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Epidemiological Factors Influencing the Development of Pigeonpea Sterility Mosaic Virus Disease in Pigeonpea

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ABSTRACT

Background: In a region of Karnataka, India with a varied type climate PPSMV infection on pigeonpea occurs in a severe form and considered as green plague and one of the most devastating diseases as it appear in severe form resulting in reduction of 100% yield loss transmitted by vector eriophyid mite *Aceriacajani* Channabasavanna. However, not much systematic and strategic research work being carried out on epidemiology. In spite of various control measures, Sterility Mosaic Disease has continued to be major constraint in pigeonpea production. A lot of variation exists among the genetic background of different varieties in different regions. These variations render it difficult to evolve a common management strategy to control SMD epidemics. Therefore, it is necessary to know the severity of disease and factors associated with disease development which helps in devising suitable management practices.

Methods: To study the influence of sowing dates on SMD and vector population under field conditions. A total of twelve sets of sowings were made at different time interval starting from first week of January 2012 to December, 2012. The SMD disease incidence and mite population were recorded in each treatment at fifteen days interval. Under artificial environment, pigeonpea seedlings of variety ICP8863 were raised. Inoculation of virus was done at different stage of plant growth *viz*., 15, 30, 45, 60, 75, 90 days after sowing. The observation on terminal disease incidence was recorded at 90 DAS to study the impact of host age on SMD. The eight pigeonpea varieties were sown near the SMD infected plot so as to facilitate the movement of vector population under natural conditions to study the reaction of pigeonpea varieties to SMD. Naturally grown weeds present in and around the sterility mosaic screening nursery were collected at weekly interval to see the presence of mites. In a glass house experiment, twenty-three cultivated species of economic importance and three *Nicotiana* species were sown three replications to see the alternate host for the virus.

Result: The fluctuation in disease incidence and mite population was recorded throughout the year and early stage of crop growth recorded less disease incidence with lower mite population and gradual increase was recorded at later stage of crop growth period. The maximum disease incidence and mite population was recorded in crop sown during month of June and July where mean temperature was 24 to 26°C, RH 67 to 71% and rainfall of 2.13mm. The disease incidence recorded at different months of sowing had a significant positive correlation with mite population. Pigeonpea plants inoculated up to age of 30 days showed complete sterility with 100% disease incidence. The Resistant genotypes recorded less per cent disease incidence and symptom development at 60 DAS. Whereas susceptible variety recorded maximum diseases incidence at early stage of crop growth and showed complete sterility. PPSMV and its vector survived on the ratooned pigeonpea plants and its wild relatives *Atylosiascaraboeides* during off season.

Key words: Epidemeology, Mite vector, Pigeonpea sterility mosaic virus, Sterility mosaic disease.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp] is an important drought resistant pulse crop cultivated mainly for its protein-enriched seeds in the semi-arid tropical and subtropical regions between 25° N and 30° S in Asia, Africa and America (Van der Maeson, 1990). In India, it is grown in the semi-arid regions of the states, Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Gujarat, Tamil Nadu and Uttar Pradesh because of its drought resistance. Although, India leads the world both in area and production of pigeonpea, its productivity is lower than the world average which may be attributed to various abiotic (*e.g*. drought, salinity and water-logging) and biotic (*e.g*. diseases like *Fusarium* wilt, sterility mosaic and insects like pod borers) factors. Among diseases, *Fusarium* wilt and sterility mosaic are the major constraints to pigeonpea production in the country.

Sterility mosaic disease (SMD), considered as the “green plague of pigeonpea” caused by *pigeonpea sterility mosaic virus* (PPSMV) (Jones *et al*., 2004) and the virus is transmitted by the vector eriophyid mite, *Aceria cajani* Channabasavanna (Kannaiyan *et al*., 1984) is one of the major biotic factors, which leads to heavy yield losses and hence poses a big challenge for pigeonpea production in the Indian subcontinent. More than 90 per cent of the crop

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would be lost if it occurs at the early stage of the crop growth (Bhaskaran and Muthiah, 2005). This disease was first reported from Pusa, Bihar state (Mitra, 1931), subsequently, from several states of India. The disease is characterized by the symptoms like bushy and pale green appearance of plants followed by reduction in leaf size, increase in number of secondary branches and mosaic mottling of leaves and finally partial or complete cessation of reproductive structures. Some parts of the plant may show disease symptoms and other parts may remain unaffected (Kumar *et al.,* 2003).

