

Biological Characterization of Sesamum Phyllody Disease in Assam, India

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ABSTRACT

To know about the transmission behavior, biological characterization of Sesamum phyllody disease was conducted. The leafhopper *Orosius albicinctus* (Dist.) could transmit the disease successfully in artificial inoculation. The rate of transmission of the disease increased significantly as the no. of leafhopper was increased from 1 per plant (29.47%) to 3 per plant (84.26%). The disease transmission also increased significantly as the acquisition feeding (AFP) period increased from 3 days (49.38%) to 5 days (64.75%). Likewise, lowest disease transmission (16.67%) was observed in plants with 5 days inoculation feeding period (IFP) and increased significantly in 10 IFP (100%). The interaction effect of no. of leaf hopper/plant, acquisition feeding period and inoculation feeding period also exhibited positive and significant increase in transmission. Highest disease incidence was observed in plants inoculating with 3 no of leafhopper per plant +5 days AFP + 7 and 10 days IFP and lowest in treatment with 1 leafhopper per plant + 3 days AFP + 5 days IFP. Similar effect was also observed in time period taken for first appearance of symptom. Lowest time period (25 days) for first appearance of symptom was taken when plants were inoculated with 3 no of leafhopper/plant + 5 days AFP + 7 and 10 days IFP and highest (39 days) in plants inoculated with 1 leafhopper/plant + 3 days AFP + 5 days IFP. The Sesamum phyllody disease was successfully transmitted by graft transmission (80%) and dodder (90%) but it was not transmitted by seed and sap inoculation. There was no effect in germination of seeds collected from infected sesamum plants.

Keywords

Sesamum Phyllody, *Orosius albicinctus* (Dist.), Acquisition feeding period, Inoculation feeding period.

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Introduction

Sesamum (*Sesamum indicum* L.) is an important ancient oilseed crop and probably the first oilseed crop used by human civilization, belongs to the family Pedaliaceae (Bedigian and Harlan, 1986). Sesamum seeds are rich source of protein (20%), edible oil (50%) and contains about 47 per cent oleic acid and 39 per cent linolenic acid (Shyu and Hwang, 2002). Sesamum yield is relatively low in Assam as well as in India due to low

harvest index, susceptibility to diseases, seed shattering, and indeterminate growth habit (Asri, 1998). Out of these major constrains of production, Sesamum Phyllody (SP) is a very serious disease characterized by different symptoms like virescence (Plate 1), phyllody (Plate 2), yellowing, floral sterility and stem proliferation of infected plants (Bertaccini and Duduk, 2009). Phytoplasmas belongs to class molecutes are wall-less, pleomorphic,

unculturable prokaryotes, reside in the plant phloem, feeds on the plant nutrients for survival and have small (500-1350 Kbp), AT rich genome (Doi *et al.*, 1967; Razin *et al.*, 1998). It has been reported to effect more than 600 different plant species. In India, the loss in yield due to sesamum phyllody was reported to be 80 to 100 percent (Sahambi, 1970; Verma and Daftari, 1976 and Kumar and Mishra, 1992). Sesamum phyllody is transmitted by leaf hopper, *Orosius albicinctus* Distant (Prasad and Sahambi, 1982) and *Hishimonus phycitis* Distant (Nabi *et al.*, 2015).

Transmission of phytoplasma from plant to plant occurs primarily during the feeding activity of inoculative vector insects, by the vegetative propagation of infected plant material or by graft inoculation (Kirkpatrick, 1991). Vectors responsible for phytoplasma transmission in nature are insects of the order Hemiptera, primarily phloem feeding leafhoppers (*Cicadellidae*) and psyllids in a persistent, propagative manner (Marzachi *et al.*, 2004). In their natural insect vectors, phytoplasmas traverse the intestinal wall, circulate in haemolymph, and multiply in tissues including salivary glands, where phytoplasma cells are incorporated into saliva injected into plants during inoculation (Weintraub and Beanland, 2006). The acquisition of multiple phytoplasmas leads to their interaction in the vector insects (Bosco and Amelio, 2010). Vector specificity varies from high, when phytoplasmas are transmitted by only one or two vectors, to extremely low, when a specific phytoplasma can be transmitted, mostly by polyphagous leafhopper species (Hogenhout *et al.*, 2008).

