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Oligonychus coffeae: Red spider mite of tea: A review

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Abstract
Tea, *Camellia sinensis* (L.) O. Kuntze, is a perennial crop and grown as a monoculture on large contiguous areas. Tea crop have great economic value in India because India is the second largest tea producing country after china. Tea plant is subjected to the attack of several notorious pests such as insects, mites, nematodes, diseases and weeds. Among them *Oligonychus coffeae* Nietner (Acari: Tetranychidae), the red spider mite (RSM), is a major pest of tea (*Camellia sinensis*) in most tea-producing countries. This causes great economic losses to the tea growing countries. Red spider mite present of the tea crop throughout the year because tea is a perennial crop provides food and shelter due to which Nymphs and adults of RSM lacerate cells, producing minute characteristic reddish brown marks on the upper surface of mature leaves, which turn red in severe cases of infestation, resulting in crop loss. The authors tried here to collect the information about Seasonal abundance, status of RSM, stages, life history, nature of damage, symptoms, reasons of occurrence of RSM as well as control measures including IPM strategies.

Keywords: Red spider mite, *Oligonychus coffeae* and tea

1. Introduction
The tea (*Camellia sinensis*. var. assamica) is the most important non alcoholic beverage in the world. The tea is appreciated both for its stimulant properties and health benefit [55]. This ubiquitous common man's drink in India was introduced by the British to this country from neighbouring China. The tea industry is one of the oldest organized industries in India. Thirty-four countries of Asia, Africa, Latin America, and Oceania, situated between latitudes 41ºN and 16ºS, produce tea and the national economy of many of these countries is largely dependent upon its production [31]. India produces three speciality teas like, Darjeeling, Assam and Nilgiris, which are exported world over. Tea is grown in 13 states and Assam, West Bengal, Tamil Nadu and Kerala are the largest producers. Of the many constraints that affect tea production, insect and mite pests play a major role, causing 11% to 55% loss in yield worth U.S. $500 million to $1 billion [31, 3].Tea plantations are evergreen and perennial (over 100 years) [7], as monoculture is a permanent ecosystem which provides habitat continuity for 1031 species of arthropods [31] and is attacked by nearly 250 insect species [9] and 82 species of nematodes as reported from different parts of the world [15]. Tea plantations roughly resemble a "single species forest" [16], and insect and mite species are thought to coexist by way of intra tree distribution [31]. The distribution and abundance of tea pests are largely influenced by weather, altitude, crop variety and the cultural operation such as pruning, manuring, regulation of shade, use of pesticides, natural enemies of pests and economics of tea production [42]. Mites, as a group, are persistent and the most serious pests of tea in almost all tea producing countries [16, 31]. In India 13 species of mites belonging to eight families were reported [27]. *Oligonychus coffeae* is one of the most destructive pests in all the tea growing regions of North East India [17, 22] causing considerable crop loss in tea [45]. RSM has been a major threat to tea cultivation, As a result of infestation by the RSM, plant growth and leaf productivity are seriously affected. This pest has been causing a considerable damage to tea cultivation in India since 1960, but recently its havoc is more prominent in North Bengal tea plantation due to environmental changes [40].

2. Seasonal abundance
RSM population continued to increase gradually with the increase in temperature from March to June. Maximum incidence of mites on tea was observed in the 1st and 2nd fortnight of June.

However, population started to decline in July and reduced further in August. This was due to the occurrence of extremely heavy rainfall which washed off large number of mites from the surface of the tea leaves. The remaining mites on the leaves again increased in number in September with the passage of the monsoon season. With the decrease in environmental temperature from October, population of mites started to decrease and this trend continued up to the 2nd fortnight of December. Very low number of mites was recorded to be present on the collected tea leaves in November and December [39]. The incidence of red spider mite, *O. coffeae* on tea was maximum during the month of April to May-June and September-October. Afterwards their population declined gradually and reached a very low level during month of December –January due to adverse effect of low temperature [18]. Incidence of red spider mite, *O. coffeae* on tea was maximum during the month April to June and September- October due to high temperature. However, during the month of July-August a minimum population was sustained because rain water washed away the mites. During December to January mite population was very low due to adverse effect of low temperature. Again from February onwards population of mites was increased to reach its peak in the month of April [33].

