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Pigeonpea sterility mosaic virus disease in Karnataka: Epidemiological aspects

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Abstract
Pigeonpea sterility mosaic virus infection on pigeonpea occurs in a severe form in its growing areas of Karnataka and considered as green plague of pigeonpea and transmitted by vector eriophyid mite *Aceria cajani* Channabasavanna. In an effort to greater understanding of the epidemics of PPSMV in this environment during the year 2013, various epidemiological factors were examined, especially the effect of different sowing months with variety ICP8863 on per cent disease incidence and mite population, weather factors, age of host in disease development, effect of popular varieties on Sterility Mosaic Virus Disease incidence and alternate sources of PPSMV. 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. August and September sown crop recorded higher disease incidence and mite population where the mean temperatures were 25.12 ^{0}C, 23.08 ^{0}C and relative humidity of 70.64 per cent, 73.84%, respectively. 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 60DAS. 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 *Atylosia scaraboeides* during off season. The results demonstrated the different epidemiological factors in the level of PPSMV infection and can be used to recommend modifying the sowing dates as a means to escape the disease in the SMD hot spot regions.

Keywords: Pigeonpea sterility mosaic virus, mite vector, sterility mosaic disease, epidemiology

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 25º N and 30º S in Asia, Africa and America (Van der Maeson, 1990) [16]. In India it is grown in the semi-arid regions of the states, Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Gujarath, 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. This is a matter of concern since the domestic demand of pigeonpea is rapidly increasing.

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 would be lost if it occurs at the early stage of the crop growth (Bhaskaran and Muthiah, 2005) [1]. 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) [5].

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) [7]. 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 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 avoid the SMD incidence.

Material 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 Krishi Vigyan Kendra, Bangalore, Karnataka, India during 2013. A total of twelve sets of sowings were made at different time interval starting from first week of January 2013 to December 2013. 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 Awanindra Kumar (1992) [15]. 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 2013. 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 30cm 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 10mites/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 48hrs for easy migration of mites. These plants were kept in glasshouse for further observations. The observation on terminal disease incidence was recorded at 90DAS.

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 m^2 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 steriobinocular 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 10cm 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. At 90 DAS almost all the months recorded 100% disease incidence except March (85.32), January (58.13), November (52.57), December (52.40) and least was recorded in February (52.5) sown crop. Whereas, at 110 DAS 100% disease incidence was recorded in almost all months of sowing except January (58.13) and February (60.00) 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.

During the year 2013, early appearance of disease incidence at 30 DAS was recorded in May month sown crop followed by September and July sown crop this is due to the build-up of mite population during the early stage of crop growth and 100% disease incidence was recorded at 90 and 110 DAS with more number of mite population. January and February month sown crop did not attained 100% terminal disease incidence because of less number of mite population (table 1).

Studies with TTB-7 and ICP-8863 (Maruthi) varieties revealed that though vector mites were present throughout the cropping period, their number was low at early stages of the crop at Bangalore. The vector population gradually increased from 45 to 60 DAS reaching peak on 120 to 150 days old crop. Increased vector population associated with simultaneous increase in the extent of disease incidence was reported by Prabhuswamy *et al*. (1995) [9].

The average disease incidence recorded at different growth stages during the year 2013 revealed that higher disease incidence in the months of August and September compared to subsequent months. This could be attributed to the higher mite population in the month of August and September where mean temperature was 25.12 ^{0}C, 23.08 ^{0}C and relative humidity was 70.64% and 73.74%, respectively and also long dry spell in the months of January, February, March, April, May and June (Table 2 and Table 9). Vishwa Dhar *et. al*. (1995) [18] also reported that pigeonpea plants remain vulnerable to infection throughout the year. A minimum and maximum temperature range of 10-25 ^{0}C and 25-35 ^{0}C, respectively and relative humidity above 60% were congenial for build-up of vector population which coincides with severe outbreak of SMD in the field. During the months of January, February and March d less disease incidence with less number of mite population was recorded because of higher temperature and low relative humidity. But in the month of April again build-up of mite population was observed hence more disease incidence was recorded which coincides with low temperature (24.80 ^{0}C) and relative humidity of 69.64%. Reddy and Raju (1993) [11] reported that during the month of November and December less disease incidence was observed which coincides with lower mite population due to very low temperature of 20 ^{0}C.