Transmission of phytoplasmas through propagation material can occur and lead to their long-distance dispersal and introduction into regions where they have not previously been found (Constable, 2010). Recent reports

on the detection of phytoplasma in both the seed and seedling progeny of alfalfa (Khan *et al.*, 2002), canola (Olivier *et al.*, 2006), corn, tomato and oilseed rape (Alberto *et al.*, 2011) plants indicate that seed transmission in certain plant-host phytoplasma pathosystems is possible. In addition, all phytoplasmas can be transmitted experimentally by plant parasitic dodder (*Cuscuta* spp.) and by grafting infected plant material onto healthy plants. Though, many times sesamum phyllody suspected symptoms have been observed in Assam but not much attempt has been made to record the incidence, economic damage and the biological properties. Therefore, the present investigation was undertaken to carry out a systematic study on the biological characterization of SP disease in Assam.

Materials and Methods

Insect transmission

Healthy seeds of sesamum plants were sown in earthen pots and placed in insect free green house. Thinning was done after fifteen days of germination of seeds and four plants per pot was maintained (Plate 3). Adult *Orosius albicinctus* Dist. leafhopper from established leafhopper colonies maintained inside insect proof cages was used as vector for the transmission test. The leafhopper was first given acquisition feeding on the Sesamum phyllody infected plant (Plate 4) for required period of time and then inoculation feeding access on the healthy sesamum plants (Plate 5). There were altogether 18 combination of number of leafhopper per plant, acquisition feeding period and inoculation feeding period with a control (no inoculation) for the transmission test which is presented in Table 1. For each treatment of insect transmission test, three pots containing four sesamum plants each were used to release the LH and another pot with four healthy sesamum plants

was used for control where no leafhopper was released. The leafhopper in the inoculated pots was killed using insecticide after required inoculation access period was over. The killed insects were collected and stored at -20°C and further analysis. Inoculated plants were continuously monitored for symptom expression. Data on percent disease incidence, time required for first appearance of the symptoms and yield parameters were recorded. The data on disease incidence and time required for first expression of symptom was analysed statistically by using Factorial CRD with three factors and data on yield parameters were analysed statistically using simple CRD (Gomez and Gomez, 1984).

Mechanical transmission by grafting

Four week old sesamum plants were used for graft inoculation using Sesamum phyllody phytoplasma (Akhtar *et al.*, 2009) under net house conditions. For grafting, a sliced cut was made on the stem about 2-3 cm below the tip (Plate 6). About 13 cm long sesamum branch exhibiting typical phyllody symptoms was detached from an infected plant and a similar cut (as on the test plant) was made on this branch. The corresponding cut surfaces were tied together with parafilm (Plate 7). The grafted plants were kept inside humid chamber created artificially with the help of polythene bag (Plate 8) and removed after 7 days. Altogether 10 plants were grafted and the grafted plants were observed daily for symptom development.

Dodder transmission

Dodder transmission study was made according to Marcone *et al.*, (1997). Dodder (*Cuscuta campestris*) strands were established on Sesamum phyllody disease-infected sesamum plants for 4 weeks. The newly developed dodder strands from diseased plants were then attached to healthy four week-old sesamum seedlings (Plate 9). The

dodder bridge between the Sesamum phyllody infected plant and the inoculated plants were detached after 4 weeks and observed regularly for symptom development.

Sap transmission

For sap transmission Sesamum plant tissues with typical Sesamum phyllody disease symptom were collected and ground in 0.02M phosphate buffer (pH 7.4) with mortar and pestle (Plate 10) and then squeeze through very fine muslin cloth as described by Akhtar *et al.*, (2009). A pinch of Carborandum powder was sprinkled over the leaves to be inoculated to cause injury in the leaf tissues for the penetration of the Phytoplasma (Plate 11). Two young leaves from 4 week old healthy sesamum plants were mechanically inoculated with the freshly extracted sap using cotton pads. Inoculated leaves were rinsed with a gentle stream of water immediately after inoculation to remove superfluous inoculums and place in insect proof cages. Altogether 10 plants were used for sap inoculation and the inoculated plants were observed regularly for symptom development.