3. Whether parameters which influence the red spider mite population

3.1 Temperature

Temperature is an important unique meteorological parameter that influences the growth and development of tea as well as pest infestation. High temperature influences the infestation of red spider mite in tea. Multiplication rate is greatly increased in higher temperature. In low temperature, population is reduced during winter season but unreasonable low temperature followed by wind during spring leads to high mortality. Infestation increases with the increase of temperature and vice-versa [1].

3.2 Relative Humidity

Humidity is an important climatic factor that influences the growth and development of tea plant. It interferes with the population build-up of red spider mite. Hot and dry weather with low humidity lead to high infestation of red spider mites. It encourages less feeding, slower egg laying and shorter life span. Like temperature, relative humidity was also found to be positively related with the infestation of red spider mites in tea. Infestation increases with the increase of relative humidity and vice-versa [2].

3.3 Rainfall

Rainfall is one of the major climatic factors that affect the growth, development and yield of tea as well as outbreak of red spider mite. The minimum annual rainfall of 1150–1400 mm is generally considered necessary for successful cultivation of tea. Too much water can be devastating for some pests. Raindrops can physically dislodge them from their host plant and behaviour patterns can be disrupted. Prolonged or heavy rain with big rain drop washes off mites from host. Mites move to underside of the leaf. It leads to high mortality of mites. It also escorts to less breeding of mites. Eggs of red spider mite is least affected [2].

3.4 Sunshine hours

Sunshine hour is a major weather parameter. Red spider mite is a positively phototropic pest. Light duration (sun light intensity and penetration) in daytime influences the buildup of mite population. Light has the positive response in the upper surface of the leaves. It influences egg laying, oviposition rhythm, with the maximum oviposition at dawn and dusk when there is a rapid change in light intensity. Changes in light regime i.e. light to dark leads to peak oviposition. Egg hatching is the maximum at red light. Light penetration within the canopy regulates the distribution of mites. Sunshine hours were found to be positively related with the infestation of red spider mite in tea; the higher sunshine hours, the higher was the percentage of infestation [2].

4. Status of RSM

RSM economic threshold level (ETL) in tea is reported to be 4 mites per leaf in South India [41, 44] and in North East India 2–3 mites/cm^2 [5]. But ETLs change with crop phenology, cost of pesticides and labour, weather conditions, market prices, etc., and they vary from region to region and even from field to field.

5. Nature of damage in tea

Larvae, nymphs and adult RSM causes damage to the tea plant which feed on the sap of the leaves and occasionally on petioles. Their attack is mainly confined to the upper surface of the mature foliage. As a result of feeding, mature leaves become reddish bronze, and consequently RSM-infested fields can be identified even from a distance. RSM infestation reduces the photosynthetic capacity of leaves and ultimately leaves wilt, due to increased transpiration and moisture loss. Such leaves are then abscissed, resulting in defoliation. This is more evident where a severe attack is followed by a drought, when weak bushes and young plants may be killed [19]. High temperatures, dry conditions and the absence of shade are conducive to outbreak of this pest. The optimum temperature for growth and development is 30ºC [20] the lower threshold for development is 10ºC and 23.26 degree days are required to complete the life cycle from egg to egg [26].

6. Life stages and life cycle of RSM

6.1 Eggs

Eggs are laid singly on the upper surface of the leaf along the mid-rib and veins [23, 56]. The eggs are blood red to chrome red glossy and shining, but change to light orange before hatching [20]. The egg is ovoid or spherical, smooth, with a slight depression on the exposed top side and flattened on the lower surface [19, 46].

6.2 Larva

The larva is almost round and has three pair of legs. A freshly hatched larva is yellow orange. The larval period is followed by the first quiescent stage.

6.3 Nymphs

The protonymph carries four pairs of legs. The body is oval, the anterior legs are pale crimson, whereas the posterior pairs are deep reddish brown. Deutonymphs are like protonymphs, but larger. At the deutonymph stage the sexes can be differentiated; the female is slightly bigger and has the abdomen rounded at the posterior end, whereas the abdomen of the male is pointed. After the third quiescent stage the adult emerges.

