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Influence of abiotic factors and dates of sowing on sterility mosaic disease of Pigeon pea incited by *Aceria cajani*

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Abstract
Pigeonpea, *Cajanus cajan* (L.) Millspaugh, is one of the major pulse crop of the tropics and subtropics also popularly known as red gram, tur or arhar. It is a primary source of protein for millions in India. Sterility mosaic disease (SMD) caused by mite (*Aceria cajani*) is a major disease limiting the pigeonpea production in the Indian subcontinent. The field experiment was conducted during the year 2018-20 at RARS, Warangal to study the effect of abiotic factors on mite population and disease incidence of sterility mosaic disease. Among the various factors studied relative humidity and wind speed had a strongly positive with mite population. The studies on effect of different sowing dates on sterility mosaic disease was observed and be concluded that sever disease incidence was observed with late sowing of the crop *i.e.*, from First week of August than early (before June 15th) or on timely sowing (June 15th to July 15th) of the crop.

Keywords: Pigeonpea, *Aceria cajani*, Sterility mosaic disease, correlation coefficient, weather factors

Introduction
Pigeonpea (*Cajanus cajan* L. Millsp.) is a major grain legume crop. Globally, it is cultivated in an area of about 95.72 million ha with annual production of 92.27 million tonnes. India accounts for 90 per cent of the global production with area 28.45 million ha and production 2.3 million tonnes (FAOSTAT, 2019) [1]. Despite of larger area under pigeonpea in India, the production levels are stagnant due to various biotic and abiotic stresses. Among the biotic stresses, sterility mosaic disease (SMD) is considered as major biotic constraint. Sterility mosaic disease (SMD), often referred to as "Green Plague", as the affected plants are green with excessive vegetative growth but with no flowers or pods, under congenial conditions spreads rapidly leading to severe epidemics (Singh *et al*. 1999) [11]. SMD infection at an early stage (<45-day-old plants) results in a 95–100% loss in yield (Reddy *et al*. 1990) [8]. Yield losses due to SMD were estimated at 205, 000 t of grain valued at US $ 76 million annually (Kannaiyan *et al*. 1984) [2] in India and Nepal in 1993, losses were US$280 million (Reddy *et al*. 1993) [9]. SMD is reported from the states of Karnataka, Andhra Pradesh, Telangana, Bihar, Maharashtra, Tamilnadu, Chattisgarh, Gujarat, Pujab, Uttar Pradesh and West Bengal (Kannaiyan *et al*. 1984; Narayana *et al*. 2000; Sing and Raghuraman, 2011; Zote *et al*. 1991) [2, 6, 12, 13]. Apart from India it has been reported from Nepal, Bangladesh and Myanmar, Thailand and Sri Lanka (Nene and Sheila 1990) [7]. SMD is caused by Pigeonpea Sterility mosaic virus and is transmitted by an eriophyid mite (*Aceria cajani*) (Kumar *et al*. 2000) [4].

In spite of various control measures, SMD has continued to be major constraint in Pigeonpea production. A lot of variations exist in the occurrence of the disease varies to season to season and region to region. Therefore, it is necessary to know the severity of disease and factors associated with disease development which helps in devising suitable management practices.

Materials and Methods
Two years of Field experiments were conducted at Regional Agricultural Research station, located at Logitude 79.28ºE and Latittude 17.58ºN, Warangal, Telangana state, during 2018 - 2020 with susceptible variety (ICPL-8863). A total of three different sowings were made at 15 days interval *i.e.*, i) At 15days earlier than normal date of sowing; ii) Normal date of sowing; iii) At 15 days later than normal date of sowing.

Each date of sowing was considered as one treatment with three replications. Standard agronomic practices were followed throughout the crop period. The SMD disease incidence and mite population were recorded in each treatment at fifteen days interval. The SMD disease incidence was observed visually and percent disease incidence (PDI) was calculated by using formula of Singh Awanindra Kumar (1992). The mite population per trifoliate leaf was estimated by direct count method under steriobinocular microscope. Simultaneously, weather parameters like maximum and minimum temperatures, relative humidity (morning and evening), rainfall, rainy days and wind speed collected from meteorological observatory, RARS, Warangal were used for correlation and regression studies to know the influence of weather parameters on the sterility mosaic disease incidence as well on the population of mite *Aceria cajani*.