Seed transmission

Matured seeds from Sesamum phyllody infected and healthy sesamum plants were collected and stored in the laboratory. One hundred seeds each from diseased and healthy sesamum plants were raised on earthen pots inside insect proof cages. Germination percentage, number of plants showing symptoms and time taken for symptom development was observed until maturity.

Results and Discussion

Insect transmission

Sesamum phyllody phytoplasma was successfully transmitted from infected

sesamum plants to healthy sesamum plants (Plate12) by the leafhopper vector *Orosius albicinctus* Dist. (Plate 13) under net house condition. Successful transmission of Sesamum phyllody disease with the same vector was also reported (Akhtar *et al.*, 2009; Pathak *et al.*, 2013 and Cengiz *et al.*, 2014). The percent disease transmission was significantly influenced by the number of leafhopper released per plant, acquisition feeding period and inoculation feeding period of the leafhopper vector (Table 2). Highest disease transmission (84.26%) was observed in plants inoculated with 3 leafhopper/plant. This was followed by 57.41 percent and 29.47 per cent in plants inoculated with 2 leafhopper/plant and 1 leafhopper per plant respectively. Likewise, the disease transmission was also influenced by the duration of acquisition feeding period. Lowest disease transmission (49.38%) was observed in plants inoculated with leafhopper allowing 3 days acquisition feeding access which increased significantly to 64.75 per cent when inoculated with leafhopper allowing 5 days acquisition feeding period. The Inoculation feeding period also exhibited influence in the rate of disease transmission. The disease transmission increased with the increase in inoculation feeding period of the leafhopper. The disease transmission was observed to be 52.16, 57.87 and 61.11 per cent in plants in which leafhopper were given inoculation feeding period of 5, 7 and 10 days respectively. There was no significant difference in disease transmission in plants inoculated with leafhopper allowing 5 days and 7 days inoculation feeding and 7 days and 10 days inoculation feeding period. The percent disease transmission differed significantly between 5 days and 10 days inoculation feeding period. There was significant increase in the rate of disease transmission as the number of leafhopper was increased from 1 to 3 per plant. This may be due to deposition of more inoculums in the

sesamum plant where 3 leafhopper per plant was released as compared to 1 or 2 leafhopper per plant. The positive correlation between higher disease incidences with increased number of vectors was also reported by Jayashree *et al.*, (1999) in Pumpkin Yellow Mosaic virus disease as observed in the present investigation.

The interaction between acquisition feeding period and number of insects per plant was seen to influence the rate of disease transmission. Highest disease transmission (97.22%) was observed in treatments where leafhoppers were given 5 days acquisition feeding and 3 leafhoppers were released per plant. This treatment differed significantly with all other treatments. Lowest disease transmission (23.15%) was observed in treatments where leafhopper was given 3 days acquisition feeding and 1 leafhopper per plant was released.

The interaction between inoculation feeding period and number of insects per plant also influence the rate of disease transmission. Highest disease transmission (87.50%) was observed in treatments where leafhoppers were given 10 days acquisition feeding and 3 leafhoppers were released per plant. Lowest disease transmission (23.15%) was observed in treatments where leafhoppers were given 5 days inoculation feeding and 1 leafhopper per plant was released. There was no significant difference in the disease transmission when same number of leafhopper per plant was used but the rate of disease transmission varied significantly when number of leafhopper was increased from 1 to 3 irrespective of inoculation feeding period.

Among the three combinations of treatments, highest disease transmission (100%) was observed in plants inoculated with 3 leafhopper/plant + 5 days acquisition feeding period + 7 days inoculation feeding period

and 3 leafhopper/plant + 5 days acquisition feeding period + 10 days inoculation feeding period. Lowest disease transmission (16.67%) was observed in plants inoculated with 1 leafhopper/plant + 3 days acquisition feeding period + 5 days inoculation feeding period.