6.4 Adult

Both males and females are sexually mature on emergence [19]. Males are short-lived whereas females are known to live

for about 3 weeks during summer and for a couple of months or more during winter [46]. The male differs from the female in size and also in shape of the body. The female is nearly elliptical or oval, the abdomen being broadly rounded at its posterior end. The male is smaller, and has a slimmer body, the abdomen being much narrower posteriorly, almost tapering to a point [19].

6.5 Life cycle

The bio ecology of these mites was studied on tea in India by (Das, 1955) [21]. The duration of the various stages in days at a constant temperature of 22 ^{0}C are eggs 4 to 5, larva 4 to 5, protonymph 4, deutonymph 2 to 3, development from egg to adut occupies 10 to 15 days. Females are capable of laying 40 to 50 eggs each. In North East India, the duration of egg to adult is shorter in the summer months and may be completed in 9.4–12 days in May and June, whereas it may take as much as 28 days in cold weather [19]. Hu and Wang (1965) reported that under laboratory conditions, the mites passed through 22 generations in a year [32]. Das and Das (1967) and Haque *et al.* (2007) studied the effect of temperature and relative humidity (RH) on its biology and identified 30 ^{0}C as the critical temperature. They also reported that the mite did not survive beyond 35 ^{0}C [20, 30]. Eggs failed to hatch under constant temperature of 34 ^{0}C and 17% RH [20]. At 33 ^{0}C none of the eggs hatched if RH was below 72% [20]. However, in their natural habitat the mite is not only affected by abiotic challenges like temperature, RH, and others, but also by biotic factors, mainly host plant and predators [23].

7. Habitats

The RSM live under the cover of a silken web spun on the leaf surface as a protection against inclement weather [22]. Leaf temperature and light penetration within tea bushes also influence mite distribution; *O. coffeae* prefers the middle zone of the bush (30 cm below the plucking surface) because of optimum temperatures associated with plant shading [6]. The temperature in the upper zone of the tea plant may reach 40–45 ^{0}C yet shading can bring down the temperature of the middle tier of a bush to ambient levels of 30–32 ^{0}C [29].

8. Dispersion

Dispersion is also effected by wind, which carries the mites for considerable distances. Labourers working in tea plantations are also responsible for spreading the mites by carrying them on their clothes and baskets. Cattle, goats, birds and insects too play an important role in dispersion, carrying the mites on their bodies [19]. The bushes touch each other, and it is reasonable to expect that mites migrate from bush to bush by crawling from leaf to leaf and some time by crawling over the intra bush ground [19, 34].

9. Integrated Pest Management

9.1 Pruning

Pruning is an essential agronomic practice implemented in winter for renovating vegetative growth at the expense of reproduction, to increase crop productivity in subsequent years. Pruning removes a large part of the RSM populations present on the Leave. Red spider mite, scarlet mite and purple mite are removed during pruning operation [36].

9.2 Shade regulation

The culture of shade trees and many ancillary crops in the tea ecosystem is considered to be a necessary evil. In tea, shade regulation plays a predominant role in mites is seen more in tea fields devoid of shade. So, the recommendation of shade management will help to prevent the excessive build up of mites.

9.3 Filed sanitation

Field sanitation assumes significance in the management of several pests. Weeds offer excellent hiding places and serve as alternate hosts for Red spider mites. Weeds like *Urena lobata* weeds act as alternate host of Red spider mite. Weed free cultivation and preventing trespassing of cattle, goat, and other animals from RSM-infested fields reduce its spread [37].

9.4 Trap crop

A trap crop also manipulates the habitat in an agro ecosystem, which can be included under the ecological engineering approaches for the purpose of IPM [28]. However, Marigold is an ornamental plant and in tea it can be used as a trap crop of red spider mite. In cases where part of a garden becomes badly affected with Red spider mite every year it is essential to put down a protective barrier between the affected and unaffected tea. One row of marigold can be planted at the outer periphery and also in the vacant area of the section. Border plantings of *Adhatoda vesica serve* as a barrier for red spider mite, *Oligonychus coffeae* [59].

9.5 Effect of shade

Shade is an integral part of tea cultivation in most of the tea-producing countries. Temperature of tea leaves under shade is 1–2 C below ambient temperature while in the unshaded areas it may go up by 2–4 C [43, 45]. The incidence of RSM is less in shaded areas and their vertical distribution is also remarkably different in shaded and unshaded bushes, indicating the influence of leaf temperature and light penetration [43].