In Karnataka, sterility mosaic disease is an important disease affecting pigeonpea. The disease is prevalent in almost all the pigeonpea growing areas of the state. The disease results in significant yield reduction. It is considered to be one of the most devastating diseases as it appear in severe form resulting in reduction of 100% yield loss (Muniyappa and Chandrashekhariah, 1980). However, not much systematic and strategic research work being carried out on epidemiology. In spite of various control measures, SMD has continued to be major constraint in pigeonpea production. A lot of variation exists among the genetic background of different varieties in different regions. These variations render it difficult to evolve a common management strategy to control SMD epidemics. Therefore, it is necessary to know the severity of disease and factors associated with disease development which helps in devising suitable management practices. The influence of SMD incidence mainly based on the several epidemiological factors which, involves the virus, mite vector, cultivar and environmental conditions. Infected perennial and volunteer plants serve as a source for both the virus and its vector mites play an important role in the disease cycle (Basa and Kumar, 2015). Different abiotic factors *viz*., temperature, relative humidity and rainfall had significant effect on the mite population (Kaushik *et al*., 2013, Singh and Rathi, 1997).

Various reports exist on the effect of weather conditions on the epidemiology of SMD (Dhar *et al*., 1995, Reddy *et al*., 1993; Singh and Rathi, 1997) but it is accepted that crops grown under irrigation or near irrigated fields are the most vulnerable to early SMD infection (Padule *et al*., 1982). Information on the sources of primary inoculum is limited owing to the diversity of crop seasons in marginal farming systems. However, likely sources include diseased plants left in fields after harvest, on field banks, or in kitchen gardens the presence of perennial pigeonpea or wild relatives of pigeonpea such as C. scarabaeoides. Disease spread within fields in a season depends on proximity to the source of inoculum, plant age, pigeonpea cultivar, climatic factors mite populations (Teifion Jones *et al*., 2004; Rathi *et al*., 1983; Ghanekar *et al*., 1992; Singh and Rathi; 1997). PPSMV and its vector survive on the pigeonpea, Oxalis corniculata Rathi (1983) and off-season and ratooned pigeonpea. Ghanekar (1992) observed *A. cajani* and mild mosaic symptoms on *Atylosia scarabaeoides* but failed to transmit the pathogen to healthy pigeonpea. Later, Reddy, confirmed *Cajanus (Atylosia) scarabaeoides* as an alternate host of PPSMV and its vector.

The objectives of this study were to investigate the influence of different sowing months on per cent disease incidence and mite population, influence of weather parameters on mite vector population, age of host in disease development, effect of popular varieties on Sterility Mosaic Virus Disease incidence and alternate sources of PPSMV to manage the SMD incidence.

MATERIALS AND METHODS

Influence of Sowing Dates on Incidence of SMD and Vector Population

Source of material and experimental conditions

The SMD susceptible variety ICP8863 of pigeonpea was obtained from AICRP on Pigeonpea, GKVK Bangalore. Filed experiments were conducted at Zonal Agriculture Research Station, Gandhi KrishiVigyan Kendra, Bangalore, Karnataka, India during 2012. The trial was laid with net plot size 5×5m and spacing of 60×20m. The design adopted was RCBD with three replications. A total of twelve sets of sowings were made at different time interval starting from first week of January 2012 to December, 2012. The each date of sowing was considered as one treatment. Standard agronomic practices were followed throughout the crop period.

Disease incidence and mite population

The SMD disease incidence and mite population were recorded in each treatment at fifteen days interval. The SMD disease incidence was assessed visually and Percent Disease incidence (PDI) was calculated by using formula of Singh (1992). The Mite population per trifoliate leaf was estimated by direct count method under steriobinocular microscope.

Impact of weather parameters on the mite vector population and SMD incidence

The weather parameters *viz*., maximum and minimum temperature, relative humidity (morning and evening) and rainfall were recorded at experimental location from January to December 2012. The mean disease incidence and vector population in each treatment was correlated with weather parameters using SPSS 16.0 software.

