hence,; thereby we can conclude that *H. phycitis* cannot be considered is not an -as insect vector in the responsible for transmission of sesame phyllody disease caused by phytoplasma.~~

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The ~~findings/results~~ from the ~~transmission studies of phytoplasma by mechanical sap transmission in this study support earlier report by current experiment were in accordance with Akhtar et al. (2009ab) when they who reported that sap transmission of chickpea phyllody was not achieved indicating that phyllody is not by mechanically transmissible. Similarly, earlier The research findings by of Gogoi et al. (2017), Karra (2017) and Yadav et al. (2021) using mechanical sap inoculations did not induce any typical phyllody symptoms on when sap was inoculated mechanically onto healthy sesame seedlings, which further confirm the results obtained during the present study. However, Akhtar et al. (2009ab) reported that the leafhopper, *O. rosarius albicinctus* transmitted 60 per cent phyllody disease from phyllody infected sesame plants to healthy plants by showing symptoms of floral virescence and proliferation with acquisition and inoculation feeding of seven days, respectively. The finding in this study that Ikten et al. (2014), Gogoi et al. (2017), Omidi et al. (2010) and Prasindhu et al. (2020) reported that phytoplasma is was successfully transmitted by leafhoppers is supported by earlier research finding by several by several authors/authors (Ikten et al., 2014; Gogoi et al., 2017; Omidi et al., 2010; Prasindhu et al., 2020) which confirm the results obtained during the present study.~~

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The ~~present findings that the percent phyllody transmission increased as DAF and DIF increased were~~ in accordance with earlier research findings (Jayashree et al., 1999; Gogoi et al., 2017; Akhtar et al., 2009ab; Akhtar et al., 2012; Prasindhu et al., 2020). Jayashree et al. (1999) ~~noticed who noticed~~ increase in per cent disease transmission of pumpkin yellow vein

mosaic virus and decrease in number of days required for symptom expression with an increase in acquisition feeding period and inoculation feeding period. ~~Similar results were reported by Gogoi et al. (2017) reported where an increase in sesame phyllody disease transmission with increase was observed when the~~ acquisition feeding (AFP) ~~increased from~~ 3 days (49.38%) to 5 days (64.57%). ~~The findings were in close agreement with Akhtar et al. (2009a,b) recorded who noticed successful in the~~ transmission of chickpea phyllody from infected to healthy chickpea plants by insect vector, *O. rosius orientalis* with transmission rate of 70 per cent, ~~and Akhtar et al. (2012) who reported 70-80 per cent of phyllody transmission by leafhoppers from infected to healthy mungbean plants, while, per cent phyllody transmission by leafhoppers from infected sesame plants to healthy periwinkle plants and days taken for symptom expression were 100.00 per cent and 55-60 days, respectively as given by Prasindhu et al. (2020) were in close association with the current results. The infected plants showed symptoms of reduction of leaf size, yellowing and stunted growth in periwinkle.~~ However, the results from ~~thise~~ present study ~~are were~~ in contradiction ~~with finding by~~ Jutimala et al. (2019) who reported that *H. phycitis* was found to transmit sesame phyllody phytoplasma with a transmission rate of 83.33 per cent to healthy sesame plants. ~~The presence of phytoplasma in H. phycitis was confirmed by nested PCR assays and concluded that H. phycitis can be considered as a new vector of phyllody from North East region of India in addition with O. rosius albicinctus.~~

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Leafhopper species belonging to cicadellidae ~~regarded were reported~~ as the major insect vectors ~~for~~ transmitting sesamum phyllody of which, *O. rosius orientalis* ~~is the was considered as~~ a major insect vector transmitting the phyllody disease in India, Iran, Turkey and other Asian countries (Esmailzadeh et al., 2007; Akhtar et al., 2009b; and Pathak et al., 2013); ~~and~~ *O. albicinctus* in India (Gogoi et al., 2017) and Iran (Esmailzadeh et al., 2007). However recent reports have ~~suggested-implicated~~ another species (*Hishimonas*) ~~also acting as~~ vector in the transmission of sesamum phyllody ~~that is acquiring and transmitting the phyllody~~ from infected to healthy plants (Nabi et al., 2015 and Jutimala et al., 2019).

