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INTEGRATED PEST MANAGEMENT IN TEA: RECENT ADVANCES AND FUTURE CHALLENGES#

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ABSTRACT

Tea, *Camellia sinensis* (L.) O. Kuntze, is a perennial plantation crop and grown as a monoculture on large contiguous area of about 5.79 lakh ha in India. The major insect pests of tea include hemipteran mosquito bugs, lepidopteran tortricids, geometrid loopers, coleopteran scolytid shot-hole borer and scale insects. Besides insects, mites and root knot nematodes are important. This review provides a brief account of major pests of tea in Indian context, enlists strategies for sustainable IPM and underline the major challenges in view of pest diversity, climate change and sensitive nature of the produce with high export value.

Key words: Tea, IPM strategies, challenges, tea mosquito bug, tortricids, geometrid, shot hole borer, scale insects, diversity, climate change

An array of pests and diseases attack tea, (*Camellia sinensis* (L.) O. Kuntze) plants. Over one thousand arthropods have been reported to infest different parts of the tea plant throughout the world (Chen and Chen, 1989), while in Asia about 230 species of insects and mites have been reported (Muraleedharan, 1992). In north eastern India, 172 arthropods and 16 nematode species attack the tea plants. Dhanapati and Varatharajan (2016) studied diversity and density of tea pests in the tea gardens of Manipur in North East India. The estimated yield loss due to these pests range from five to 55 per cent (Rattan, 1992; Sivapalan, 1999) and in some cases it is almost 100 per cent (Muraleedharan and Chen, 1997). Among the major pests, hemipteran mosquito bugs *Helopeltis theivora* Waterhouse and *H. shoutedeni* are serious in Africa (Rattan, 1992), and Asia (Sundararaju and Sundarababu, 1999) causing 55 to 100% crop loss (Muraleedharan, 1992).

Among the lepidopteran pests, the tea tortricids, the bunch caterpillar and the loopers can cause substantial damage. The Tortricid *Homona* spp. and *Adoxophyes* spp. attack tea in Japan, China, India, Sri Lanka, Taiwan, Turkey and Bangladesh. *Adoxophyes honmai* is serious in central and south Japan. But *Homona magnanima* is seen only in south Japan. *Homona coffearia* causes significant damage in India, Indonesia and Sri Lanka with 50 per cent yield loss reported in Sri Lanka (Cranham, 1996). The tea looper, *Buzura suppressaria* was reported as a serious pest of tea in India until 2016. However, the black inch worm, *Hyposidra talaca* (Walker) has earned considerable importance as a defoliator during last decade in north east India (Roy et al*.,* 2017). The scolytid shot-hole borer *Xyleborus fornicatus* is a major pest in Sri Lanka causing up to 100 per cent damage. Scale insect, *Ceroplastes rubens* (Maskell) has become a major threat to the tea plantations in the North East India, especially in the Upper Assam region (Rahman et al*.,* 2018). The honey dew excreted by these insects encourage development of fungus called sooty mold that gives the plants a characteristic black, "sooty" appearance. Besides insects, mites are highly persistent pests and are known to cause serious damage to tea plants. The red spider mite *Oligonychus coffeae* causes serious damage in India, Sri Lanka, Bangladesh, Taiwan, Kenya, Malawi, Uganda and Zimbabwe (Gotoh and Nagata, 2001; Han, 2000). Tea plant is also attacked by the root knot nematode *Meloidogyne incognita* and the lesion nematodes *Pratylenchus brachyurus* and *P. loosi* affecting the productivity under severe infestation. Phytoparasitic nematodes are also known to be associated with fungal pathogens causing wilt diseases in plants. In this chapter major pests of tea in India are briefly described and available management options in Indian context are enumerated prior to discussion on IPM in tea. Earlier reviews on the subject include Cranham (1966), Sudoi (1997), Muraleedhanran and Chen (1997), Agnihotrudu (1999), Hazarika et al. (2009) and Babu (2010).

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Major pests

1. Tea mosquito bug, *Helopeltis theivora* Waterhouse: Nymphs and adults feed on buds, leaf and young shoots by sucking phloem sap and lay eggs in the leaf axils. This results in feeding marks on leaf and stem. Severe incidence leads to stunted growth of plant and bushy appearance. Peak population is seen during June-September.

