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Climate impact on spider mite (*Tetranychus sp.* Koch) on som plant leaves (*Machilus bombycina* king) and control using phyto-chemicals

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Abstract
Som plant (*Machilus bombycina* King) is an important plant in agroforestry system. Localized cottage industries are involved with this plant like sericulture industry (muga silk worm cultivation). Leaves of som plants are major food of muga silk worm (*Antherea assama*). The plant is susceptible to mite pest (*Tetranychus sp.*) causes heavy damage to tender leaves. Higher mite population was recorded during 46th to 51st standard week, during 3rd week of November to 3rd week of December and peak population (6.06/3 leaves) was recorded on 46th standard week that is on 3rd week of November. Correlation studies revealed that mite population had a significant negative correlation with temperature and non-significant positive correlation with relative humidity. Water extracts of tobacco leaf was found most effective against mite providing 40.51% suppression, closely followed by methanol extracts of *Spilanthes* (39.06% suppression). Methanol extracts of Garlic bulb and *Polygonum* gave moderate results, recording about 38.10% and 37.78% mite suppression respectively. Synthetic insecticides contaminate plant leaves with the toxic chemicals. Plant extracts are of biological origin having low or no hazardous effect on health and environment and so can be incorporated in organic cultivation.

Keywords: Abiotic factors, incidence, botanical extracts, organic cultivation, silk industry

1. Introduction
Som plant (*Machilus bombycina* King), an important medium sized tree is cultivated by the farmers in certain areas in India as small scale. The tree is used for rearing of muga silk worm (*Antheraea assama* West wood). *Antheraea assama* is polyvoltine in nature with 5-6 generations per year and the seasons affect its commercial characters. Nutritional value of food plants i.e. leaves of som plant plays an important role in the larval growth and productivity of silk. The plant has also some timber values. Benchamin and Giridhar (2005) [2] reported that muga silk (*Antherea assama*) is cultivated and produced only in India. Its rearing is restricted to the north-east India, mainly at Bhrambhaputra valley of Assam state and adjoining foothills in India. North east parts of West Bengal province, India mainly Jalpaiguri, Coochbehar and Alipurduar districts have possibility of muga silk cultivation for eco-climatologically similarity with lower Assam (Mandal *et al*., 2016) [17] . Som plant (*Machilus bombycina*) cultivation faces large problems from infestation of insect and mite pests. Due to attack of the large number of pests, it becomes difficult for the growers to conduct rearing (Singh *et al.*, 2000) [21]. The activity of mite population always remained higher on the upper canopy of the plant (Ghosh, 2013a) [8]. Weekly population counts on mites showed non-significant positive correlation (p=0.05) with temperature, maximum relative humidity, total rainfall and significant positive correlation with minimum and average relative humidity (Ghosh, 2013a) [8]. Mite infestation removes leaf cell contents, including the chlorophyll. Without the chlorophyll, those empty cells appear whitish or bronze. Heavily infested leaves turn completely pale, dry up, and fall off.
Farmers become increasingly dependent on synthetic chemical pesticides to which pests have developed resistances (Osteen and Szmedra, 1989) [18]. As som plant leaves provide the major food component of muga silk worm rearing, toxic synthetic insecticide should not be used for insect and mite pests control (Ghosh *et al*., 2016) [15]. Neem, Pongamia, Adathoda, Turmeric, Tobacco, Indian privet, Chrysanthemum, Onion, Garlic, Ocimum, Custard apple, *Polygonum*, *Spilanthes*, Zinger are reported as most common plants having insecticide properties used for management of pest in sericulture (Singh and Saratchandra, 2005; Subba *et al.*, 2017) [22, 26].