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In all our field experiments at S.V. Agricultural College, Tirupati; *O. rosius albicinctus* was found to be most abundant in addition to other species such as *H. phycitis* which were less abundant. ~~An attempt was made in~~ The aimed present investigations to demonstrate the ability of both the species of leafhopper i.e., *O. albicinctus* and *H. phycitis* to acquire and transmit the disease from infected to healthy sesame plants. The results revealed that *O. albicinctus* was the main vector in transmitting the disease from infected plant to healthy plants and did produce the phyllody symptoms ~~at around 30 days after 7 days of active inoculation period~~. However, studies with *H. phycitis* ~~did have not~~ produced any conclusive results on appearance of symptoms

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even after 40 days of inoculation, where the insect was given a maximum period of 7 days of acquisition and 7 days of inoculation feeding period. This probably could be due to the occurrence and abundance of different leafhopper species across various geographical locations, along with differences in genetic variation among the population of same species at different geographical ~~locations, that~~ locations, which could affect the acquisition and transmission of the phyllody by the insect vector. Among the leafhopper species that were found to be vectors of sesamum phyllody, *Hishimonus* sp. was found to be more abundant in Northern part of India (Nabi *et al.*, 2015) and was able to ~~transit-transmit~~ the disease ~~into~~ healthy plants, whereas, *Orosius* spp. was found to be more prevalent in Southern India (Manjunatha *et al.*, 2012 and Madhupriya *et al.*, 2015). Additionally, the genetic differentiations among the *H. phycitis* populations, at different geographical location could also affect the vectoring capability in transmitting the disease of the vector and thus the appearance of the symptoms (Hemmati *et al.*, 2018). Because of the As-of-variation in in the different geographical areas, the abiotic factors also vary and accordingly can influence the acquisition and transmission of phyllody by the insect vector and the expression of symptom (Chellappan *et al.*, 2005; Anhalt and Almeida, 2008). The abiotic factors present at Tirupati with the prevailing during the period of experimentation with vector Hishimonus at Tirupati may be different from the experimental conditions IARI, New Delhi where prevailed by the work of Nabi et al. (2015) carried out their study at IARI, New Delhi, which might have contributed to non-appearance non-appearance of phyllody symptoms when Hishimonus was used as vector for disease transmission in the present investigations. Also mere acquisition of phytoplasma in the insect vector doesn't mean that the insect can transmit the disease successfully from an infested plant in to a healthy plant and the success of the transmission by the vector also depends on the quantity or titer load of the pathogen during the acquisition period (Alma *et al.*, 2019).

It has also been demonstrated that the latent period *i.e.* the period between acquisition of phytoplasma (AAP) and the ability of the insect vector to transmit the phytoplasma into a healthy plant ranges from 7 to 80 days, which is also again temperature dependent (Nagaich *et al.*, 1974; Murrall *et al.*, 1996 and Moya-Raygoza and Nault, 1998). In our experiments we have given an maximum of 7 days as inoculation period for the phyllody infected insect vector (after a maximum of 7 days of acquisition period on phyllody infected plant) which could also be one of the reasons for absence of appearance of any phyllody symptoms when *Hishimonus* was used

as vector in the present transmission studies. However the studies on insect vector transmission with species of leafhoppers other than *O. albicinctus* is still in the infancy stage and further studies on identification of all the available leafhopper species at different agro climatic zones have to be undertaken by taxonomic keys as well as molecular identification and the acquisition, inoculation, latent period of phyllody in the insect vector and the presence of phyllody and the titer of load in the insect vector as well as presence and expression of symptoms in the healthy plants have to be confirmed with insect vector transmission studies as well as molecular confirmation with the help of specific primers.