Results and Discussion

The results revealed that during 2018 in the treatment I (at 15 days earlier than normal date of sowing), incidence of sterility mosaic disease was initiated from 28th standard week (9-15th July 2018) with less number of vector *Aceria cajani* and it was increased actively up to first week of January. The highest percent of disease incidence (23%) with highest vector population (20) was observed at last week of December (52nd standard week) Table 1. During 2019-20 disease incidence was initiated at 47th standard week (12-18 Nov 19) with 2.0 numbers of vectors and 12.8 percent of disease incidence and it was increased thereafter (Table 2). The highest percent of disease incidence (23.6%) was observed at last week of January (4th standard week).

The correlation and regression studies conducted on the percent of disease incidence and weather parameters revealed that highly significant positive correlation obtained between sterility mosaic disease and Relative humidity (RH II) and wind speed with correlation coefficient (r) being0.310, 0.527 respectively. The population of mites was showing positively correlation with correlation coefficient (r) 0.648. The max temperature showed negative correlation with correlation coefficient (r) being -0.229 (Table.3).

The correlation and regression studies conducted during 2019-20 on the percent of disease incidence and weather parameters revealed that highly significant positive correlation obtained between sterility mosaic disease and wind speed with correlation coefficient (r) being 0.609 and vector population also positively correlate with correlation coefficient (r) being 0.863. The max temperature, Relative humidity and Rainfall showed negative correlation with correlation coefficient (r) being -0.538, -0.071, -0.489 (Table 3).

Treatment II (At Normal date of sowing): Revealed that Sterility mosaic disease was initiated at 29th standard week (16-22nd July 18) with 4.0 numbers of vectors and 0.3 percent of disease incidence was recorded at normal date of sowings (June 15th to July 15th) and it reached to highest percent of disease incidence (41%) with moderate vector population (15) at 31st standard week (30-5 Aug 2018) and it was gradually decrease due to heavy rains (Table 1). In 2019-20 due to heavy rains immediately after sowing, the disease incidence (11.0%) was initiated lately after 47th standard week (12-18 Nov 19) with low number of vectors (2.0) (Table 2) and it reached to highest percent of disease incidence 20.7% with highest vector population (45) at 4th standard week (19-24 JAN 2020)

Correlation between the weather parameters and sterility mosaic disease was revealed that highly significantly positive correlation obtained between disease incidence of sterility mosaic disease and wind speed, Relative humidity with correlation coefficient (r) being 0.341, 0.218 positive correlation coefficient (r) being 0.811 was observed with vector population. During 2019-20 Correlation between the weather parameters and sterility mosaic disease was revealed that highly significantly positive correlation obtained between sterility mosaic disease and wind speed and vector population with correlation coefficient (r) being 0.627, 0.877 respectively (Table 3). This investigation confirmed with Lakshmikantha and Prabhuswamy (2002) [5]. The population of *A. cajani* and incidence of sterility mosaic disease were found to be positively correlated.

At 15days later than normal date of sowing: Sterility mosaic disease symptoms were initiated at 48th standard week (1-7th Oct 18) with 20 numbers of vectors and 4.5 percent of disease incidence was recorded and it was gradually increased up to 52nd standard week (24-31st December 2018) (Table 1). Sterility mosaic disease symptoms were initiated at 47th standard week (12-18 Nov 19) with 3.0 numbers of vectors and 13.2 percent of disease incidence was recorded and it reached to highest percent of disease incidence 35.8% and vector population (65) was observed at 4thst standard week (19-24 JAN 2020)

Correlation between the weather parameters and sterility mosaic disease at the time of 15 days later than normal sowing revealed that significantly negative correlation obtained between sterility mosaic disease and Temperature, Relative humidity, wind speed, and Rainfall with correlation coefficient (r) being -0.49194, -0.84035, -0.25752, -0.46195, -0.10823 and -0.4131 respectively. Only the vector population showing highly significant positive correlation with correlation coefficient (r) being 0.901 during 2018-19 (Table 3).