The interaction between the number of leafhopper per plant and acquisition feeding period, number of leafhopper per plant and inoculation feeding period, acquisition feeding period and inoculation feeding period and among number of leafhopper per plant, acquisition feeding period, inoculation feeding period had significantly influenced the transmission of the disease. The interaction effect of the factors (i.e. number of leafhopper released per plant, acquisition feeding period and inoculation feeding period) was increased corresponding to the increase of the individual factors. The phytoplasma for insect transmission has a latent period (Webb *et al.*, 1999 and Bertaccini and Duduk, 2009). Again, the percent transmission of the disease increased with the increased number of vectors, acquisition feeding period and inoculation feeding period (Jayashree *et al.*, 1999). The facts of all these earlier report might have contributed for more percent of disease incidence observed in the present study with more number of leafhopper vector per plant, increased acquisition feeding period and increased inoculation feeding period.

Effect on duration for first appearance of symptoms

The leafhopper *Orosius albicinctus* Dist. successfully transmitted Sesamum phyllody disease from infected plant to healthy sesamum plant. It was observed that the period for first appearance of disease symptom was significantly influenced by the number of leafhopper released per plant, acquisition feeding period and inoculation

feeding period of the leafhopper vector (Table 3). There was significant reduction in the time period required for first appearance of disease symptoms as the number of leafhopper was increased from 1 to 3 per plant. Highest (36.39 days) was required in plants inoculated with 1 insects/plant. This was followed by 32.17 days and 27.33 days in plants inoculated with 2 insect per plant and 3 insect per plant respectively. This may be due to the fact that more numbers leafhopper per plant deposited of more amount of inoculums in the healthy sesamum plant as compared to less number of leafhopper per plant. Jayashree *et al.*, (1999) reported that the days required for the symptom expression of Pumpkin yellow vein mosaic virus infection became progressively less as the numbers of whiteflies used for inoculating the test plants were gradually increased from one to twenty.

The time period required for first appearance of symptoms of Sesamum phyllody disease was decreased with the increase in the acquisition feeding period and inoculation feeding period of the leaf hopper vector *Orosius albicinctus* Dist. Lowest (30.92 days) was observed in plants inoculated with leafhopper allowing 5 days acquisition feeding access which increased significantly to 32.99 days when inoculated with leafhopper allowing 3 days acquisition feeding period. The appearance of symptom (days) decreased with the increase in inoculation feeding access of the insects. The symptom development was observed to be 33.22 days, 31.73 days and 30.95 days in plants in which leafhopper were given inoculation access period of 5 days, 7days and 10 days respectively. There was no significant difference in symptom in plants inoculated with leafhopper allowing 5 days and 7 days inoculation feeding and 7 days and 10 days inoculation feeding period. The symptom development differed significantly between 5 days and 10 days inoculation feeding period.



Plate.1 Floral virescence



Plate.2 Phyllody



Plate.3 Raising of Sesamum plants



Plate.4 Acquisition feeding of leafhopper



Plate.5 Inoculation feeding of Leafhopper



Plate.6 Slice cut for grafting



Plate.7 Para film wrapping



Plate.8 Grafted plant inside humid chamber



Plate.9 Dodder transmission
(A) Infected plant (B) Healthy plant



Plate.10 Grinding of diseased plant tissue



Plate.11 Plants just before sap inoculation



Plate.12 *Orosius albicinctus* Dist.