4. Conclusion

The transmission studies conducted with two leafhopper species, *O. albicinctus* and *H. phycitis* confirmed that leafhopper, *O. albicinctus* was the potential insect vector responsible for dissemination of phytoplasma, the causal organism of sesame phyllody from infected plants to healthy sesame seedlings. The findings revealed that leafhoppers play a major role in transmission of phytoplasma under field conditions. The sap inoculated plants did not produce any significant phyllody symptoms during the period of observation.

References

- Akhtar, K.P., Sarwar, G., Abbas, G., Asghar, M.J., Sarwar, N and Hamed, M. 2012. Mungbean phyllody disease in Pakistan: symptomatology, transmission, varietal response effects on yield characteristics. *International Journal of Pest Management*. 58 (2): 139-145.
- ~~Akhtar, K.P., Sarwar, G., Dickinson, M., Ahmad, M., Haq, M.A., Hameed, S and Iqbal, M.J. 2009a. Sesame phyllody disease: its symptomatology, etiology and transmission in Pakistan. *Turkish Journal of Agriculture and Forestry*. 33: 477-486.~~
- Akhtar, K.P., Shah, T.M., Atta, B.M., Dickinson, M., Hodgetts, J., Khan, R.A., Haq, M.A and Hameed, S. 2009b. Symptomatology, etiology and transmission of chickpea phyllody disease in Pakistan. *Journal of Plant Pathology*. 91 (3): 649-653.
- ~~Akhtar, K.P., Sarwar, G., Dickinson, M., Ahmad, M., Haq, M.A., Hameed, S and Iqbal, M.J. 2009b. Sesame phyllody disease: its symptomatology, etiology and transmission in Pakistan. *Turkish Journal of Agriculture and Forestry*. 33: 477-486.~~
- Alma, A., Lessio, F and Nickel, H. 2019. Insects as phytoplasma vectors: Ecological and epidemiological aspects. In Bertaccini, A., Weintraub, P.G., Rao, G.P and Mori, N (eds.). *Phytoplasmas: Plant Pathogenic Bacteria-II*. Springer Nature Singapore Pvt Ltd. 1-25.

- Anhalt, M.D and Almeida, R.P.P. 2008. Effect of temperature, vector life stage and plant access period on transmission of banana bunchy top virus to banana. *Phytopathology*. 98 (6): 743-748.
- Bosco, D and Marzachi, C. 2016. Insect Transmission of Phytoplasmas. In J.K. Brown (eds.) *Vector Mediated Transmission of Plant Pathogens*, The American Phytopathological Society, 319-327.
- Chauhan, S., Rao, V.P., Reddy, A.P.K., Jayasree, G and Reddy, S.N. 2016. Response of sesame (*Sesamum indicum* L.) to irrigation scheduling based on climatological approach and N fertigation levels. *Journal of Oilseeds Research*. 33 (1): 38-44.
- Chellappan, P., Vanitharani, R., Ogbe, F and Fauquet, C.M. 2005. Effect of temperature on geminivirus induced RNA silencing in plants. *Plant Physiology*. 138 (4): 1828-1841.
- Esmailzadeh, S.A.H., Mirzaie, A., Jafari-Nodooshan, A and Rahimian, H. 2007. The first report of transmission of a phytoplasmas associated with sesame phyllody by *Orosius albicinctus* in Iran. *Australian Plant Disease Notes*. 2: 33-34.
- Gogoi, S.H., Kalita, M.K and Nath, P.D. 2017. Biological characterization of sesame phyllody disease in Assam, India. *International Journal of Current Microbiology and Applied Sciences*. 6 (11): 1862-1875.
- Hemmati, C., Nikooei, M and Pasalari, H. 2018. *Cota tinctoria* and *Orosius albicinctus*: A new plant host and potential insect vector of 'Candidatus phytoplasma trifolii'. *Australasian Plant Disease Notes*. 13: 13. <https://doi.org/10.1007/s13314-018-0298-1> (Online).
- Ikten, C., Catal, M., Yol, E., Ustun, R., Furat, S., Toker, C and Uzun, B. 2014. Molecular identification, characterization and transmission of phytoplasmas associated with sesame phyllody in turkey. *European Journal of Plant Pathology*. 139 (1): 217-229.
- Jayashree, K., Pun, K.B and Doraiswamy, S. 1999. Virus-vector relationships of yellow vein mosaic virus and whitefly (*Bemisia tabaci*) in pumpkin. *Indian Phytopathology*. 52 (1): 10-13.
- Jutimala, P., Kumar, K.M., Rahman, S., Gogoi, S.H and Nath, P.D. 2019. Identification of sesame phyllody transmitting insect vectors in Assam, India. *Pathogenic Mollicutes*. 9 (1): 107-108.
- Karra, R. 2017. Transmission studies associated with sesame phyllody disease. *International Journal of Pure and Applied Biosciences*. 5 (6): 752-754.
- Madhupriya,, Rao, G.P., Kumar, A and Baranwal, V.K. 2015. Classification of sesame phytoplasma strain in India at 16Sr subgroup level. *Journal of Plant Pathology*. 97 (3): 523-528.