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. Highest mite population was found in May and August which had significant positive correlation with mean temperature of 25.12 ^{0}C, 23.08 ^{0}C and relative humidity of 70.64, 73.84%, respectively but rainfall had negative correlation. The remaining months recorded lesser mite population because of unfavourable weather conditions *viz*., higher temperature and low relative humidity (table 3). Similar observations were recorded by Kaushik Dipshikha *et al*. (2013) [4] where abiotic factors like temperature, relative humidity and rainfall had significant effect on mite population. Average temperature of about 20-30 ^{0}C was found congenial for the multiplication of mite and very high temperature was not suitable for the growth of mite. Heavy rainfall was also not suitable for the growth of mite. Singh Awanindra Kumar (1992) [15] reported the seasonal fluctuation of vector (*A. cajani*) population. Maximum population was recorded in the month of May followed by moderate population in the months of April, March, June, September, July and August, whereas low population was recorded during winter months (October to February) with the minimum in the month of January.

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 4). 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 as evidenced by earlier workers Ramakrishnan and Kandaswamy (1972) [10], Janarthan *et al*. (1972) [2] reported that per cent disease incidence was vary, depending upon the mite population/plant. Reddy *et al*. (1989) [12] 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 5). These results are with the conformity of the results obtained by Singh Awanindra Kumar (1992) [15] that pigeonpea plants infected early (45days) 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 (Table 6). 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. Variation in symptom expression at different locations by some pigeonpea genotypes has been reported by Reddy *et al*. (1998) [13]. Vijayanarasimha (2002) [17] 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 ratooned pigeonpea plants and its wild relative *A. scaraboeides* (Table 7). 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) [8] opined that *Aceria cajani* 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 Awanindra Kumar (1992) [15] 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 8). Our results are in conformity with the findings of Reddy *et. al*. (1990) [14] and Manjunatha (2012) [6] where they reported PPSMV in frenchbean and *N. benthamiana*.

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.

Table 1: SMD incidence and mite population in pigeon pea 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	4.67	0.00	4.67	0.00	32.42	0.00	58.13	0.28	58.13	0.28
FEB	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	52.50	0.00	52. 50	0.10	60.00	0.23
MARCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	71.23	0.00	85.32	0.12	100.00	0.12
APRIL	0.00	0.00	0.00	0.00	2.87	0.00	10.00	0.70	100.00	1.65	100.00	2.00	100.00	2.00
MAY	0.00	0.00	26.71	0.75	26.71	0.50	46.74	0.75	46.74	0.62	100.00	1.62	100.00	1.62
JUNE	0.00	0.00	0.00	0.00	26.65	0.37	26.74	0.40	31.67	0.12	100.00	3.37	100.00	3.37
JULY	0.00	0.00	13.63	1.50	9.67	0.62	23.39	1.75	100.00	2.12	100.00	2.37	100.00	2.37
AUGST	0.00	0.00	0.00	0.00	72.07	5.50	100.0	15.62	100.00	16.83	100.00	7.37	100.00	7.37
SEPT	0.00	0.00	31.33	0.75	31.33	1.00	100.0	6.62	100.00	5.75	100.00	4.00	100.00	4.00
OCT	0.00	0.00	5.02	0.25	5.02	0.75	100.0	0.37	100.00	0.62	100.00	4.50	100.00	4.50
NOV	0.00	0.00	0.00	0.00	0.00	0.00	18.45	2.37	30.71	1.87	52.57	0.62	100.00	0.62
DEC	0.00	0.00	0.00	0.00	0.00	0.00	29.47	0.25	30.72	0.32	52.40	0.76	100.00	0.76

*DAS-days after sowing; DI-disease incidence; MP-mite population

** Mean of three replications

Table 2: Sterility mosaic disease progress pattern and mite population in pigeonpea