Same scenario if significantly negative correlation obtained between sterility mosaic disease and max. Temperature, min. Temperature, morning Relative humidity, evening Relative humidity and Rainfall with correlation coefficient (r) being -0.492, -0.892, -0.002, -0.803 and -0.601 respectively during 2019-20. Highly significant positive correlation was observed between sterility mosaic disease and wind speed and also with vector population with correlation coefficient (r) being 0.571 and 0.891

Table 1: Influence of weather parametrs on mite population and sterility mosaic disease incidence of Pigeonpea during 2018-19

STND WK	Period	Max. TEMP	Min. TEMP	RH I	RH II	EVP	Rain Fall	Wind velocity	VP I	VP II	VP III	PDI I	PDI II	PDI III
28	09-15 July 18	27.7	22.2	86.6	68.3	1.4	60.6	11.0	2.0	0.0	0.0	0.3	0.0	0.0
29	16-22 July 18	27.7	23.0	83.6	75.0	4.2	81.4	11.9	6.0	4.0	0.0	2.0	0.3	0.0
30	23-29 July 18	30.3	24.1	87.8	69.5	18.4	7.2	7.6	10.0	10.0	0.0	18.1	11.1	0.0
31	30-5 Aug 18	30.5	24.7	86.7	68.8	17.8	32.2	22.8	20.0	15.0	0.0	41.8	21.1	0.0

32	6-12 Aug 18	29.6	23.6	88.0	69.9	5.4	158.4	16.3	12.0	12.0	0.0	15.4	12.7	0.0
33	13-19 Aug 8	28.8	23.7	89.0	72.9	1.2	48.4	23.5	15.0	18.0	0.0	23.0	21.7	0.0
34	20-26 Aug 18	29.0	22.1	89.3	71.6	14.6	57.0	14.8	10.0	10.0	0.0	13.1	12.4	0.0
35	27-2 Sept 18	30.4	23.4	91.1	62.1	23.4	16.0	11.5	10.0	10.0	0.0	14.3	13.1	0.0
36	3-9 Sept 18	31.4	23.0	88.0	62.5	0.0	19.6	19.6	2.0	8.0	0.0	14.5	14.0	0.0
37	10-16 Sept 18	32.0	24.0	90.4	59.0	0.4	7.5	7.5	2.0	8.0	0.0	9.1	13.4	0.0
38	17-23 Sept 18	32.4	22.2	88.9	59.2	6.9	19.9	19.9	6.0	14.0	0.0	9.6	14.1	0.0
39	24-30 Sept 18	31.2	23.6	80.5	69.7	0.0	5.4	5.4	5.0	12.0	0.0	9.6	19.7	0.0
40	1-7 Oct 18	33.0	30.0	90.0	57.0	6.0	0.0	5.3	2.0	17.0	20.0	6.0	19.7	4.5
41	8-14 Oct 18	32.7	24.0	88.8	54.6	6.0	0.0	18.9	5.0	6.0	35.0	11.7	22.5	14.4
42	15-21 Oct 18	33.7	22.0	87.4	51.0	5.8	0.0	10.9	4.0	4.0	10.0	6.3	3.0	7.3
43	22-28 Oct 18	33.2	20.0	87.1	43.7	5.5	0.0	7.8	4.0	4.0	10.0	6.3	3.0	7.8
44	29-4 Nov 18	29.2	17.0	87.1	52.8	5.1	0.0	18.7	4.0	4.0	40.0	6.3	3.0	32.9
45	5-11 Nov 18	30.0	16.3	84.0	36.7	4.8	0.0	5.2	5.0	6.0	30.0	6.3	3.0	32.9
46	12-18 Nov 18	30.1	17.7	89.5	49.5	4.5	0.0	2.1	4.0	6.0	30.0	8.0	3.6	26.2
47	19-25 Nov 18	31.3	19.4	81.0	61.7	5.4	0.0	6.4	10.0	8.0	12.0	8.0	8.3	26.2
48	26-2 Dec 18	29.4	14.8	80.0	60.0	5.3	0.0	6.3	16.0	10.0	15.0	11.6	16.3	26.2
49	3-9 Dec 18	29.9	19.8	89.9	52.3	4.9	0.0	2.8	21.0	22.0	26.0	10.1	15.8	28.9
50	10-16 Dec 18	27.2	19.0	88.0	61.3	3.5	15.0	11.8	20.0	20.0	25.0	10.9	22.7	32.6
51	17-23 Dec 18	24.6	15.0	87.6	71.6	2.6	15.0	27.0	16.0	35.0	40.0	22.2	28.3	47.2
52	24-31 Dec 18	27.1	14.2	84.3	49.0	4.2	0.0	9.2	20.0	50.0	45.0	23.0	31.7	58.8