2. Thrips, *Scirtothrips dorsalis* Hood: Thrips have established themselves as serious and regular pests in tea plantations of north-east India. Climate change and over reliance on chemical insecticides during the last few decades are the factors responsible for their emergence as serious pests. Tea fields recovering from pruning are more prone to the attack by this thrips. Due to their feeding leaf surface becomes uneven, curly and matty, exhibiting parallel lines of feeding marks on either side of the midrib. Heavily infested fields sometimes acquire a bronze color. Both adults and larvae live and feed inside the folds of unopened and partly opened buds and on young leaves. Eggs are laid singly, completely embedded in the tissues of leaf buds and young leaves. Total duration of life cycle is about 14- 20 days depending on the weather conditions. Pupation takes place in lichens and mosses growing on tea bushes. Peak incidence is seen during March-April.

3. Tea jassid/ greenfly, *Empoasca flavescens* F.: Also called tea leaf hopper, both adults and nymphs, suck sap of young leaves leading to uneven and downward curled leaves, the margin become re-curved and subsequently turns brown and dry up. This characteristic symptom is known as the rim blight. The damage symptoms become quite prominent on bushes in May at the time of second flush.

4. Scale insects: There are several species of scale insect observed in tea gardens and the common ones are *Eriochiton theae* (Green) on tea stem; *Fiorinia theae* (Green) on tea leaf, *Ceroplastes rubens* (Maskell) on tea stems. Now scale insects are the major problem of the gardens. The scales are the silent killers of bushes if not noticed on time. Sap feeding by scale insects causes yellowing or wilting of leaves, stunting or unthrifty appearance of the plants, and eventually cause death of all or part of the plant when infestations are heavy.

5. Bunch caterpillar, *Andraca bipunctata* Walker: Bunch Caterpillar is a common and serious pest causing considerable loss to tea cultivation in North East India. They feed on the young leaves and remove the epidermis. Young caterpillar remains in bunches on the undersurface of the leaf. First instars feeding only epidermal tissues while second instar larvae feed on leaf margin while older larve feed on the entire leaf. There are four broods during an year.

6. Tea looper, *Buzura suppressaria* (Gn.): It is another major defoliating pests of tea. While early larval instars make holes on leaves by feeding, later instars feed on entire leaves. Under severe attack the bushes are often completely stripped off their leaves.

7. New tea looper, *Hyposidra talaca* (Walker): It is also known as 'black inch worm'. The larvae are polyphagous in nature and reported to feed on a variety of trees, shrubs and weeds. Occurrence of a few more species of loppers including *H. infexaria, Ascotis* and *Ectropis* species in Upper Assam, North Bank of Assam has also been recorded. *Hyposidra talaca* is found to be the most dominant one among the newer species of the looper caterpillars.

8. Red spider mite, *Oligonychus coffeae* Nietner: This is the major non-insect pest of tea in most of the tea-plantations across countries. The pest persists on tea all the year round. The adult female is somewhat elliptical, posterior end of the abdomen is broadly rounded and dark purplish in colour. Brown patches are formed as a result of repeated sucking. With increasing damage, the whole upper surface turns brown and ultimately bronze. In severe attack leaves may dry up and fall off.

Strategies for sustainable IPM

1. Early monitoring of pests: In order to achieve successful control of pests, early detection of pests is critical. Although monitoring devices like light traps and pheromone traps may be useful, regular visual monitoring is the fool-proof method to detect the pests early for initiating pest management programmes. Precise identification of the pests becomes vital for deployment of suitable tools, be it biological control or use of pheromones. DNA Barcodes can document and confirm known species while uncovering lots of hidden variation, some of which may lead to the description of new species.