Months of sowing	Per cent disease incidence	Mite population/ trifoliate leaf
	2013	
JAN	19.75	0.08
FEB	24.28	0.04
MARCH	36.65	2.17
APRIL	57.55	0.94
MAY	49.55	3.21
JUNE	40.72	1.28
JULY	49.52	1.67
AUGST	67.43	5.76
SEPT	66.09	2.00
OCT	58.57	1.28
NOV	32.89	0.61
DEC	30.36	0.09

Table 3: Correlation among mite population, temperature, relative humidity and rainfall during the year 2013

Mite population at month of sowing	Maximum temperature	Minimum temperature	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainfall
JAN	0.757*	-0.802*	0.045*	0.802*	0.500*
FEB	-0.309*	-0.612*	0.612*	0.408*	0.212*
MARCH	-0.674*	0.356*	-0.490*	0.535*	0.674*
APRIL	-0.704*	-0.704*	-0.704*	-0.630*	0.296*
MAY	0.793*	-0.685*	-0.685*	0.342*	-0.000
JUNE	0.500*	0.852*	-0.741*	-0.556*	0.111*
JULY	0.306*	0.667*	0.523*	0.865*	-0.072*
AUGST	0.306*	-0.432*	-0.072*	0.306*	-0.378*
SEPT	0.523	-0.144*	-0.036*	0.026*	-0.757*
OCT	0.234*	0.703*	-0.631*	0.252*	-0.811*
NOV	0.571	-0.867*	0.473*	0.256*	0.685*
DEC	0.474*	-0.158*	-0.100	0.791*	-0.258

* Significant at p=0.05

** Significant at p=0.01

Table 4: Correlation between disease incidence, crop growth stage and mite population

Disease incidence at months of sowing	Crop growth stage (DAS)	Mite population
JAN	0.96**	0.57**
FEB	0.98**	0.62**
MAR	0.98**	0.87**
APR	0.97**	0.87**
MAY	0.96**	0.71**
JUN	0.80**	0.68**
JUL	0.79**	0.50*
AUG	0.93**	0.67**
SEP	0.75**	0.40**
OCT	0.90**	0.23**
NOV	0.79**	0.24**
DEC	0.95**	0.26**

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

DAS-Days after sowing

Note: Figures indicates the coefficient of correlation (r)

Table 5: 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.

Table 6: Reaction of popular pigeonpea varieties to sterility mosaic disease incidence

Variety	*Per cent Disease Incidence				
	30DAS	45DAS	60DAS	75DAS	90DAS
ICP8863	31.33	42.00	100.00	100.00	100.00
TTB7	39.65	39.65	56.00	100.00	100.00
HY3C	48.00	48.00	72.00	86.60	100.00
VIPULA	0.00	37.00	58.00	84.00	100.00
ICP7035	0.00	0.00	5.20	9.20	9.20
BRG3	0.00	0.00	0.00	3.80	5.00
IPA8F	0.00	0.00	1.00	4.20	4.20
BDN2	0.00	0.00	5.20	5.20	5.20

*Mean of three replications
DAS- days after sowing

Table 7: Natural infection of PPSMV and its vector *Aceria cajani* in weeds around SMD infected field

Sl. No.	Name of plants/weed species	Presence of sterility/sterility like symptoms	Presence of mites/ trifoliate leaf
1	*Phyllanthus niruri*	-	-
2	*Mimosa pudica*	-	-
3	*Cyprus rotundus*	-	-
4	*Blumea spp.*	-	-
5	*Convovulus arvensis*	-	-
6	*Ipomea acquaticus*	-	-
7	*Setaria italic*	-	-
8	*Cynodon dactylon*	-	-
9	*Abutilon indicum*	-	-
10	*Amaranthus trocolor*	-	-
11	*Solanum xanthocarpum*	-	-
12	*Trianthema monogyna*	-	-
13	*Physalis minima*	-	-
14	*Portulaca olearacea*	-	-
15	*Chenopodium alnum*	-	-
16	*Synapsis alba*	-	-
17	*Parthenium hysterophorus*	-	-
18	*Ageratum conizoides*	-	-
19	*Acanthospermum hispidum*	-	-
20	*Helianthus annus*	-	-
21	*Chenopodium amaranticolar*	-	-
22	*Datura stramonium*	-	-
23	*Euphorbia hirta*	-	-
24	*Tridax procumbans*	-	-
25	*Argemone mexicana*	-	-
26	*Alternanthera echinata*	-	-
27	*Cassia ceresea*	-	-
28	*Amaranthus viridis*	-	-
29	*Atylosia scarabaeoides*	+	+ December (4) January (3) February (0.5) March (4.5)
30	Ratooned pigeonpea	+	+ (250)