Impact of Host Age on the SMD Disease Development Raising of seedlings

Pigeonpea seedlings of variety ICP8863 susceptible to SMD were raised in 30 cm diameter plastic pots containing soil: sand: FYM in the ratio 1:1:1 under glass house conditions. Each pot was having 4-6 seedlings per and each treatment was replicated thrice. The design adopted was CRD. Regular watering was done to maintain the seedlings.

Inoculation of virus

Diseased leaves collected from the sterility mosaic virus infected plant, were used for inoculation purpose. Leaves bearing more than 10 mites/leaf were stapled on the leaves

of healthy plants. Inoculation was done at different stage of plant growth *viz*., 15, 30, 45, 60, 75, 90 days after sowing. Under each inoculation, inoculated plants were kept under shade for 48 hrs for easy migration of mites. These plants were kept in glasshouse for further observations. The observation on terminal disease incidence was recorded at 90 DAS

Reaction of pigeonpea varieties to SMD

Eight pigeonpea varieties comprising of four resistant *viz*., ICP 7035, BRG 3, IPA 8F, BDN 2 and four susceptible ICP 8863, TTB 7, HY3C, VIPULA were evaluated for their reaction to SMD under field conditions during 2013. The varieties were sown near the SMD infected plot so as to facilitate the movement of vector population under natural conditions. Each variety was sown in area of 2×2 m2 and each variety constitutes one treatment. No management practices for the disease or pest were employed during crop growth. However, the varieties were maintained as per other agronomic practices. The observation on disease incidence was recorded at 30, 45, 60, 75 and 90days after sowing as mentioned above.

Identification of alternate sources of PPSMV infection

Naturally grown weeds present in and around the sterility mosaic screening nursery were collected at weekly interval to see the presence of mites. The leaves of these weeds examined critically under the proper illumination of sterio binocular microscope. Simultaneously, ratoon pigeonpea plants around sterility mosaic infected plot were also observed. The weeds and ratoon pigeonpea were examined visually for SMD like symptoms.

In a glass house experiment, twenty-three cultivated species of economic importance and three *Nicotiana* species were sown in earthen pots of size 10 cm with soil: sand: FYM in three replications. Plants were inoculated at seedling stage *ie*., two leaves stage by following leaf stapling and sap inoculation technique, respectively. Plants were also observed for mites under stereo binocular microscope. Mite population per trifoliate leaf was recorded. The per cent transmission in each case and symptoms observed were documented.

RESULTS AND DISCUSSION

Fluctuation in disease incidence and mite population was recorded throughout the year in the variety ICP 8863. An experiment conducted to assess the disease incidence and mite population on pigeonpea crop sown over different months implied that, early stage crop recorded less disease incidence and gradual increase in disease incidence was recorded at later stages of crop growth period. Cent per cent disease incidence was observed at 90 DAS in almost all months except in the months of January and November month sown crop (Table 1). The disease incidence was lesser in the early stage of crop due to invasion of less number of mites and source of inoculum in early part of the season. The mite population build-up as the plant grew vigorous in the later stage of crop which could results in attaining maximum disease incidence.

The terminal disease incidence recorded in pigeonpea at different sowing months opined that, the crop sown during the month of June and July recorded higher disease incidence compared to crop sown in August and subsequent months (Fig 1). This is due to the late sown post rainy crop (September-2011) harbours the sterility mosaic disease and mite vector and source of inoculum maintained for almost 8 to 9 months up to April and May and helps for outbreak of sterility mosaic disease in the next season. The higher incidence of SMD of early sown (May-June) crop at Bangalore might be due to dispersal of vector mite from ratoon/stubbles/voluntary pigeonpea plants (Annonymous, 1995-96) which as evidenced by Muniyappa and Chandrashekhariah (1980) who also found out the variation in disease incidence was attributed to the variation in population of the mite vector (*Aceriacajani*). The results

Table 1: SMD incidence and mite population in pigeonpea as influenced by sowing month.