- Manjunatha, N., Prameela, H.A., Rangaswamy, K.T., Palanna, K.B and Wickramaaracchi, W. 2012. Phyllody phytoplasma infecting sesame in South India. *Phytopathogenic Mollicutes*. 2: 29-32.
- Moya-Raygoza, G and Nault, L.R. 1998. Transmission biology of maize bushy stunt phytoplasma by the corn leafhopper (Homoptera: Cicadellidae). *Annals of the Entomological Society of America*. 91 (5): 668-676.
- Murrall, D.J., Nault, L.R., Hoyy, C.W., Madden, L.V and Miller, S.A. 1996. Effects of temperature and vector age on transmission of two ohio strains of aster yellows phytoplasma by the aster leafhopper (Homoptera: Cicadellidae). *Journal of Economic Entomology*. 89 (5): 1223-1232.
- Nabi, S.U., Madhupriya., Dubey, D.K., Rao, G.P., Baranwal, V.K and Sharma, P. 2015. Molecular characterization of “*Candidatus Phytoplasma asteris*” subgroup I- B associated with sesame phyllody disease and identification of its natural vector and weed reservoir in India. *Australasian Plant Pathology*. 44 (3): 289 – 297.
- Nagaich, B.B., Puri, B.K., Sinha, R.C., Dhingra, M.K and Bhardwaj, V.P. 1974. Mycoplasma like organisms in plants affected with purple top roll, marginal flavescence and witches broom diseases of potatoes. *Journal of Phytopathology*. 81 (3): 273-379.
- Omidi, M., Pour, H and Massumi, R. 2010. Investigations on transmittance status of *Orosius albicinctus* (Hemiptera: cicadellidae) as a natural vector of phytoplasmas in south-eastern. *Iranian Journal of Plant Pathology*. 92 (2): 531-535.
- Pathak, D.M., Joshi, N.S., Dulawat, M.S and Patel, N.V. 2013. Control of sesame phyllody caused by PLOs. *International Journal of Green and Herbal Chemistry*. 2: 164-165.
- Prasindhu, K., Devi, R.S.J., Prasad, M.S.L., Sujatha, M., Duraimurugan, P., Reddy, A.V.V., reddy, B.V.B and Prashanthi, L. 2020. Studies on transmission of phyllody from sesame to alternate host periwinkle (*Vinca rosea*). *Journal of Oilseeds Research*. 37 (3): 190-196.
- Thangjam, R and Vastrad, A.S. 2015. Evaluation of insecticides for the management of sesame phyllody vector, *Orosius albicinctus* Distant. *Indian Journal of Entomology*. 77 (3): 230-234.
- Yadav, P.D., Rathore, G.S., Meena, R and Jajoria, A. 2021. Studies on phyllody disease of sesame (*Sesamum indicum* L.): Symptomatology and transmission. *The Pharma Innovation Journal*. 10 (8): 890-894.