RH- Relative Humidity; WS- Wind Speed; RF- Rain Fall; PDI- Percent Disease Incidence; VP- Vector Population

Table 2: Influence of weather parameters on mite population and sterility mosaic disease incidence of Pigeonpea during 2019-20

SD WK	period	T. Max (^{0}C)	T. Min (^{0}C)	RH I (%)	RH II (%)	Rain fall (mm)	Wind speed (km/h)	15 days earlier than normal date of sowing		Normal date of sowing		15 days later than normal date of sowing	
								PDI	Vector population	PDI-2	Vector population	PDI3	Vector population
37	10-16 Sept 19	30.8	24.1	91.3	66.7	4.1	12.0	5.6	0.0	0.0	0.0	0.0	0.0
38	17-23 Sept 19	30.4	23.2	87.8	65.3	20.9	15.0	10.0	0.0	0.0	0.0	0.0	0.0
39	24-30 Sept 19	29.9	22.6	88.0	68.7	6.2	11.0	0.0	0.0	0.0	0.0	0.0	0.0
40	1-7 Oct 19	31.5	22.6	91.9	59.9	1.9	10.0	0.0	0.0	0.0	0.0	0.0	0.0
41	8-14 Oct 19	31.0	22.7	87.4	66.8	1.1	8.5	0.0	0.0	0.0	0.0	0.0	0.0
42	15-21 Oct 19	30.1	21.9	91.0	65.0	15.3	9.0	0.0	0.0	0.0	0.0	0.0	0.0
43	22-28 Oct 19	29.1	21.9	91.0	65.0	6.9	10.0	0.0	0.0	0.0	0.0	0.0	0.0
44	29-4 Nov 19	30.3	22.2	89.9	66.9	10.2	10.5	0.0	0.0	0.0	0.0	0.0	0.0
45	5-11 Nov 19	29.5	20.4	89.3	63.6	0.0	20.2	0.0	0.0	0.0	0.0	0.0	0.0
46	12-18 Nov 19	30.1	18.9	89.6	59.3	0.0	15.0	12.8	2.0	11.6	2.0	13.2	2.0
47	19-25 Nov 19	30.9	18.8	91.9	59.4	0.0	12.0	12.8	2.0	11.6	2.0	13.2	3.0
48	26-2 Dec 19	29.7	19.5	92.9	63.7	0.0	12.2	16.7	5.0	12.2	4.0	21.9	6.0
49	3-9 Dec 19	29.6	17.6	90.4	52.9	0.0	11.7	20.2	8.0	14.1	8.0	22.8	10.0
50	10-16 Dec 19	29.4	17.7	80.1	49.6	0.0	13.0	20.3	10.0	15.3	18.0	24.8	28.0
51	17-23 Dec 19	28.4	16.8	91.4	47.6	0.0	13.9	21.1	15.0	17.4	25.0	25.0	40.0
52	24-31 Dec 19	27.4	15.9	89.1	42.1	0.0	20.7	21.7	15.0	19.5	34.0	25.8	45.0
1	1-7 JAN 2020	27.2	17.2	91.0	56.0	0.0	23.0	22.7	20.0	20.1	36.0	27.7	45.0
2	8-12 JAN 2020	28.7	15.4	88.9	48.6	0.0	24.3	22.9	22.0	20.3	36.0	28.7	50.0
3	13-18 JAN 2020	29.4	18.1	90.7	52.7	0.0	17.6	23.6	24.0	20.7	42.0	34.7	55.0
4	19-24 JAN 2020	30.7	17.7	90.4	55.1	0.0	16.0	23.6	26.0	20.7	45.0	35.8	65.0

RH- Relative Humidity; WS- Wind Speed; RF- Rain Fall; PDI- Percent Disease Incidence; VP- Vector Population

Table 3: Correlation coefficients between weather parameters and Percent of disease incidence of Sterility mosaic disease at RARS, Warangal (2018-20)