Months of sowing	**Per cent disease incidence and mite population/trifoliate leaf at DAS*													
	15		30		45		60		75		90		110	
	DI	MP	DI	MP	DI	MP	DI	MP	DI	MP	DI	MP	DI	MP
Jan	0.00	0.00	0.00	0.00	25.38	0.41	55.00	1.07	66.63	2.57	75.00	2.00	80.00	5.43
Feb	0.00	0.00	0.00	0.00	24.02	0.56	46.86	1.37	64.00	1.87	100.00	2.71	100.00	2.71
March	0.00	0.00	0.00	0.00	17.43	0.50	51.12	1.37	63.57	4.85	100.00	22.80	100.00	25.04
April	0.00	0.00	5.50	0.38	41.85	1.50	66.86	4.85	85.00	22.72	100.00	25.04	100.00	27.00
May	0.00	0.00	0.00	0.00	27.88	5.14	28.60	26.00	71.23	24.14	100.00	24.42	100.00	57.16
June	0.00	0.00	73.97	1.00	100.00	12.58	100.00	73.87	100.00	78.25	100.00	98.12	100.00	80.37
July	0.00	0.00	43.25	0.62	80.00	1.50	100.00	3.00	100.00	2.12	100.00	14.12	100.00	16.25
August	0.00	0.00	0.00	0.00	18.15	0.30	80.66	0.62	100.00	3.00	100.00	7.75	100.00	3.00
Sept	0.00	0.00	30.33	1.62	31.33	1.25	100.00	0.75	100.00	4.62	100.00	0.62	100.00	0.75
Oct	0.00	0.00	34.91	1.00	51.33	0.62	100.00	0.62	100.00	1.90	100.00	2.00	100.00	0.00
Nov	0.00	0.00	53.57	0.00	55.31	0.78	74.79	0.80	75.00	0.80	75.00	1.00	75.00	0.00
Dec	0.00	0.00	0.00	0.00	33.82	0.30	53.85	0.67	53.85	0.72	53.85	1.00	100.00	1.75

*DAS-days after sowing; DI-disease incidence; MP-mite population. **Mean of three replications.

obtained in this study are in line with findings of Thirumalakumar and Rangaswamy (2000) who recorded higher incidence of the disease on May and June sown crops compared to those sown during July and beyond.

Correlation analysis between the mite population and weather parameters recorded during different dates of sowing was done. Vector mite *A. cajani*remains present throughout the year. However, data obtained during the year showed that mite population fluctuated from month to month at various crop growth stages. Maximum population was recorded in the month of May, June and July followed by April and March (Table 2 and Fig 2). The increase in mite population was significantly correlated with weather parameters *viz*., mean temperature of 24 to 26°C, relative humidity of 67 to 71% and rainfall of 1 to 2.33 mm (Table 7). Lowest number of mite population during the months of September, October, November and December was due to heavy rainfall in September month, higher relative humidity in the month of October, higher maximum temperature in the month of November and in December month and all the weather factors showed negatively significant correlation (Table 2). The results are supported by the work of Reddy and Raju (1993) who recorded lesser number of mite population in semi-arid zones at higher temperatures. Thirumalakumar and Rangaswamy (2000) also recorded higher vector population on early sown crop (May and June). Thus, it was opined that maximum temperature (27.6 to 38.9°C), minimum temperature (17.1 to 19.6°C), maximum relative humidity (82.4 to 91.3%) and minimum relative humidity (35.3 to 59.0%) coupled with scanty rains prevailing during April-June at Bangalore favoured the rapid multiplication of the vector leading to higher disease incidence. Kaushik *et al*. (2013) recorded that heavy rainfall was not congenial for mites and had negligible correlation of mite with rainfall and also recorded highest mite population in month of April where the mean temperature was 22.44°C with relative humidity of 64.30%.