Table 2 Transmission of sesame phyllody disease by mechanical sap inoculation

Test plant	No. of plants taken	No. of plants inoculated	No. of plants showing phyllody symptoms	Days taken for appearance of phyllody symptoms	Per-cent phyllody transmission
Sesame	150	150	0	0	0.00

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Table 3 Transmission of sesame phyllody disease by insect vector, *Orosius albicinctus*

Treatment No	Treatments	Days required for appearance of phyllody symptoms	Per-cent phyllody transmission (%)
T ₁	3 insects/plant + 3 DAF+ 3 DIF	38-41	13.3 ^h
T ₂	3 insects/plant + 3 DAF+ 5 DIF	33-36	26.7 ^g

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T ₃	3 insects/plant + 3 DAF+ 7 DIF	33-34	46.7 ^f
T ₄	3 insects/plant + 5 DAF+ 3 DIF	32-38	53.3 ^e
T ₅	3 insects/plant + 5 DAF+ 5 DIF	32-36	60.0 ^d
T ₆	3 insects/plant + 5 DAF+ 7 DIF	29-33	86.7 ^b
T ₇	3 insects/plant + 7 DAF+ 3 DIF	31-35	73.3 ^c
T ₈	3 insects/plant + 7 DAF+ 5 DIF	31-34	93.3 ^a
T ₉	3 insects/plant + 7 DAF+ 7 DIF	29-31	93.3 ^a
T ₁₀	No inoculation (Control)	0	0.00 ⁱ
Mean			54.67
F-test			Sig.
SEm±			1.37
CD (P=0.05)			4.05
CV (%)			4.38

DAF – Days of Acquisition Feeding; ————DIF – Days of Inoculation Feeding;
 Sig – Significant at 5 per cent level of significance

Table 4 Transmission of sesame phyllody disease by insect vector, *Hishimonus phycitis*

Treatment No	Treatments	Days required for appearance of phyllody symptoms	Per-cent phyllody transmission (%)
T ₁	3 insects/plant + 3 DAF+ 3 DIF	0	0.00
T ₂	3 insects/plant + 3 DAF+ 5 DIF	0	0.00
T ₃	3 insects/plant + 3 DAF+ 7 DIF	0	0.00
T ₄	3 insects/plant + 5 DAF+ 3 DIF	0	0.00
T ₅	3 insects/plant + 5 DAF+ 5 DIF	0	0.00
T ₆	3 insects/plant + 5 DAF+ 7 DIF	0	0.00
T ₇	3 insects/plant + 7 DAF+ 3 DIF	0	0.00

T ₈	3 insects/plant + 7 DAF+ 5 DIF	0	0.00
T ₉	3 insects/plant + 7 DAF+ 7 DIF	0	0.00
T ₁₀	No inoculation (Control)	0	0.00
Mean			0.00
F-test			-
SEm±			-
CD (P=0.05)			-
CV (%)			-

DAF – Days of Acquisition Feeding; _____ DIF – Days of Inoculation Feeding; **Sig** – Significant at 5 per cent level of significance

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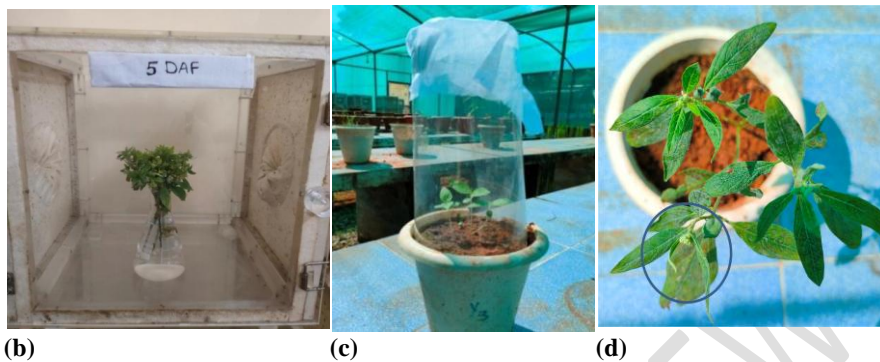


Plate 1: Phytoplasma transmission studies in green house

- (a) Pots maintained in insect proof cages for mechanical sap inoculation
- (b) Acquisition feeding cage
- (c) Inoculation feeding cage
- (d) Symptoms of phyllody in insect transmitted pots

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