Plate.13 Symptom in insect transmitted Plants



Plate.14 Symptom in graft transmitted plant

Plate.15 PCR analysis of graft transmitted plants

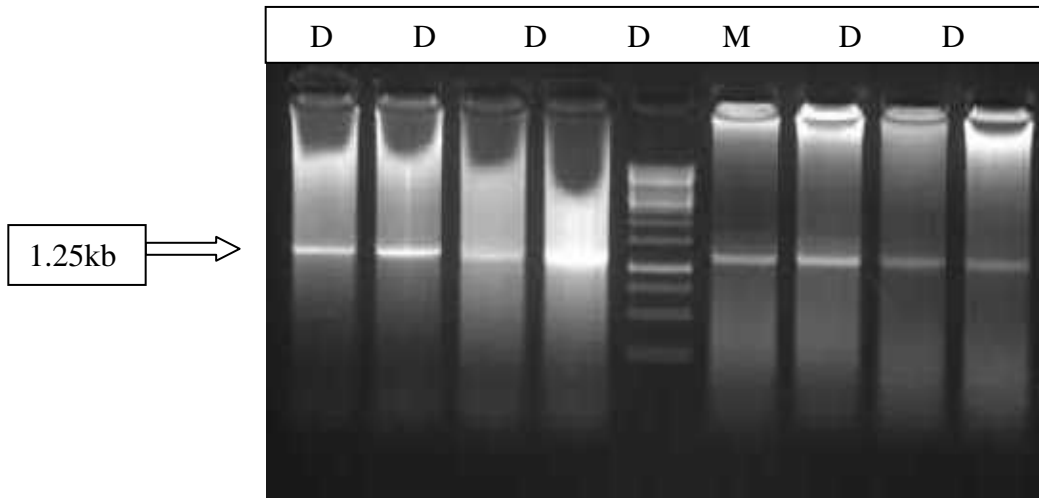


Plate.16 Symptom in dodder transmitted plant



Table.1 Treatments for conducting insect transmission of sesamum phyllody disease

Treatment No.	Treatments
T ₁	1 insect/plant + 3 DAF + 5 DIF
T ₂	2 insect/plant + 3 DAF + 5 DIF
T ₃	3 insect/plant + 3 DAF + 5 DIF
T ₄	1 insect/plant + 3 DAF + 7 DIF
T ₅	2 insect/plant + 3 DAF + 7 DIF
T ₆	3 insect/plant + 3 DAF + 7 DIF
T ₇	1 insect/plant + 3 DAF + 10 DIF
T ₈	2 insect/plant + 3 DAF + 10 DIF
T ₉	3 insect/plant + 3 DAF + 10 DIF
T ₁₀	1 insect/plant + 5 DAF + 5 DIF
T ₁₁	2 insect /plant + 5 DAF + 5 DIF
T ₁₂	3 insect/plant + 5 DAF + 5 DIF
T ₁₃	1 insect/plant + 5 DAF + 7 DIF
T ₁₄	2 insect/plant + 5 DAF + 7 DIF
T ₁₅	3 insect/plant + 5 DAF + 7 DIF
T ₁₆	1 insect/plant + 5 DAF + 10 DIF
T ₁₇	2 insect/plant + 5 DAF + 10 DIF
T ₁₈	3 insect/plant + 5 DAF + 10 DIF
T ₁₉	No inoculation (Control)

* DAF- Days of Acquisition Feeding

* DIF- Days of Inoculation Feeding

Table.2 Effect of Leaf hoppers per plant, acquisition and inoculation feeding period and their interactions in the incidence of Sesamum phyllody disease

No of insect per plant	Disease incidence (%)											
	3 DAF*			5 DAF				DAF x No. of insect		DIF x No. of insect		
	5 DIF**	7 DIF	10 DIF	5 DIF	7 DIF	10 DIF	Mean	3 DAF	5 DAF	5 DIF	7 DIF	10 DIF
1	16.67	25.00	27.78	29.62	36.11	41.66	29.47	23.15	35.80	23.15	30.56	34.72
2	50.00	52.77	58.33	58.33	61.11	63.89	57.41	53.70	61.24	54.15	56.95	61.11
3	66.67	72.22	75.00	91.67	100.00	100.00	84.26	71.30	97.22	79.17	86.11	87.50
Mean	44.45	50.00	53.70	59.87	65.74	68.52		49.38	64.75	52.16	57.87	61.11
Control	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00