9.6 Water management

Water plays a significant role not only in plant nutrition [8], but also in IPM [31]. Mulching also helps to increase humidity in the field, and therefore may help to control mites.

9.7 Use of botanicals

Botanical products are environmentally safe, less hazardous, economic and easily available. Certain products derived from indigenous plants are used for tea pest control. Recently, Neem (*Azadirachta indica*), in various commercial formulations, is widely recommended in tea plantations against the RSM [44, 57]. *Clerodendrum* extracts may also effective against major pests of tea such as red spider mites etc [37] and *Melia azadirach* (Meliaceae) showed great promise in controlling RSM population at field level [49, 50]. Roy *et al.* (2008) reported that effectiveness of garlic lectin (The LC_{50} value: 12.4 ± 1.918 lg/ml) on RSM in tea [48]. Roobakkumar *et al.* (2010) indicated that Neem Kernel Aqueous Extract (NKAE) @ 5.0% concentration was effective against RSM [47].

9.8 Biological control

Biological methods of control involve the conservation, preservation and introduction of natural enemies like predators, parasitoids and pathogens for suppression of pests within tolerable levels. Sarkar *et al.* (2007) reported that the period of peak incidence of the predatory mites groups was March– April followed by another small peak during October–November. The density of predatory mites (*Amblyseius* sp. and *Agistemus* sp.) coincided with that of RSM population in N.E India [53]. Borthakur and Das (1987)

and Borthakur *et al*. (1992, 2005) reported that Agistemus sp. was the predominant natural enemy in North East Indian tea plantation and has promising biological control potential against RSM in tea [11-13]. Saha *et al.* (2001) suggested that *Amblyseius coccosocius* Ghai and Menon was the most suitable predator of tea RSM in North East Indian tea plantation [52]. All these studies indicated richness of predatory mite species in tea which acts as natural biocontrol agents against RSM. *Oligota flaviceps* is identified as a predator of Red spider mite in tea [4]. The ladybird beetle, *Stethorus gilvifrons* Mulsant, is a major predator of the RSM. Adults and larval stages of *S. gilvifrons* predate indiscriminately on the eggs, nymphs and adults of the RSM (Banerjee, 1971). Roy *et al.* (2010) reported that *Micraspis discolor* F. was the dominant coccinellid predator of RSM in the conventionally managed tea plantations in North Bengal, India [51]. Green lacewings (Neuroptera) are important predators of various soft-bodied arthropods, including RSMs in tea. *Mallada boninensis* Okamoto, *Mallada basalis* Walker and *Mallada desjardinsi* Navas had been reported as efficient predators of RSM infesting tea in India [58].

9.9 Pathogens

Use of entomopathogenic fungi is a new area of research for management of RSM. Fungi are the predominant pathogens found in RSM populations, and are unique in their ability to infect their hosts through the external cuticle. *Paecilomyces fumosoroseus* from south Indian tea field has been found effective against RSM [54] and another fungal pathogen *Hirsutella thompsonii* has been found efficient against RSM in North East India [24].

9.10 Chemical control

Chemical control is the primary mode of management of RSM and a wide range of acaricides belonging to different chemical groups is currently used worldwide to control this pest. Elbert *et al.* (2005) reported that Spiromesifen (oberon) 240 SC @ 72-96 g*.a.i*/ha gave an excellent result for the control of red spider mite, *O. coffeae* in tea [25]. Chakrabotry *et al.* (2015) reported that Cyflumetofen 20 SC which at 125 g a.i./ha gave excellent (95 to 100%) reduction and the molecule was found to be soft on natural enemies and all the doses did not produce any phytotoxic symptoms on tea bushes [14]. Mamun *et al.* (2016) reported that Hexythiazox (75.88%) showed the highest performance in reducing red spidermite population on tea followed by Fenazaquin (74.12%) in the laboratory. The similar trend was observed in case of field condition. The order of performance of the tested pesticides was Hexythiazox> Fenazaquin> Spiromesifen> Fenpyroxymate> Propargite> Fenpropathrin> Chlorfenapyr> Abamectin [38]. Biswas *et al.* (2009) reported that sedna 5 SC Sedna 5 SC (fenpyroximate) @ 600 ml/ha was highly effective to combat red spider mites of tea up to 35 days of application followed by propargite 57 EC @ 400 ml/ha compared to other acaricides [10].