2. Shade regulation: Shade in the tea garden plays a major role in sustainable crop production and influences colonization pattern of pest species and disease incidence. Optimum shade levels maintain the productivity as well as quality of tea. Lopping of dense branches early in the season reduces the incidence of the tea mosquito bug *H. theivora* as well as the diseases. Absence of shade on the other hand may result in favorable conditions for multiplication of red spider mites and thrips. Level off skiff (LOS) and black plucking help remove the unproductive shoots and reduce the density of eggs of *Helopeltis* and thrips. Growing of hedge plant, *Phlogacanthus thrysiflorus* along the road side reduces dust on the tea bushes and thereby egg laying by the mites. Bouquine tree, Lantana camera, *Clerodendro ninermi* and lemon grass repel insect pests and hence can be used as shade plants. Some native plants like *Azadiracta indica*, *Polygonum hydropiper*, *Clerodendron infortunatus*, *Xanthium strumarium*, *Pongamia pinnata* and *Acorus calamus*is reported to reduce incidence of tea pests (Rahman et al. 2007). Besides, shade trees often act as a refugia for many generalist predators particularly spiders and insectivorous birds. However, the choice of the species of shade plants has to made very carefully since some shade trees like *Dalbergia assamica* and *Albizziaodo retissima* are alternate host plants for the tea looper and hence should be avoided (Borthakur et al., 2010). Some shade trees enhance pests like *Lasperesia leucostoma*, *E. flavescens*, Glyptotermes sp. and *H. theivora* but is known to reduce *O. coffeae* populations (TRA 1994).

3. Soil conservation: Conservation tillage aids in soil and water conservation and improves plant nutrition and health (Zehnder et al., 2007) thereby providing protection against certain herbivores. Application of organic amendments and manures such as coconut and neem oil cakes, well decomposed refuse of tea, decaffeinated tea waste, well decomposed poultry and green manure can tremendously enhance plant health and aid in raising healthy tea plants. The biggest challenge however would be accessing sufficient quantities of these organic materials in time.

4. Balanced fertilizer application: Chemical fertilizers have to be judiciously applied, as excessive application of nitrogenous fertilizers is known to result in the outbreak of sucking pests as well as live wood termites (Sudoi et al., 2001). Appropriate levels of N and K reduce the incidence of *X. fornicates* due to rapid regeneration of new tissues as a support bracket as well as inducing tolerance to the pest (Wickremesinge and Thirignanasunderan, 1980). Balanced NPK application produces robust plants that can resist *Brevipalpu sphenicis* (Sudoi et al., 2001). Phosphorus is known to induce resistence in tea to *T.* kanzawai (Cranham, 1996). Application of potash enhanced nematode resistance in plants (Kamunya et al., 2008).

5. Water management: Proper water management through regulated irrigation and mulching has been recommended for soil conservation as well as control of *Empoasca* sp. (Zhang et al., 1992). Drainage system also can provide a physical barrier to restrict the migration of *E. magnifica* and *B. suppress* aria under epidemic conditions.

6. Crop habitat diversity and intercropping: Less incidence of yellow mite *Polyphagotarsonemus latus* has been documented by altering the microclimate by inter-planting tea with cedar, peach, plum or pear in China (Jiang et al., 2003). Similarly, intercropping with soybean and mulching with soybean straw improved the soil nutrient status, vigour of the tea plant and yield while reducing the incidence of pests, diseases and weeds (Li et al. 2008). Citrus inter-planted with tea is known to encourage indigenous parasitoids to suppress *Toxoptera aurantii* on tea and *Aphis craccivora* on citrus in Georgia (Hazarika et al., 2001). Border planting of *Adhatod avesica* can act as a barrier crop for *O. coffeae* (What and Mann, 1903). Hence, a planned crop diversity programmes provide ecosystem services which are likely to impact favorably the tri-trophic interaction between the plant, herbivore and natural enemies.

7. Use of trap crop: Use of trap crop is not common in tea cultivation. It has been suggested that susceptible tea clones such as Tocklai vegetative clone TV1 may be utilized as a trap crop for *H. theivora* (Hazarika et al., 2009). Also, leaving a few tea bushes un-pruned in the centre of a tea garden for a day or two at the time of pruning to attract *H. theivora* and killing them by chemical sprays has been proposed (TRA, 1994). A systematic search for alternate host plants which can be deployed for push-pull strategy (Cook et al., 2007 and Khan and Picket, 2004) in the tea ecosystem has to be made.

8. Host plant resistance: Choudhary et al. (2006) identified some clones of tea resistant to *Oligonychus coffeae*. Clones that are rich in polyphenols but low in nitrogen are resistant to *O. coffeae* and *B. phoenicis* (Sudoi, 1997). Higher amounts of catechins and phenyl alanine ammonia lyase and glutamate dehydrogenase in these clones are also believed to be the reason for resistance (Chen et al., 1996; Xu et al., 1996). The Chinese clone Luxi white containing a high polyphenol content and wild teas rich in caffeine (Yu and Xu, 1999) are likely to be resistant to mites (Sudoi, 1997) and can be used in resistance breeding programmes. Leaf structure and texture govern the susceptibility of tea clones to *Empoasca vitis* and *H. theivora* (Zhang et al., 1992). Succulent clones from Assam TV I, TV9, TV22, TV25 and TV26 are more susceptible to *H. theivora* (Sundararaju and Sundarababu, 1999). UPASI-10 clonal tea showed good tolerance to shot-hole borer (Murthy and Rao, 1979). Identification of resistance conferring genes and their incorporation into commercial cultivars would be worthwhile research agenda for the future.