Treatments	SEm ±	CD (p=0.05)	Treatments	SEm ±	CD (p=0.05)
No. of Insect	3.92	6.54	Acquisition period x No. of insect	5.54	9.25
Acquisition period	3.20	5.34	Inoculation period x No. of insect	5.56	9.27
Inoculation period	3.94	6.56	Acquisition period x Inoculation period	6.79	11.33
Acquisition period x Inoculation period x No. of insect				9.6	16.03

*DAF- Days of Acquisition Feeding

**DIF- Days of Inoculation Feeding

Table.3 Effect of leaf hoppers per plant, acquisition and inoculation feeding period and their interactions in the time period for first appearance of symptom

No of insect per plant	Time period for first appearance of symptom (No. of days)											
	3 DAF*			5 DAF				DAF x No. of insect		DIF x No. of insect		
	5 DIF**	7 DIF	10 DIF	5 DIF	7 DIF	10 DIF	Mean	3 DIF	5 DIF	5 DIF	7 DIF	10 DIF
1	39.00	37.67	35.00	37.00	35.00	34.67	36.39	37.22	35.56	38.00	36.34	34.84
2	33.67	32.00	31.67	33.67	31.67	30.33	32.17	32.44	31.89	33.67	31.84	31.00
3	30.00	29.00	29.00	26.00	25.00	25.00	27.33	29.33	25.33	28.00	27.00	27.00
Mean	34.23	32.89	31.89	32.22	30.56	30.00		32.99	30.92	33.22	31.73	30.95
Control	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00

Treatments	SEm ±	CD (p=0.05)	Treatments	SEm ±	CD (p=0.05)
No. of Insect	0.43	0.73	No. of insect x Acquisition period	0.62	1.03
Acquisition period	0.35	0.59	No. of insect x Inoculation period	0.76	1.27
Inoculation period	0.45	0.75	Acquisition period x Inoculation period	0.64	1.05
Acquisition period x Inoculation period x No. of insect				1.07	1.79

*DAF- Days of Acquisition Feeding

**DIF- Days of Inoculation Feeding

Table.4 Transmission of sesamum phyllody disease by graft transmission method

No of plant grafted	Symptom observed after grafting (days)	Symptom	Plant showing symptom/ Total number of plants	PCR positive plants/Total number of test plant	Percent transmission (%)
10	30-40	Yellowing of leaves, Phyllody	6/10	8/10	80

Table.5 Transmission of sesamum phyllody disease by dodder transmission method

No of plant inoculated	Symptom observed after grafting(days)	Symptom	Plant showing symptom/ Total number of plants	PCR positive plants/Total number of test plant	Percent transmission (%)
10	35-45	Yellowing of leaves, Phyllody, Floral virescence	7/10	9/10	90

Table.6 Germination percentage of sesamum seed

No of seed taken	Seed germinated	Germination percentage	Symptom observed
Healthy	100	80	-
Diseased	100	78	-

More the acquisition feeding period and inoculation feeding period lesser was time period required for first appearance of symptoms of the disease. Jayashree *et al.*, (1999) observed that as the acquisition and inoculation feeding period was increased there was higher percentage of Pumpkin yellow vein mosaic virus infected plants, and the days required for symptom expression became less. Similar observations were also made by Rashid *et al.*, (2008) in case of Tomato Yellow Leaf Curl Virus.

The interaction between the number of leafhopper per plant and acquisition feeding period, number of leafhopper per plant and inoculation feeding period, acquisition feeding period and inoculation feeding period and among number of leafhopper per plant, acquisition feeding period, inoculation feeding period had significantly influenced the time period required for first appearance of disease symptoms. Highest percent of disease transmission (68.52%) was observed in plants inoculated with leafhopper giving 5 days acquisition feeding and 10 days inoculation feeding period.

The lowest disease transmission (44.45%) was observed in plants inoculated with leafhopper giving 3 days acquisition feeding and 5 days inoculation feeding period and also differed significantly. Among the three combinations of treatments, lowest time period (25 days) for symptom expression was observed in plants inoculated with 3 leafhopper/plant + 5 days acquisition feeding period + 7 days inoculation feeding period and also in plants inoculated with 3 leafhopper/plant + 5 days acquisition feeding period + 10 days inoculation feeding period. Highest time period (39 days) for first appearance of symptom was observed in plants inoculated with 1 leafhopper/plant + 3 days acquisition feeding period + 5 days inoculation feeding period.