10. References

1. Ahmed M, Haq M. Biological attributes of Red Spider Mites and their integrated control approaches in tea. Circular No.128. Bangladesh Tea Research Institute, 2007, 1-8.
2. Ahmed M, Mamun MSA, Hoque MM, Chowdhury RS. Influence of Weather Parameters on Red Spider Mite- A Major Pest of Tea in Bangladesh. Journal of Science and Technology. 2012; 19(5):47-53.
3. Anonymous. 57th Annual Report, Tea board of India: Tea Board website: http:// teaboard.gov.in, 2010-2011
4. Babu A, Roobak Kumar A, Perumalsamy K, Sachin P, James. New record of a predator of RSM. Newsletter of UPASI Tea Research Institute. 2008; 18(1):4.
5. Banerjee B. The threshold values in mite pest control. Two Bud. 1971; 18(1):20-21.
6. Banerjee B. Intratree variation in the distribution of the tea red spider mite *Oligonychus coffeae* (Nietner). Acarologia. 1979; 21:216-220.
7. Banerjee B. Arthropod accumulation on tea in young and old habitats. Ecological Entomology.1983; 18(2):339-342.
8. Barua DN. Science and practice in tea culture. Tea Res Assoc, Calcutta, 1994, 509.
9. Bathakur BK. Recent approach of Tocklai to plant protection in tea in North East India. Scientific Culture. 2011; 77(9-10):381-384.
10. Biswas K, Mallikarjunappa S, Ganesh Bhat U, Koneripalli N. Evolution of novel acaricides, Sedna 5% SC (Fenpyroximate) against red spider mite of tea, *Oligonychus coffeae* Nietner. Pestology. 2009; 33(12):22-24.
11. Borthakur M, Das SC. Studies on some predatory mites of phytophagous mites of tea in N.E. India. Two Bud. 1987; 34(1-2):21-24.
12. Borthakur M, Rahman A, Sarmah M, Gurusubramanian G. Predators of phytophagous mites of tea (*Camellia sinensis*) in North East India. In: Proceedings of 2005 International symposium on innovation in tea science and sustainable development in tea industry, Hangzhou, China, 2005, 749-755.
13. Borthakur M, Saikia MK, Singh K. Effect of a few pesticides on the predators of red spider mite in tea. Two Bud. 1995; 42(2):28-33.
14. Chakrabotry G, Roy D, Sarkar PK. Effect of Temperature on Tea Red Spider Mite (*Oligonychus coffeae* Nietner) and its Management Using Cyflumetofen 20 Sc. The Bioscan. 2015; 10(1): 00-00.
15. Chen ZM, Chen XF. An analysis of world tea pest fauna. Journal of Tea Science. 1989; 9:13-22.
16. Cranham JE. Tea pests and their control. Annual Review of Entomology. 1966; 11:491-514
17. Das GM. Termites in tea. Termites in the Humid Tropics, Humid Tropics Research UNESCO (Proceeding, New Delhi Symposium), 1962, 229-231.
18. Das GM. Pests of tea in North East India and their control. Memorandum No. 27 Tocklai Experimental Station, Tea Research Association, Jorhat, 1965, 169-173.
19. Das GM. Bionomics of the tea red spider, *Oligonychus coffeae* (Nietner). Bulletin of Entomological Research. 1959a; 50:265-274.
20. Das GM, Das SC. Effect of temperature and humidity on the development of tea red spider mite, *Oligonychus coffeae* (Nietner). Bulletin of Entomological Research. 1967; 57(3):433-436.
21. Das GM. Bionomics of the tea red spider, *Oligonychus coffeae* (Nietner). Bulletin of Entomological Research. 1955; 50:265-274.
22. Das GM. Occurrence of red spider mite in relation to cultural practices in North-East India. Two Bud. 1959b; 6(4):3-10
23. Das P, Saikia S, Kalita S, Hazarika LK, Dutta SK. Effect of temperature on biology of red spider mite