PDI and Vector population	Weather parameter	2018-19		2019-20	
		Correlation coefficient	R^2	Correlation coefficient	R^2
PDI @ 15days earlier than normal date of sowing	Max T (ºC)	-0.22994	0.053	-0.5383	0.2898
	Min T (ºC)	0.015191	0.0002	-0.8745	0.7648
	RH-I (%)	0.091805	0.008	-0.0711	0.0050
	RH-II (%)	0.310242*	0.096	-0.8261	0.6825
	RF (mm)	0.079215	0.006	-0.4896*	0.2397
	Wind speed (Km/hr)	0.527496*	0.278	0.60975*	0.3718
	Vector population	0.648437*	0.420	0.86370	0.7459
PDI @ normal date of sowing	Max T (ºC)	-0.26942	0.073	-0.5535	0.3339
	Min T (ºC)	-0.02886	0.001	-0.9431	0.8806
	RH-I (%)	0.063152	0.004	0.01091	0.0005
	RH-II (%)	0.218826	0.048	-0.8453	0.7298
	RF (mm)	-0.12754	0.016	-0.6202*	0.3709

	Wind speed (Km/hr)	0.341184*	0.116	0.62725*	0.3999
	Vector population	0.811125*	0.658	0.87706	0.7749
PDI @ 15days later than normal date of sowing	Max T (ºC)	-0.49194	0.242	-0.4926	0.2699
	Min T (ºC)	-0.84035*	0.706	-0.8988*	0.8053
	RH-I (%)	-0.25752	0.066	-0.0021	0.0012
	RH-II (%)	-0.46195	0.213	-0.8037	0.6639
	RF (mm)	-0.4131	0.171	-0.6015	0.3501
	Wind speed (Km/hr)	-0.10823	0.012	0.57150	0.3350
	Vector population	0.901321*	0.812	0.89173*	0.8004
Vector population in 15days earlier than normal date of sowing (Block I)	Max T (ºC)	-0.5403*	0.292	-0.5349	0.2861
	Min T (ºC)	-0.35961	0.129	-0.8031	0.6449
	RH-I (%)	-0.09366	0.009	-0.0064	4.1752
	RH-II (%)	0.199012	0.040	-0.7557	0.5712
	RF(mm)	0.070423	0.005	-0.4718	0.2226
	Wind speed (Km/hr)	0.175981	0.031	0.67647	0.4576
Vector population in normal date of sowing (Block II)	Max T (ºC)	-0.49911*	0.249	-0.5551*	0.3273
	Min T (ºC)	-0.34462	0.119	-0.7868	0.6138
	RH-I (%)	0.005498	3.022	-0.0183	0.0018
	RH-II (%)	0.031333	0.001	-0.7622	0.7298
	RF (mm)	-0.11044	0.012	-0.4460*	0.3709
	Wind speed (Km/hr)	0.174073	0.030	0.69433	0.3999
Vector population in 15days later than normal date of sowing (Block III)	Max T (ºC)	-0.30123	0.091	-0.5321	0.3027
	Min T (ºC)	-0.63736*	0.406	-0.7912	0.6204
	RH-I (%)	-0.0427	0.002	-0.0404	0.0041
	RH-II (%)	-0.56249*	0.316	-0.7737	0.6111
	RF (mm)	-0.46326	0.215	-0.4485*	0.1995
	Wind speed (Km/hr)	-0.06018	0.004	0.66572*	0.4505

Table 4: Correlation co efficient of weather parameters and sterility mosaic disease incidence & Vector population of pigeonpea

Weather parameters	Max T	min T	RH I	RH II	RF	Wspeed	PDI 1	VP-1	PDI-2	VP-2	PDI3	VP-3
Max Temperature	1											
min Temperature	0.667138	1										
Relative humidity (morning)	0.060666	0.077049	1									
Relative Humidity-II	0.612743	0.899341	0.179553	1								
Rain Fall	0.258746	0.624005	-0.03695	0.534024	1							
Wind speed	-0.67428	-0.67067	-0.03784	-0.5792	-0.34036	1						
Percent disease Incidence-I	-0.53838	-0.87454	-0.07119	-0.82614	-0.48968	0.609755	1					
Vector Population-1	-0.53495	-0.8031	-0.00646	-0.75578	-0.47189	0.676475	0.863703	1				
Percent disease Incidence-2	-0.55355	-0.94319	0.010917	-0.84531	-0.6202	0.627252	0.96881	0.900984	1			
Vector Population-2	-0.55519	-0.78688	-0.01831	-0.76225	-0.44603	0.694337	0.827769	0.987775	0.877066	1		
Percent disease Incidence-3	-0.49262	-0.89885	-0.00214	-0.80375	-0.60155	0.571509	0.96441	0.922398	0.983328	0.888347	1	
Vector population-3	-0.53215	-0.79129	-0.04046	-0.77378	-0.44854	0.665727	0.830323	0.98641	0.876476	0.995729	0.891735	1