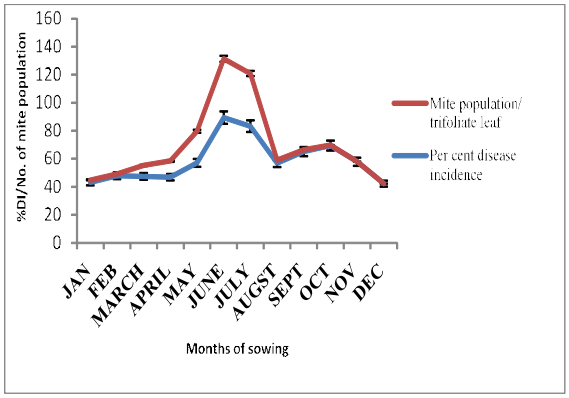


Fig 1: Sterility mosaic disease progress pattern and mite population in pigeonpea.

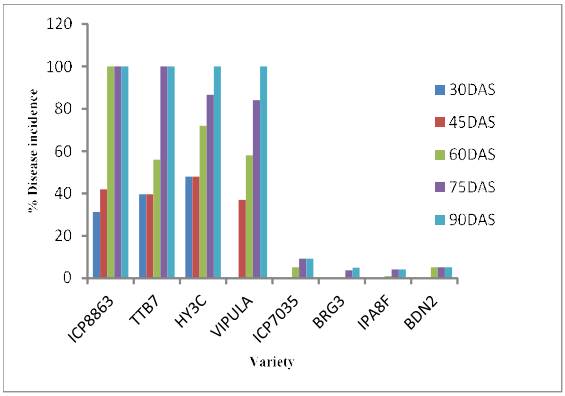


Fig 2: Reaction of popular pigeonpea varieties to sterility mosaic disease incidence.

The observation recorded on the correlation of disease incidence at different months of sowing with mite population and days after sowing reveals that the plant gets infected at all the planting dates. Higher positive correlation between all the three parameters indicated that increase in crop growth period, mite population was also increased with increased disease incidence (Table 3). Seasonal variation in the mite population was correlated with seasonal variation in the disease incidence. In almost all dates of sowing, there was 100 per cent terminal disease incidence. This significant variation in disease incidence may be attributed to reason that even a single mite is sufficient to transmit the disease

Table 2: Correlation among mite population, temperature, relative humidity and rainfall during the year 2012.

Mite population at month of sowing	Maximum temperature	Minimum temperature	Relative humidity (Morning)	Relative humidity (Evening)	Rainfall
Jan	-0.661**	0.708**	0.520*	-0.520*	0.859**
Feb	-0.226	-0.527	-0.361	-0.006	0.952**
March	-0.513	0.398	0.917**	0.981**	0.463
April	-0.742	0.086	-0.641**	0.810	-0.178*
May	-0.802**	0.753**	-0.542*	0.491*	-0.137
June	-0.817**	-0.758**	0.902**	-0.500*	0.783**
July	0.018	0.429	0.071*	0.321*	-0.143*
August	-0.340*	-0.487	-0.954**	-0.225*	0.019
Sept	0.018*	-0.270*	-0.162*	0.018*	-0.865*
Oct	0.239*	0.478*	-0.359	0.777*	0.478*
Nov	-0.612*	-0.204	0.204*	-0.408*	-0.424
Dec	-0.757*	-0.445	0.356	-0.401	-0.516

Table 3: Correlation between disease incidence, crop growth stage and mite population.

Disease incidence at months of sowing	Crop growth stage (DAS)	Mite population
Jan	0.92**	0.59**
Feb	0.92**	0.74**
Mar	0.90**	0.60**
April	0.87**	0.57**
May	0.95**	0.62**
Jun	0.91**	0.60**
July	0.91**	0.55**
Aug	0.86**	0.65**
Sep	0.89**	0.56**
Oct	0.87**	0.57**
Nov	0.92**	0.02**
Dec	0.91**	0.70**

DAS-Days after sowing.

Note: Figures indicates the coefficient of correlation (r).

Table 4: Transmission of pigeonpea sterility mosaic disease as influenced by age of plants.