(*Oligonychus coffeae*) on three different TV clones. Indian Journal of Agriculture Science. 2012; 82(3):255-259
24. Debnath S. Natural occurrence of entomopathogenic fungus, *Hirsutella thompsonii* on red spider mite, *Oligonychus coffeae* (Nietner) infesting tea plants *Camellia sinensis* L. (O) Kuntze in North East India. In: Proceedings of the international conference of tea culture and science, ICOS-2004, November 4–6, 2004, Shizuoka, Japan, 2004, 1204-1206.
25. Elbert EB, Melgarejo J, Schnorbach HJ, Sone S. Field Development of Oberon® for whitefly and mite control in vegetables, cotton, corn, strawberries, ornamentals and tea. Pflanzenschutz-Nachrichten Bayer. 2005; 58(3):441-468.
26. Gotoh T, Nagata T. Development and reproduction of *Oligonychus coffeae* (Acari: Tetranychidae) on tea. International Journal of Acarology. 2001 27(4):293-298.
27. Gupta SK. Mites occurring on tea plants in India with a key for their Identification. In: Channabasavanna GP, Viraktamath CA (eds) Progress in acarology, Oxford and IBH, New Delhi. 1989; 2:177-182
28. Gurr GM, Wratten SD, Altieri MA. Ecological Engineering for Pest Management: Advances in Habitat Manipulation for Arthropods. Wallingford, UK: CABI Publication, 2004.
29. Hadfield W. Leaf temperature, leaf pose and productivity of the tea bush. Nature. 1968; 219:282-284.
30. Haque M, Wahab A, Naher N, Begum A. Developmental stages of red the spider mite, *Oligonychus coffeae* Neitner (Acari: Tetranychidae) infesting rose. University Journal of Zoology. 2007; 26:71-72.
31. Hazarika LK, Bhuyan M, Hazarika BN. Insect pest of tea and their management. Annual Review of Entomology. 2009; 54:267-284.
32. Hu CC, Wang LC. A study of the annual lifecycle of the tea red spider mite *Oligonychus coffeae* (Nietner).Journal of the Agricultural Association of China. 1965; 50:1-4.
33. Kachhawa D, Rahman R. Evalution of meteorological factors on incidence of red spider mite of tea, *Oligonychus coffeae* (Nietner) under the natural conditions of Assam. Asian Journal of Environmental Science. 2015; 10(1):7-12.
34. Light SS. Mites as pests of the tea plant. Tropical Agriculture. 1927; 68(4):229-238.
35. Mamun MSA, Ahmed M. Evaluation of indigenous plant extracts against major pests of tea. Entomology Division, Bangladesh Tea Research Institute, Srimangal, Moulvibazar, 2012.
36. Mamun MSA. Integrated approaches to tea pest management in South India: *A way of sustainable tea cultivation*. LAP LAMBERT Academic Publishing GmbH & Co. KG Dudweiler Landstr. 99, 66123 Saarbrücken, Germany, 2011, 68p.
37. Mamun MSA, Ahmed M. Prospect of indigenous plant extracts in tea pest management. International Journal of Agricultural Research Innovation & Technology, 2011; 1(1-2):16-23.
38. Mamun MSA, Hoque MM, Ahmed M, Akandha MYH, Paul K. Evaluation of Some Potential Miticides against Red Spider Mite Infesting Tea In Bangladesh. Tea Journal, Bangladesh. 2016; 45:52-64.
39. Mazid S, Rajkhowa RC, Kalita JC. Seasonal incidence of red spider mite, *Oligonychus coffeae* Nietner on tea plantation in Assam. Indian Journal of Research. 2015; 4(3):6-7.
40. Mukhopadhyay A, Gurusubramanian G, Somnath R. A preliminary toxicological study of commonly used acaricides of tea red spider mite (*Oligonychus coffee* Nietner) of North Bengal, India Resistant Pest Management Newsletter. 2009; 18(1):7-10.
41. Muraleedharan N, Selvasundaram R. An IPM package for tea in India. Planters Chron. 2002; 98:107-124.
42. Muraleedharan N. Pest control in Asia. In: Wilson KC, Clifford MN (eds) Tea: cultivation to consumption. Chapman and Hall, London, 1992, 375-412.