-(absence), + (presence)

Table 8: Cultivated crop species to pigeonpea sterility mosaic virus disease under glass house conditions**.**

Sl. No.	Hosts	No. of plants infected/ inoculated	Per cent disease transmission	Symptoms	Number of mites/ trifoliate leaf
1	*Phaseolus vulgaris* Kintoki	2/5	40.00	Vein thickening vein clearing	0
2	*V. radiata* (L) Wilzek	0/5	0	NS	0
3	*Arachis hypogaea*	0/5	0	NS	0
4	*Macrotyloma uniflorum*	0/5	0	NS	0
5	*Cajanus cajana* (L.) Millsp	0/5	0	NS	0
6	*Cicer arietinum* L.	0/5	0	NS	0
7	*Vigna unguiculata subsp. sesquipedalis*	0/5	0	NS	0
8	*Phaseolus lunatus*	0/0	0	NS	0
9	*Glycine max* (L.) Merr.	0/5	0	NS	0
10	Rice bean	0/5	0	NS	0
11	Winged bean	0/5	0	NS	0
12	Horse gram	0/5	0	NS	0

13	*Vigna mungo* (L.) Hopper	0/5	0	NS	0
14	Cluster bean	0/5	0	NS	0
15	*Cassia sp.*	0/5	0	NS	0
16	*Cucumis sativus* L.	0/5	0	NS	0
17	*Benincosa hispida* Thumb.	0/5	0	NS	0
18	*Cucurbita moschata* Duchsne	0/5	0	NS	0
19	*Memordica charantia*	0/5	0	NS	0
20	*Capsicum annuum*	0/5	0	NS	0
21	*Medicago sativa*	0/5	0	NS	0
22	*Gossypium hirsutum*	0/5	0	NS	0
23	*Lycopersicon esculentum*	0/5	0	NS	0
24	*N. tobaccum*	0/5	0	NS	0
25	*N. glutinosa*	0/5	0	NS	0
26	*N. benthamiana*	5/5	100	Chlorosis, mosaic, vein clearing, necrosis at later stage	0

Table 9: Weather parameters recorded during different months of sowing in the year 2013

Sl. No.	Month of sowing	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Mean Temperature (^{0}C)	Rainfall (mm)	Relative Humidity (Morning) (%)	Relative Humidity (Evening) (%)	Mean Relative humidity (%)
1	Jan	31.23	17.087	24.16	0.45	88.19	40.44	64.32
2	Feb	32.64	19.05	25.85	0.58	87.28	37.72	62.50
3	March	33.43	20.35	26.89	2.11	87.32	39.81	63.57
4	April	32.16	20.83	26.50	2.38	87.54	44.26	65.90
5	May	30.08	20.17	25.13	2.42	89.32	49.96	69.64
6	June	28.44	19.46	23.95	2.94	91.20	54.89	73.05
7	July	27.71	19.12	23.42	4.77	92.20	55.80	74.00
8	August	27.36	18.80	23.08	4.82	91.37	56.31	73.84
9	Sept	27.16	18.014	22.59	4.70	90.27	55.15	72.71
10	Oct	26.37	16.35	21.36	1.23	87.15	52.60	69.88
11	Nov	26.62	15.38	21.00	0.88	88.90	49.55	69.23
12	Dec	27.02	14.48	20.75	0.34	87.60	44.94	66.27

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