RH- Relative Humidity; WS- Wind Speed; RF- Rain Fall; PDI- Percent Disease Incidence; VP- Vector Population

Fig 1: *Aceria cajani* under sterio binocular microscope

Conclusion

It can also be concluded that, in 2018 and in 2019 temperature and relative humidity is the main factor effecting mite population, while effect of rainfall was negligible. From this result it appears that heavy rainfall is unfavorable for the multiplication of mite. Relative humidity is strongly correlated with mite population in 2018 and showed significant correlation, same scenario was observed with Kaushik and his co workers during the year 2013. In 2018, relative humidity in the month October to November is 90-84% and there was no rainfall during that period, heavy rainfall showed negative effect on rapid multiplication of mite. In 2019-2020, relative humidity favorable was 91-89.6% and rainfall is almost negligible. regarding the wind velocity; it was found that high wind velocity can also spread the disease. High mite population was found in the month of December and January where the wind velocity was high as compared to that in the month of June to October. In December it was 23 km/hr in January 24 km/hr, whereas in November and December it September and October it was 5.3 and 5.0 km/hr, this speed does not allow the mite in their spreading to long distance. Reddy *et al*. (1990) [8] observed the role of wind in transferring the inoculum. They reported that disease can spread up to 2 km downwind from the source of inoculum but the spread in an up-wind direction was very limited (less than 200m) confirming that wind assist in mite dispersal.

References

1. Faostat. Food and Agriculture Organisation Statistics Database, 2019. http://faostat3.fao.org/faostat-gateway/go/to/home/E.
2. Kannaiyan J, Reddy MV, Nene YL, Ryan JG, Raju TN. Prevalence of pigeon pea disease and associated crop losses in Asia, Africa and Americas. Tropical Pest Management. 1984;30:62-71.
3. Kaushik D, Srivastava S, Nath BC, Chauhan VB, Singh R. Correlation between mite population (*Aceria cajani)* and environmental factors causing sterility mosaic disease of Pigeon pea, International journal of Life Sciences. 2013;1(3):228-232.
4. Kumar PL, Jones AT, Sreenivasulu P, Reddy DVR. Breakthrough in the identification of the causal agent of pigeonpea sterility mosaic disease. Journal of Mycology and Plant Pathology. 2000;30:249.
5. Lakshmikantha BP, Prabhuswamy HP. Reaction of pigeon pea varieties to mite (*Aceria cajani* Channabasavanna) transmitting sterility mosaic disease. Plant Protection. Bulletin. 2002;54:6-7.
6. Narayana YD, Mahalinga DM, Jayalakshmi SK, Benagi VI. Prevalence of SMD of pigeonpea in northern Karnataka. Karnataka Journal of Agricultural Science. 2000;13:470-472.
7. Nene YL, Sheila VK. Pigeonpea: geography and importance. In Y. L. Nene, S. D. Hall, & V. K. Sheila (Eds.), The pigeonpea, Wallingford: CAB International, 1990, pp. 1–14.
8. Reddy MV, Sharma SB, Nene YL. Pigeon pea: Disease management. in: The Pigeon pea. Y. L. Nene, S. D. Hall, and V. K. Sheila, eds. CAB International, Wallingford, UK, 1990, pp. 303-347.
9. Reddy MV, Raju TN, Nene YL, Ghanekar AM, Amin KS, Arjunan G, *et al*. Variability in sterility mosaic pathogen in pigeonpea in India. Indian Phytopathology. 1993;46:206-212.
10. Singh AK, Rathi YPS. Epidemiology of vector of pigeon pea sterility mosaic virus. Indian Journal of Virology. 1997;13:143-145.
11. Singh AK, Rathi YPS, Agarwal KC. Sterility mosaic of pigeonpea: A challenge of the 20th century. Indian Journal of Virology. 1999;15:85-92.
12. Singh J, Raghuraman M. Emerging scenario of important mite pests in north India. Zoosymposia. 2011;6:170-179.
13. Zote KK, Mali VR, Mayee CD, Kulkarni SV, Mote TS. Outbreak of sterility mosaic of pigeonpea in Marathwada region Maharashtra, India. International Pigeonpea Newsletter. 1991;14:19-21.