It acts in different ways viz. repellents, insect growth regulators (IGR), feeding deterrents and confusants (Schmutterer, 1990) [23]. Mixed formulation of botanical pesticide, azadirachtin (neem) and chemical pesticide, dicofol provided best mite control (71.41% suppression) (Ghosh and Chakraborty, 2014) [13]. The most abundant neem constituent, azadirachtin is considered an excellent botanical pesticide because of its environmental safety, biodegradability, demonstrated low toxicity to vertebrates and safety to non-target organisms (Jacobson, 1989; Rembold, 1989) [16, 20]. Azadiractin individually did not produce good results (moderate mite suppression) but when used as a mixture with low dose of (1.5 ml/L) of synthetic chemical insecticide , propergite provided better results recording more than 85% suppression (Ghosh, 2013b) [14] . The mite mortality percent on chilli crop was found high from Propergite 57 EC, Prophenophos 50 EC and Fenazaquin 10 EC (Bala and Ghosh, 2016) [3] . Ten days after spraying dicofol was found to be the most effective acaricide against mite, *Aceris tulipae* closely followed by ethion and fenazaquin (Bala *et al*., 2015) [4]. *Polygonum* is well known weed in the Coochbehar District of West Bengal, India locally known as "Biskanthali" (Sarkar and Mukherjee, 2005) [24]. Ghosh *et al*., (2009) [11] reported that polygonum plant extracts provided 59.77% aphid suppression in ladysfinger field. Nicotine, an alkaloid obtained from *Nicotiana tabacum, N. glutinosa and N. rustica* is another well-established botanical insecticide (Ujvary, 1999) [27]. Nicotin was recorded to be highly toxic to *Bemisia tabaci* Genn. (Dhaliwal and Arora, 2001) [6]. Use of synthetic insecticides and tobacco together was more economically beneficial than using synthetics alone (Opolot *et al.*, 2006) [19]. The objective of this study was to determine the efficacy of the plant extracts against spider mite, *Tetranychus sp.* infesting som plant and to formulate suitable control measure.

2. Materials and Methods

2.1. Study period and location

Experiments were conducted in the Farm of UBKV-Agriculture University at Coochbehar, West Bengal, India for two years (2010-11). The experimental area is situated in the sub-Himalayan region of West Bengal, India, between $25^0$57' and 27^0 N latitude and $88^0$25' and $89^0$54' E longitude (Subba and Ghosh, 2016) [25] . The soil of the cultivated field was sandy to sandy-loam with pH value 6.9. The climatic condition of this region is subtropical humid having a short winter spell during December to February (Ghosh, 1999) [7].

2.2. Population fluctuation of mite (*Tetranychus sp.*)

For the study of seasonal fluctuation pattern of mites on som plant and their influence on prevailing climatic condition, selected som plants were taken during 2010 and 2011 for this experiment. Som plants were grown under recommended fertilizer doses and cultural practices. Spacing was taken as 3 m X 3 m in 5 m X 5 m sized plots having 5 plants with five replications without adopting any plant protection measures. The total mite population/3 leaves from bottom, middle and top leaves from five randomly selected plants per replication was recorded at seven days (Standard Meteorological Week) interval all the year round. The reading started during January and ended in December for both the years. Data thus obtained over two years, 2010 and 2011 were presented graphically with important weather parameters viz. temperature, relative humidity. Correlation co-efficient (r) was worked out between incidence of mites and important weather parameters during the period to find out influence of weather on population fluctuation.

2.3. Evaluation of plant extracts (botanicals) against mite (*Tetranychus sp.*)

2.3.1. Cultivation practices

The study was conducted with an objective to evolve environmentally sound, technically feasible, and economically viable safe pest control strategy of som plant due to unique pest problem under terai zone of West Bengal, India. Som plants were grown under recommended fertilizer doses and cultural practices. Spacing was taken as 3 m X 3 m in 5 m X 5 m sized plots containing 5 plants with five replications.

2.3.2. Treatment details

Seven pesticides were taken and three sprays at 10 day intervals were made. Generally March-April and August-September are the suitable time for spraying to control insects pests on som plant as the plant remain vacant from rearing of muga silk worm. Hence, under the present investigation, spraying has been done during August- September.

Treatments details are given here under.

Treatments	Dose ml/L (%)
Polygonum hydropiper (T1)	50.00 ml/L (5%)
Pongamia ponnata (T2)	50.00 ml/L (5%)
Azadirachtin (NIMARIN 1500 ppm) (T3)	2.5 ml/L
Garlic (*Allium sativum*) (T4)	50.00 ml/L (5%)
Immidachlorprid (C0NFIDOR 17.8 SL) (T5)	1 ml/ 5L
Tobacco (*Nicotiana tabacum)* (T6)	50.00 ml/L (5%)
Spilanthes paniculata (T7)	50.00 ml/L (5%)
Untreated Control (T8)	---

Five botanical extracts, viz. *Polygonum hydropiper* floral parts, *Pongamia pinnata* leaves, Garlic bulb (*Allium sativum*), Tobacco (*Nicotiana tabacum)* leaves, and *Spilanthes paniculata* floral parts, one plant based insecticide formulation, azadirachtin (Nmarin1500 ppm) were evaluated and compared with the chemical insecticide, Imidacloprid (Confidor 17.8 SL).