43. Muraleedharan N. Ecology of tea pest and strategies for their management. In: Upadhyay RE, Mukerji KG, Dubey OP (eds) IPM system in agriculture, vol 6. Aditya Books Pvt Ltd., New Delhi, 1999, 1-6.
44. Muraleedharan N. Sustainable cultivation of tea. Handbook of tea culture, section UPASI tea Research Foundation, Niran Dam, Valparai. 2006; 24:1–12.
45. Muraleedharan N, Sudarmani DNP, Selvasundaram R. Bioecology and management of the red spider mite infesting tea in south India. In: Proceedings of International symposium on Innovation in tea science and sustainable development in tea industry. China Tea Sci. Soc., Hangzhou, China, 2005, 756-766.
46. Rao GN. Control of tea mites in South India-I. Planters Chron. 1974; 69(5):91-94.
47. Roobakkumar A, Subramaniam MSR, Babu A, Muraleedharan N. Bioefficacy of certain plant extracts against the red spider mite, *Oligonychus coffeae*, Nietner (Acari: Tetranychidae) infesting tea. International Journal of Acarology. 2010; 36(3):255-258.
48. Roy A, Chakraborti D, Das S. Effectiveness of garlic lectin on red spider mite of tea. Journal of Plant Interaction. 2008; 3(3):157-162.
49. Roy S, Gurusubramanian G, Nachimuthu SK. Anti-mite activity of *Polygonum hydropiper* L. (Polygonaceae) extracts against tea red spider mite, *Oligonychus coffeae* Nietner (Tetranychidae: Acari). International Journal of Acarology, 2011; 37(6):561-566.
50. Roy S, Mukhopadhyay A, Gurusubramanian G. Baseline susceptibility of *Oligonychus coffeae* to acaricides in North Bengal tea plantations, India. International Journal of Acarology. 2010; 36(5):357-362.
51. Roy S, Mukhopadhyay A, Gurusubramanian G. Relative susceptibility of tea mosquito bug, *Helopeltis theivora* and red spider mite, *Oligonychus coffeae* eggs to commonly used pesticides. Journal of Plant Protection Research. 2010; 50(3):271-276.
52. Saha K, Somchoudhury AK, Sarkar PK, Gupta SK. Effect of temperature on the rate of development, fecundity, longivity, sex ratio and mortality of *Amblyseius coccosocius* Ghai and Menon (Acari, Phytoseiidae), an important biocontrol agent against tea red spider mite in India. In: Halliday RB, Walter DE, Proctor HC, Norton RA, Colloff MJ (eds) Acarology: proceedings of the 10th international congress. CSIRO Publishing, Melbourne, 2001, 470-472.
53. Sarkar PK, Somchoudhury AK, Sekh K. Role of predators in management of *Oligonychus coffeae* Nietner in tea in India. In: The 5th international symposium on biocontrol and biotechnology. At Khon Kaen University, Nong Khai Campus, Nong Khai, Thailand, 2007, 15p.
54. Selvasundaram R, Muraleedharan N. Red spider mite-biology and control. Hand Book of Tea Culture. UPASI Tea Research Institute, Valparai, 2003.

55. Shimizu M, Kubota M, Tanaka T, Moriwaki H. Nutraceutical approach for preventing obesity-related colorectal and liver carcinogenesis. International Journal of Molecular Sciences. 2012; 13(1):579-595.
56. Sudoi V, Cheramgoi E, Langat JK, Kamunya SM, Wachira FK. Screening of Kenyan tea clones at different ecological zones for their susceptibility to mite attack and effect on the crop yields. In: Proceedings of the 4th national conference on science, technology and innovation as a platform for national development, Kenyatta International Conference Centre (KICC), Nairobi, Kenya, 2011, 25-43.
57. TRA. Pests of tea in North-East India and their control. Memo. No. 27. Tocklai Experimental Station, Jorhat, India, 1994, 231.
58. Vasanthakumar D, Babu A. Life table and efficacy of *Mallada desjardinsi* (Chrysopidae: Neuroptera), an important predator of tea red spider mite, *Oligonychus coffeae* (Acari: Tetranychidae). Experimental and Applied Acarology. 2013; 61(1):43-52.
59. Watt G, Mann HN. The Pests and Blights of the Tea Plant. Calcutta: Gov. Printing Press. 1903, 429p.