The interaction effect of the factors (i.e. number of leafhopper released per plant, acquisition feeding period and inoculation feeding period) was increased with the increase of the individual factors and there was corresponding decrease in the time period required for first appearance of disease symptoms.

The Phytoplasmas enter the body of the insect through the stylet, move through the intestine, and are then absorbed into the haemolymph. From haemolymph they proceed to colonize the salivary glands, reaching an infectious titer and after that only it can transmit the phytoplasma to the plant. To complete this process a time period of up to three weeks is required (Carraro *et al.*, 2001; Christensen *et al.*, 2005). This might be the cause of the findings of the present study where reduced time period required for symptom development was observed in case of increased number of vector per plant, increased acquisition feeding period and increased inoculation feeding period of the leafhopper vectors.

Graft transmission

In the present study Sesamum phyllody disease was successfully transmitted from infected plant to the healthy sesamum plant by grafting. Symptom started appearing from 30th day of grafting and continued up to 40th day (Plate 14).

Out of 10 grafted plants 6 plants showed distinct Sesamum phyllody symptoms. When the grafted plants were analysed by PCR assay 8 out of the 10 grafted plants showed positive result (Plate 15). This result indicated that Sesamum phyllody was transmitted to 80 per cent of the graft transmitted plants (Table 4). Similar observations were also reported by Salehi *et al.*, (1992), Akhtar *et al.*, (2009) and Pathak *et al.*, (2012). The Phytoplasmas move

within plants through the phloem from source to sink and they are able to pass through sieve tube elements in phloem tissues (Christensen *et al.*, 2004). Due to this nature probably they are transmitted in the process of grafting. Jarausch *et al.*, (1999) observed successful transmission of European stone fruit yellows (ESFY) phytoplasma by graft transmission. Kamińska and Korbin (1999) reported graft transmission of phytoplasma affecting Lily plant. Likewise, Salehi *et al.*, (2009) could successfully transmitted Sunflower phyllody phytoplasma by graft transmission.

Dodder transmission

Dodder (*Cuscuta campestris*) successfully transmitted the Sesamum phyllody phytoplasma from infected plant to healthy sesamum plants under net house conditions (Plate 16). The dodder transmitted sesamum plants took 35 to 45 days to express the symptoms after transmission (Table 5).

Out of 10 plants used for dodder transmission, 7 plant exhibited typical phyllody symptom followed by yellowing of leaves and floral virescence. In the PCR assay 9 plants out of 10 plants used for dodder transmission showed positive result indicating 90 per cent transmission by dodder.

This indicated that dodder can be a effective means in natural transmission of the disease in the field. Earlier, Abraham *et al.*, (1977) reported that dodder (*Cuscuta campestris*) played role for transmission, donor as well as reservoir of sesamum phytoplasma.

Similarly many other workers could also successfully transmit the disease from infected plant to healthy plant with the help of dodder (Salehi and Izadpanah, 1992; Akhtar *et al.*, 2009 and Pathak *et al.*, 2012). Marcone *et al.*, (1997) reported successful dodder transmission of alder yellows phytoplasma to

the experimental host *Catharanthus roseus* (periwinkle). Similarly, Salehi *et al.*, (2009) could successfully transmitted Sunflower phyllody phytoplasma by dodder.

Seed and sap transmission of Sesamum phyllody phytoplasma

In the present investigation, the Sesamum phyllody phytoplasma could not be transmitted by seed or sap inoculation method (Table 6). The plants raised from seed collected from Sesamum phyllody infected plant did not show any symptoms.

Likewise, plants inoculated with sap extracted from Sesamum phyllody infected plants were also remained free from infection. Out of the ten plants inoculated with sap, no symptom was observed in the plants. The present finding is in conformity with the earlier reports (Fletcher *et al.*, 1998; Akhtar *et al.*, 2009 and Pathak *et al.*, 2012).

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