Age of the plant (days)	*Per cent disease incidence	Type of sterility
15	100.00 (10.02)	Complete
30	100.00 (10.02)	Complete
45	60.00 (7.77)	Partial
60	50.00 (7.10)	Partial
70	42.28 (6.54)	Partial
90	30.00 (5.52)	Partial
110	30.00 (5.51)	Partial
CV (%)	3.18	-
Sem±	1.08	-
CD @0.05	3.33	-

*mean of three replications Figures in the parentheses indicate square root transformed values.

as evidenced by earlier workers Janarthan *et. al*., 1972; Ramakrishnan and Kandaswamy, 1972. Janarthan *et al*. (1972) reported that per cent disease incidence was vary, depending upon the mite population/plant. Reddy *et al*. (1989) reported about 35% (range 20-60%) transmission with one viruliferous mite/plant, while 2-10 mites/plant were able to transmit 77-84% disease. A mite population of 20 per plant invariably resulted in 100 per cent disease transmission.

Age of the plant is important for development of disease. In the present study, plants of all age group ranging from 15 to 110 days were found susceptible to sterility mosaic disease infection. The maximum (100%) disease development with complete sterility was observed on 15 to 30 days old plants and >50% in case of 45 to 60days old plants with partial sterility. By visual observations it was found that early infected (upto 30 days old) plants, were more severely affected than the older one and exhibited severe stunting, increased number of secondary branches and prolonged duration of crop (Table 4). These results are with the conformity of the results obtained by Singh (1992) that pigeonpea plants infected early (45 days) exhibited complete sterility, wherein infection at older stage showed partial sterility and produced pods and seeds.

The resistant verities (ICP7035, BRG3, IPA8F, BDN2) recorded less per cent disease incidence and symptom development observed at 60 days after of sowing whereas, susceptible varieties (Vipula, ICP 8863, TTB 7 and HY3C,) recorded maximum disease incidence at early stage of crop growth and showed complete sterility (Fig 2). The variation in disease reaction might be attributed to the probable changes in resistance phenomenon or to variation in resistance reaction at different geographical locations.

Table 5: Natural infection of PPSMV and its vector *Aceriacajani*in weeds around SMD infected field.

Name of plants /weed species	Presence of sterility /sterility like symptoms	Presence of mites / trifoliate leaf
Phyllanthus niruri	-	-
Mimosa pudica	-	-
Cyprus rotundus	-	-
Blumea spp.	-	-
Convovulus arvensis	-	-
Ipomea acquaticus	-	-
Setaria italic	-	-
Cynodon dactylon	-	-
Abutilon indicum	-	-
Amaranthus tricolor	-	-
Solanum xanthocarpum	-	-
Trianthema monogyna	-	-
Physalis minima	-	-
Portulaca olearacea	-	-
Chenopodium alnum	-	-
Synapsis alba	-	-
Parthenium hysterophorus	-	-
Ageratum conizoides	-	-
Acanthospermum hispidum	-	-
Helianthus annus	-	-
Chenopodium amaranticolar	-	-
Datura stramonium	-	-
Euphorbia hirta	-	-
Tridax procumbans	-	-
Argemone mexicana	-	-
Alternanthera echinata	-	-
Cassia ceresea	-	-
Amaranthus viridis	-	-
Atylosia scarabaeoides	+	+ December (4) January (3) February (0.5) March (4.5)
Ratooned pigeonpea	+	+ (250)

-(absence), + (presence)

Variation in symptom expression at different locations by some pigeonpea genotypes has been reported by Reddy *et al*. (1998). Vijayanarasimha (2002) reported that the resistance of the genotype ICP 7035 is due to inability of the mite vector to multiply feed and inoculate the virus into living epidermal cells because of the thick cuticle which is larger than mite stylet size which is about 2.03µm and low density of leaf hairs.

Observations related with the survival of vector (*A. cajani*) and sterility mosaic disease on alternate hosts indicated that *pigeonpea sterility mosaic virus* vector survived only on the rationed pigeonpea plants and its wild

Table 6: Cultivated crop species to pigeonpea sterility mosaic virus disease under glass house conditions.