2.3.3. Preparation of Extracts

For the plant based extract preparation standard extraction methodology developed by Ghosh (2019) [9] was followed. The polygonum (*Polygonum hydropiper*) plants (floral parts), pongamia (*Pongamia pinnata*) leaves, garlic (*Allium sativum*) bulb, spilanthes (*Spilanthes paniculata*) (floral parts) were extracted in methanol. The plant parts after washing with water were dried and powdered in grinder. 50 g powder of plant parts were transferred separately to the conical flask (500 ml capacity) field with 250 ml methanol. The powdered material was dipped in 250 ml of methanol. The material was allowed to stand for 72 hours at room temperature with occasional stirring. After 72 hours the extract was filtered through whatman 42 filter paper and residues was washed twice with methanol. The tobacco (*Nicotiana tabacum)* leaves were extracted in water as follows (Ghosh and Chakraborty, 2012) [10]. After washing with water the leaves were dried and powdered in a grinder. The powdered sample (100 g) were transferred to a container and dipped in one litre of water. The material was allowed to stand for 72 hours at room temperature with occasional stirring. After 72 hours the extract was filtered through Whatman 42 filter paper and added 15 ml liquid soap.

2.3.4. Data recording

Mite population densities were recorded 3, 6, and 9 days after each spraying. The total mite population/3 leaves from top, middle and bottom leaves from five randomly selected plants per replication was recorded. The results were expressed as mites population suppression (%) compared to densities recorded on the control treatment. Percent reduction of mite population over control was calculated by the following formula (Abbott, 1925) [1]:

$$\text{Percent reduction over control} = \frac{\text{Percent reduction in treatment - Percent reduction in control}}{\text{100 - Percent reduction in control}} \times 100$$

INDO-STAT- software were used for Data analysis and variance following randomized block design (RBD). Treatment means were separated by applying CD Test (critical difference) at 5% level of significance.

3. Results and Discussion

3.1. Population fluctuation of mite (*Tetranychus sp.*)

Mite (*Tetranychus sp.*) (Acarina: Tetranychidae), an important pest of som plant, appeared in both the years (2010 and 2011). Its occurrence and degree of infestation not only varied with seasons but also over the years (Figure 1). In 2010, its incidence was witnessed at the very beginning of the year and higher population level was recorded during 46th standard week to 51st standard week that is during 3rd week of November to 4th week of December when average temperature, relative humidity and weekly average rainfall were 19.60 ^{0}C - 28.15 ^{0}C, 76.42%-83.28% and 0.00mm-19.20mm, respectively. Highest population (7.83/3 leaves) was recorded on 49th standard week that is on 1st week of December when average temperature, relative humidity and weekly average rainfall were 22.05 ^{0}C, 77.83% and 19.20mm, respectively. Initially during January, moderate infestation was observed but from 7th week (mid of February) onwards no mite population was recorded and this continued upto 27th (1st week of July) standard week. After that the population was initiated and increased gradually. Lower population level was observed during 28th standard week to 38th standard week that is during 2nd week of July to 4th week of September when average temperature, relative humidity and weekly average rainfall were 28.55 ^{0}C - 31.10 ^{0}C, 77.56%-90.56% and 19.10mm-134.50mm, respectively.

In 2011, the pest appeared in the first week of January (3.37/3 leaves) and higher population level was recorded during 44th standard week to 51st standard week that is during 1st week of November to 3rd week of December when average temperature, relative humidity and weekly average rainfall were 16.29 ^{0}C - 23.99 ^{0}C, 65.29%-92.85% and 0.00mm-5.10mm, respectively. Highest population (4.47/3 leaves) of mite was recorded on 48th standard week that is on last week of November when average temperature, relative humidity and weekly average rainfall were 21.71 ^{0}C, 76.49% and 0.00mm, respectively. Lower population level was observed during 12th standard week to 40th standard week that is during 4th week of March to 1st week of October when average temperature, relative humidity and weekly average rainfall were 23.14 ^{0}C - 30.78 ^{0}C, 68.49%-92.50% and 0.40mm-344.70mm, respectively.