9. Semiochemicals: Semiochemicals, particularly the pheromones, have not been exploited to their full potential in tea pest management. Pheromone activity has been detected in the abdominal extracts of *H. antonii* (Bhat and Raviprasad, 2008). Sachin *et. al. (*2008) highlighted the behavioral responses of the tea mosquito, *H. theivora* to female sex pheromones. Wang et al. (2005) used 25 pheromone traps per ha to reduce the egg and larval population of *Euproctis pseudoconspersa* by about 50 per cent. Sex pheromone-based attractants were used for monitoring *Adoxophyes* sp. (Hiyori et al*.,* 1986 and Tamaki et al*.,* 1979), *H.* coffearia (Noguchi et al*.,* 1981) and *Ascotisselena riacretacea* (Ohtani et al*.,* 2001). Otais et al. (1991) reported that a pheromone concentration of >20 ng/ m^3 will be required for the suppression of the smaller tea tortrix *Adoxophyes* sp. in Japan. These studies indicate the possibility of using insect pheromones for the management of emerging lepidopteran pests particularly *B. suppressaria* in India. However, no mass trapping or mating disruption technologies have been explored in tea pest management. Han et al. (2006) used semiochemicals to attract *Apanteles* sp. for the management of *Ectropis obliquae* in tea. The larval populations were reduced by 50 per cent and the biodiversity index increased considerably. Tea plants-release the volatiles 2-6 dimethyl-3, 7 octadien 3-01 and indolewhich are perceived by *Apanteles* sp. for locating their geometrid host and thus act as synomones. Xu et al. (1998) showed that the *Apanteles* are attracted by the volatiles produced by leaves fed by geometrids but not by mechanically injured leaves. The Neuropteran *Chrysopa* sp., the coccinellid, *Leixa xiridis* and the syrphid, *Spherophori amentbastri* were attracted to tea plants emanating methyl salicylate due to damage caused by feeding of *E. vitis* (Han and Chen, 2004). Synthetic synamones such as salicylate may be useful for attracting natural enemies to the host plants.

10. Botanical pesticides: In view of the great concern for the insecticide residues in the made tea at consumer level, major focus is on use of botanical pesticides. Among several alternative strategies attempted to manage the red spider mite on tea use of plant-based biopesticides is considered appropriate (Vasanthakumar et al*.,* 2012b). Neem-seed kernel aqueous extract (NKAE) gave appreciable control of red spider mites as well as pink, purple, yellow and scarlet mites in tea (Radhakrishnan, 2010). Babu et al. (2008) demonstrated NKAE as non-phytotoxic, safer to beneficial insects like predators and its use does not leave any undesirable residues on black tea. Rahman et al. (2006) could get 50 to 75% reduction of different pests like *Empoasca javescens*, red spider mite and thrips with sprays of azadiractin. Neem formulations reduced the purple mite *Calacarus carinatus* population by 70 per cent in seven days and no residues were detected one day after the spray (Subaharan and Regupathy, 2006). Several other botanical extracts were also found possessing significant antifeedant/ ovipositional deterrent or toxic effects on some tea pests (Hazarika et al*.,* 2008). Methanolic extracts of *Clerodendrum infortunatum* was toxic to *H. theivora* producing 95 per cent mortality (Roy et al. 2009). Efficacy of solvent extracts of certain locally available plants such as *Polygonum hydropiper* L., *Vitex negundo* L., *Tithoniadi versifolia* (Hemsl.) (wild sun flower), *Artemisia vulgaris* L. and *Clerodendrum infortunatum* L. have been evaluated against tea red spider mite (Deka et al*.,* 2017). The bioactivity of an organic synergist in enhancing the efficacy of Neem Kernel Aqueous Extract (NKAE) in controlling *Oligonychus coffeae* has been studied by Deka et al. (2017). Many studies have demonstrated that, neem based pesticides are safe to green lacewings (Agaarwal and Brar, 2006). Vasanthakumar et al. (2013) showed efficacy of Azter (a neem-based pesticide) against the tea red spider mite and its safety to the predators, *M. desjardinsi* and *O. pygmaea*. In view of low persistence, more frequent sprays of botanicals may be necessary increasing the cost of control. Further, no cost-effective formulations of these botanicals have been developed and made available commercially.