Hosts	No. of plants infected/ inoculated	Per cent disease transmission	Symptoms	Number of mites/ trifoliate leaf
Phaseolus vulgaris Kintoki	2/5	40.00	Vein thickeningvein clearing	0
V. radiata (L.) Wilzek	0/5	0	NS	0
Arachishypogaea	0/5	0	NS	0
Macrotyloma uniflorum	0/5	0	NS	0
Cajanus cajana (L.) Millsp	0/5	0	NS	0
Cicer arietinum L.	0/5	0	NS	0
Vigna unguiculata subsp. sesquipedalis	0/5	0	NS	0
Phaseolus lunatus	0/0	0	NS	0
Glycine max (L.) Merr.	0/5	0	NS	0
Rice bean	0/5	0	NS	0
Winged bean	0/5	0	NS	0
Horse gram	0/5	0	NS	0
Vigna mungo (L.) Hopper	0/5	0	NS	0
Cluster bean	0/5	0	NS	0
Cassia sp.	0/5	0	NS	0
Cucumis sativus L.	0/5	0	NS	0
*Benincosahispida*Thumb.	0/5	0	NS	0
Cucurbitamoschata Duchsne	0/5	0	NS	0
Memordicacharantia	0/5	0	NS	0
Capsicum annuum	0/5	0	NS	0
Medicago sativa	0/5	0	NS	0
Gossypium hirsutum	0/5	0	NS	0
Lycopersicon esculentum	0/5	0	NS	0
N. tobaccum	0/5	0	NS	0
N. glutinosa	0/5	0	NS	0
N. benthamiana	5/5	100	Chlorosis, mosaic, vein clearing, necrosis at later stage	0

Table 7: Weather parameters recorded during different months of sowing in the year 2012.

Month of sowing	Maximum temperature (°C)	Minimum temperature (°C)	Mean temperature (°C)	Rainfall (mm)	Relative humidity (Morning) (%)	Relative humidity (Evening) (%)	Mean relative humidity (%)
Jan	31.75	17.20	24.47	0.009	86.34	39.94	63.14
Feb	32.33	17.96	25.15	0.331	83.97	34.88	59.42
March	33.52	19.77	26.64	0.89	83.80	37.58	60.69
April	32.90	20.54	26.72	1.143	85.32	41.21	63.27
May	31.19	20.44	25.82	2.059	88.19	46.91	67.55
June	29.81	19.95	24.88	2.132	90.31	50.44	70.37
July	28.84	19.48	24.16	2.416	91.81	51.42	71.62
August	28.49	19.14	23.82	2.022	91.66	52.84	72.25
Sept	28.25	18.25	23.25	3.013	90.22	52.76	71.49
Oct	27.48	16.82	22.15	2.402	87.37	50.54	68.96
Nov	27.48	15.65	21.57	1.61	86.69	49.33	68.01
Dec	28.64	15.38	22.01	0.309	85.57	44.17	64.87

relative *A. scaraboeide* (Table 5). It was clear that none of the weeds collected from the vicinity of experimental plot harboured mite vector and sterility mosaic disease except *A. scaraboeides* during the off season. Narayanaswamy (2004) opined that *Aceriacajani* survived on ratoon pigeonpea crop. It also survived on *A. scarabaeoides* almost throughout the year, but its higher population from April and June was of greater significance as a potential source for carryover of the mite to the rainy season crop (*Kharif*) in the absence of other sources like, infected stubbles/ratoons, stray/voluntary pigeonpea plants *etc*. Singh (1992) reported that only ratooned and perennial pigeonpea as active source of vector mite *A. cajani*.

Under glasshouse conditions, among 23 cultivated crop species and 3 *Nicotiana* species tested, PPSMV infection observed only in *Phaseolus vulgaris* and *Nicotiana benthamiana* and none of the plants supported mite multiplication (Table 6). Our results are in conformity with the findings of Reddy *et al*. (1990) and Manjunatha (2012) where they reported PPSMV in frenchbean and *N. benthamiana*.

CONCLUSION

The data obtained in this study has contribute to the current knowledge on epidemics and include some opportunities for further control strategies *viz*., modifying the sowing dates as a means to escape the disease in Sterility Mosaic Disease hot spot regions, removal of all potential PPSMV hosts prior to crop sowing to ensure there is no inoculums for spread to new pigeonpea crop, late sowing when temperatures are not so conducive to mite population build-up or movement and use of resistant varieties. However in the long term, further investigation is needed to determine the effect of wild hosts in the regional epidemiology of PPSMV to arrange a forecasting system or at least estimate disease incidence.

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