The pooled data on mite incidence for the two years (2010 and 2011), showed that mite was found active all throughout the year. Lower population level was recorded during 7th standard week to 38th standard week that is during 3rd week of February to 4th week of September and higher population level was maintained during 46th standard week to 51st standard week that is during 3rd week of November to 3rd week of December and peak population (6.06/3 leaves) was recorded on 46th standard week that is on 3rd week of November.

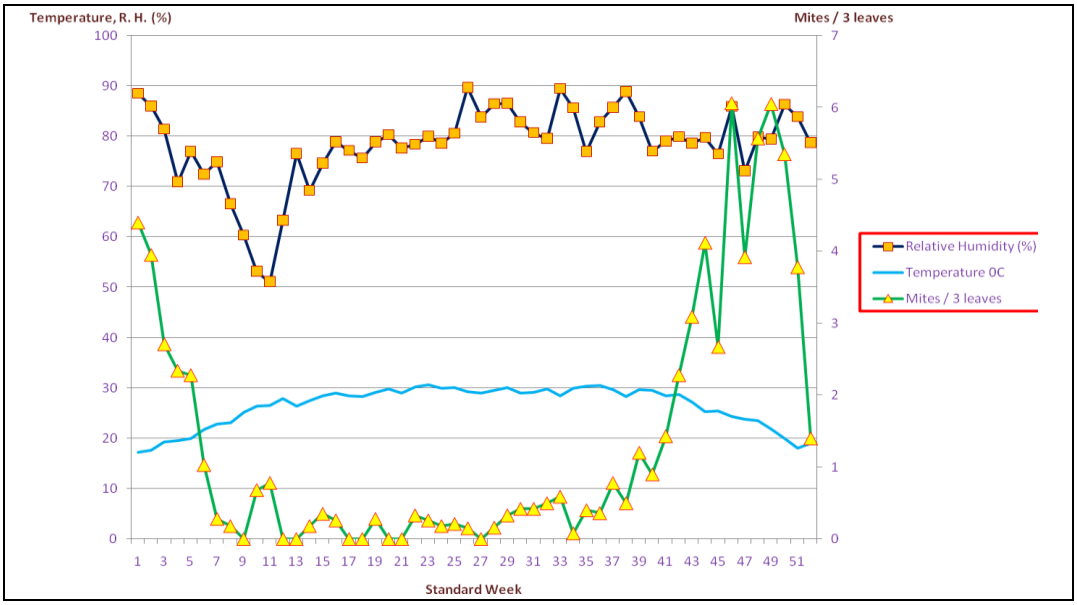

Fig 1: Seasonal incidence of mite (*Tetranychus sp.*) population (Average) as influenced by temperature and relative humidity

Correlation studies (Table 1) between mites population and Environmental parameter revealed that mites population had a significant positive correlation with temperature difference while significant negative correlation with temperature (maximum, minimum and average). On the other hand non-significant positive correlation found between mites population and relative humidity. This indicates that activity of mites population increase with the rise of relative humidity and population decrease with the rise of temperature. Weekly population counts on mites showed significant positive correlation with minimum and average relative humidity (Ghosh, 2013a) [8].

Table 1: Correlation co-efficient between mite (*Tetranychus sp.*) and environmental parameters

Environmental parameter		Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Temperature ^{0}C	Maximum	-0.662**	0.438	Y= -0.404x + 13.98
	Minimum	-0.629**	0.395	Y= -0.211x + 5.979
	Difference	0.448**	0.200	Y= 0.254x - 0.998
	Average	-0.661**	0.436	Y= -0.296x + 9.206
Relative Humidity (%)	Maximum	0.207	0.043	Y= 0.052x - 2.978
	Minimum	0.197	0.038	Y= 0.034x - 1.090
	Average	0.215	0.046	Y= 0.047x - 2.297

* Significant at 5% level of significance; ** Significant at 1% level of significance

3.2. Evaluation of plant extracts (botanicals) against mite (*Tetranychus sp.*)

The different treatments and their persistence at different days after application varied significantly in their suppression of mite populations (Table 2 and Table 3). None of the compounds evaluated under the present investigation gave satisfactory mite control. However, among the seven pesticides evaluated (Table 3) under the present investigation extracts of Tobacco was found most effective against mite providing 40.51% suppression, closely followed by extracts of *Spilanthes* providing 39.06% suppression. From over all observation it was revealed that extracts of Garlic and extracts of *Polygonum* plant gave moderate results, recording about 38.10% and 37.78% mite suppression respectively. Least effectiveness against mite was recorded from Imidaclorprid, *Pongamia* leaf extracts and Azadirachtin providing 31.90%, 33.20% and 33.81% suppression, respectively.