11. Biological control: Biological control using insect parasitoids, predators and pathogens through conservation of native biodiversity has the major thrust in tea pest management. Introduction of the braconid parasitoid, *Macrocentrus homonae* from Java, Indonesia into Sri Lanka for the management of the tea Tortricid, *H. cofearria* has been very successful example of classical biocontrol (Cranham, 1996). But such attempts against mites and *X. fornicatus* were not successful in Sri Lanka. Biological control through augmentative releases of entomophagous species like *Trichogramma* spp. has been attempted against tea tortricids (Ishijima et al., 2008). *Cotesia* sp. was found to be effective against *B. suppressaria* to an extent of 48 per cent and the tachinid, *Argyrophyllax* sp. could parasitise 42 per cent of *Eterusia magnifica*. Augmentation of *M. homonae* against the Tortrix and *A. deleoni* against the scarlet mite is part of an IPM in Indonesia. Release of C. carnea at the rate of 2000/ha has given encouraging results against the tea mosquito bug (Borthakur et al., 2010). Mass production and augmentation of *A. nicholsi* against the yellow mite, *I. dendrolimi* against the smaller tea tortrix and *Apanteles* sp. against the tea looper have given encouraging results in China. Efforts have been made to develop mass rearing technology for the green lacewing, *Mallada boninensis* an important predator of various soft-bodied arthropods, including red spider mites in tea, (Vasanthakumar et al., 2012a). *M. desjardinsi* has been reported for the first time as a predator of tea red spider mite. Limited work has been done on its biology and mass rearing on artificial diets (Babu et al., 2004, 2011; Vasanthakumar et al., 2012a). *M. desjardinsi*is an important predator of tea red spider mite, *Oligonychus coffeae* (Vasanthakumar et al., 2011; Vasanthakumar et al., 2013) and has potential for use in integrated pest management.

In organically grown tea, parasitism by the tachinid increased to 80 per cent. This indicates the importance of conservation biocontrol. Tea plantations are like single species forests (Cranham, 1996) and natural enemies prefer to remain below the plucking table (Kawai, 1997). In contrast, chemical pesticides are known to eliminate parasitoids and predators. For example, sprays of synthetic pyrethroids reduced the population of the Eulophid parasitoid *Sympiesis dolichogaster*, of the gracillarid, *Coloptilia theivora* significantly while phosalone was relatively safer to the parasitoid (Selvasundaram and Muraleedharan, 1993). Vasanthakumar et al. (2011), highlighted the impact of temperature and pesticide applications on the prey consumption of *Malladades jardinsi,* an important predator of red spider mite. A synthetic pyrethroid-tolerant *Amblysieus omersleyi*s train successfully controlled *Tetranychus kanzawai*, *Scirtothrips dorsalis* and *Empoasca onukii* on tea along with synthetic pyrethroid application (Mochizuki, 2003).

12. Microbial control: Baculoviruses particularly the nuclear polyhedrosis and granulosis viruses have been tested for the management of some caterpillar pests of tea in Japan (Ishii et al., 2002) and China (Hazarika et al., 2001). Granulosis viruses have been extensively used for the control of the Tortricids, *Adoxophyes sp.* and *Homona magnanima* in Japan (Tanaka and Nonaka, 1996). Formulations of a GV gave more than 90 per cent control of *Andraca bipunctata* and the virus persisted for several years, 60 % natural mortality being seen even three years after the initial sprays (Ding et at., 1999). Spraying a nuclear polyhedrosis virus brought the population of the tea geometrid (*Ectropis obliqua*), below ETL with an increase in the natural enemy population, control cost reduced by 27 per cent and tea output increased by 46.8 per cent (Yin et al., 1996). Control of *Hyposidra talaca* using a Nucleopolyherdralvirus (NPV) based biopesticides has been reported by Yin et al., 1996).