Three days after spraying, extracts of Tobacco was found most effectively against mite providing 45.81% suppression, closely followed by Garlic extracts providing 43.29% suppression. Extracts of *Spilanthes* and *Polygonum* plant extracts were found to be moderately effective against mite providing 42.51% and 40.68% suppression, respectively. Six days after spraying, Tobacco leaf extracts was found to be superior insecticide (38.70% suppression) closely followed by *Polygonum* plant extracts (37.69% suppression). Extracts of *Spilanthes* and Garlic extracts were found to be moderately effective against mite providing 37.55% and 35.18% suppression, respectively. Nine days after spraying, extracts of *Spilanthes* was found to be most effective (37.12% suppression) against mite, closely followed by Tobacco leaf extracts (37.03% suppression). Garlic extracts and *Polygonum* plant extracts were found to be moderately effective against mite providing 35.83% and 34.94% suppression, respectively.

Table 2: Efficacy of plant extracts against Mite *(Tetranychus sp.*) on Som plan (2010 and 2011)

Treatments	Dose ml / Litre (%)	Over all efficacy (% reduction or increase) 2010					Over all efficacy (% reduction or increase) 2011				
		Pre-Treatment Obs. Mites / 3 Leaves	3 DAT	6 DAT	9 DAT	Mean	Pre-Treatment Obs. Mites / 3 Leaves	3 DAT	6 DAT	9 DAT	Mean
Polygonum (T1)	50.00 ml/L (5%)	02.67	39.88 (39.13)	37.18 (37.56)	33.39 (35.27)	36.81 (37.32)	03.47	41.49 (40.09)	38.21 (38.17)	36.55 (37.15)	38.75 (38.47)
Pongamia (T2)	50.00 ml/L (5%)	03.54	34.83 (36.15)	31.54 (34.16)	30.13 (33.25)	32.17 (34.52)	04.67	35.58 (36.56)	32.73 (34.85)	34.40 (35.88)	34.23 (35.76)
Azadirachtin (NIMARIN 1500 ppm) (T3)	2.5 ml/L	03.17	36.63 (37.21)	33.26 (35.14)	30.81 (33.66)	33.57 (35.34)	03.83	36.01 (36.84)	35.53 (36.54)	30.60 (33.50)	34.05 (35.62)
Garlic (T4)	50.00 ml/L (5%)	04.63	44.15 (41.62)	34.87 (36.15)	34.29 (35.81)	37.77 (37.86)	04.57	42.44 (40.64)	35.49 (36.50)	37.38 (37.67)	38.44 (38.27)
Imidaclorprid (C0NFIDOR 17.8 SL) (T5)	1 ml/ 5L	03.91	35.07 (36.27)	32.52 (34.71)	30.77 (33.64)	32.79 (34.87)	05.91	34.59 (35.95)	30.59 (33.53)	27.86 (31.76)	31.01 (33.75)
Tobacco (T6)	50.00 ml/L (5%)	04.62	45.01 (42.14)	38.79 (38.51)	37.18 (37.54)	40.32 (39.39)	04.63	46.62 (43.06)	38.62 (38.39)	36.89 (37.38)	40.71 (39.61)
Spilanthes (T7)	50.00 ml/L (5%)	03.25	42.84 (40.88)	37.20 (37.56)	32.14 (34.51)	37.39 (37.65)	03.95	42.18 (40.49)	37.90 (37.98)	42.10 (40.42)	40.73 (39.63)
Untreated Control (T8)	---	04.17	0.00	0.00	0.00	0.00	03.19	0.00	0.00	0.00	0.00
S Em (±)	---	---	1.46	1.76	1.44	---	---	1.62	1.90	1.89	---
CD at 5%	---	NS	4.50	5.43	4.45	---	NS	5.01	5.86	5.81	---

Figure in the parenthesis are angular transformed values, DAT = Days after treatment, NS = Not significant

Table 3: Over all efficacy of plant extracts against Mite *(Tetranychus sp.*) on Som plan (Grand Mean of 2010 and 2011)

Treatments	Dose ml / Litre (%)	Over all efficacy (% reduction or increase)				
		Pre-Treatment Obs. Mites / 3 Leaves	3 DAT	6 DAT	9 DAT	Mean
Polygonum (T1)	50.00 ml/L (5%)	03.07	40.68 (39.61)	37.69 (37.86)	34.97 (36.21)	37.78 (37.89)
Pongamia (T2)	50.00 ml/L (5%)	04.10	35.20 (36.35)	32.13 (34.50)	32.26 (34.56)	33.20 (35.14)
Azadirachtin (NIMARIN 1500 ppm) (T3)	2.5 ml/L	03.50	36.32 (37.02)	34.39 (35.84)	30.70 (33.58)	33.81 (35.48)
Garlic (T4)	50.00 ml/L (5%)	04.60	43.29 (41.13)	35.18 (36.32)	35.83 (36.74)	38.10 (38.06)
Imidaclorprid (C0NFIDOR 17.8 SL) (T5)	1 ml/ 5L	04.91	34.83 (36.11)	31.55 (34.12)	29.31 (32.70)	31.90 (34.31)
Tobacco (T6)	50.00 ml/L (5%)	04.62	45.81 (42.60)	38.70 (38.45)	37.03 (37.46)	40.51 (39.50)
Spilanthes (T7)	50.00 ml/L	03.60	42.51	37.55	37.12	39.06

	(5%)		(40.68)	(37.77)	(37.46)	(38.64)
Untreated Control (T8)	---	03.68	0.00	0.00	0.00	0.00
S Em (±)	---	---	1.54	1.83	1.66	---
CD at 5%	---	NS	4.75	5.64	5.13	---

Figure in the parenthesis are angular transformed values, DAT = Days after treatment, NS = Not significant

From the overall observations it was revealed that Tobacco leaf extracts was found to be most effective against mite providing more than 40% suppression. Persistency is enough high for extracts of *Spilanthes* where nine days after spraying higher mite suppression was observed than all other treatments. Nicotin was recorded to be highly toxic to *Bemisia tabaci* Genn. (Dhaliwal and Arora, 2001) [6]. Use of synthetic insecticides and tobacco together was more economically beneficial than using synthetics alone (Opolot *et al.*, 2006) [19]. However, Imidaclorprid gave least effectiveness against mite control, recording only about 30% suppression. Das *et al.* (2010) [5] and Ghosh *et al.* (2012) [12] reported that a rapid degradation of persistency was observed in Imidacloprid which had a greater importance in muga silk worm rearing. But most of the synthetic insecticides are highly toxic, so there is every possibility to contaminate som plant leaf with the toxic chemicals, as som leaf is the major food component of muga silk worm rearing. Plant extracts are of biological origin having low or no hazardous effect on health and environment and so can be incorporated in Integrated Pest Management (IPM) programme against mite on som plant.

As muga silk worm is rearing on som plants so it is not possible to spray on som plant leaves year round. Higher population level is found during July- August – September, when the temperature and relative humidity remain high. So under this study spray has been done during August-September. It is also noted that during August-September the plant remain vacant from rearing of muga silk worm. Chemical synthetic insecticides should not be used for pest control on som plant as because the muga silk worm is rearing on som plants and there is every possibility of killing of muga silk worm. Microbial pesticides also should not be used as they kill the muga silk worm causing different diseases. So plant based products are suitable and safe for controlling insect pest on som plants. Plant based products when used singly they did not record higher control of mite on som plant. But Imidacloprid or other chemical synthetic pesticides being highly toxic, should not be used in pest control on som plant. There is every possibility to contaminate som plat leaf and the muga silk worm may be damages with the toxic chemicals. So use of highly toxic insecticides should be avoided and alternative pesticides like plant extracts should be used.

4. Conclusion/ Recommendation

Mite population was found active all throughout the year. Lower population level was recorded during 3rd week of February to 4th week of September and higher population level was maintained during 3rd week of November to 3rd week of December and peak population (6.06/3 leaves) was recorded on 3rd week of November. Correlation studies revealed that activity of mites population increase with the rise of relative humidity and population decrease with the rise of temperature. Tobacco leaf extracts was found most effective against mite providing 40.51% suppression, closely followed by extracts of *Spilanthes* providing 39.06% suppression. From over all observation it was revealed that extracts of Garlic and extracts of *Polygonum* plant gave moderate results, recording about 38.10% and 37.78% mite suppression respectively. Plant extracts are of biological origin having low or no hazardous effect on health and environment and so can be incorporated in IPM programme against mite on som plant.

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