Entomopathogenic fungal pathogens particularly *Beauveria bassiana* has shown promise in the control of a variety of pests including *Hetopeltis* (Hazarika and Puzari, 2001). Addition of crude sugar helped as a surfactant as well as a nutrient base for the fungal growth (Babu, 2010). Many entomopathogenic fungi either alone or in combination with synthetic pyrethroids or OP compounds have been tested with promising results in China, India and Sri Lanka (Hazarika and Puzari, 2001, Hazarika et al., 2001). Development of formulations with good shelf life and field persistence is the key to successful use of fungal pathogens for the management of pests on a large scale.

The bacterial insecticide *Bacillus thuringiensis* (Bt) is a potent biocontrol agent particularly against the lepidopteran pests as well as the dipteran pests (Agnihothrudu, 1999). Addition of adjuvants has enhanced the efficacy of Bt (Hazarika et al., 2005). Outbreaks of caterpillar pests like the looper *Buzura* can be controlled by Bt products provided they are targeted against the younger larvae. However, it should be borne in mind that pests can develop resistance to Bt products and hence their use has to be properly regulated. Given the safety of this bacterial insecticide to higher animals as well as the non-target insect species like the natural enemies, honey bees and pollinators, Bt should be used as a sustainable tool for pest management. Non-availability of quality indigenous products as well as the high cost of imported ones are a major constraint in the large-scale use of Bt.

13. Chemical pest control: A large number of chemical insecticides have been used in tea from time to time starting with inorganic acaricides like Sulphur. With the banning of conventional organochlorine and OP compounds as well as development of resistance, several new molecules are being introduced. Neonicotinoids, spinosyns, avermectins, pyrazoles and oxydizines are being tried. Synthetic pyrethroids are known to kill predators and induce resurgence of pink mites and hence their use in tea is restricted (Muraleedharan, 1992). In addition to dicofol and ethion (Cranham, 1996) new compounds like pyridaben, accquinocyle, diafenthiuron, etoxazole, spirodiclofen and bifenzile are now more widely used (Hazarika et al., 2009). It should however be remembered that long term use of chemical pesticides can never be sustainable and hence a sound pest management package will have to be developed with less reliance on chemical pesticides. Strategies for bio-intensive integrated management of tea pests for sustainable tea production in the north east India has been described by Gurusubramanian et al. (2008). Sarmah et al. (2016) demonstrated that, acaricides could be used alternately for effective and sustainable management of red spider mite in tea plantation.

Future challenges

Several strategies of lPM have been put forth for sustainable production of tea from time to time (Gurusubramaian, 2008; Muraleedharan, 2008; Hazarika et al., 2009). However, the tea industry is yet to see an appreciable level of adoption. While the use of synthetic chemical pesticides appears to be indispensable due to various reasons, efforts should not cease in developing eco-friendly alternate strategies. It should also be borne in mind that the alternate options should match the chemical agents in terms of efficacy, speed of action and cost competitiveness. Intensive research should pave the way for identification of pest-resistant clones of tea. Molecular marker technology for genetic improvement of tea is being explored (Bandyopadhyay, 2011) but no specific attempt of marker assisted selection of insect resistance reported. Though agrobacterium mediated transformation protocols have been developed for tea plant transformation (Mondal et al., 2001), no transgenic tea with insecticidal genes has been reported so far. There have been attempts to develop information based expert systems like TEAPEST (Ghosh and Samanta, 2003) as decision support systems, these need to be fine-tuned to specific situations. Pheromones and botanicals are good options but good quality products have to be made available at affordable cost and in time. Quality of these soft products has been a matter of concern for the past several decades. Since Mother Nature has a rich diversity of biological control agents, conservation of these precious resources should be prime motto in tea pest management. While new chemistries can provide quick relief, lessons learned from the past on their deleterious impact should not be forgotten. Synthetic pyrethroids once much-admired as the miracle insecticides with no obvious harmful impact are now known to be not so safe anymore. In view of pesticide residues in tea and a greater awareness of their ill effects on human health, there is now a growing aspiration for organically grown tea (Mohan and Bachi, 1999). Hence, only a healthy soil can produce a healthy plant and any incidence of pest or disease would naturally be a sign of poor growing conditions of the agro ecosystems. Enhancing and maintaining the soil health should be the primary step for sustainable cultivation of tea and anything unsustainable becomes unethical. Restoration of soil health and the environment, we should demonstrate moral courage and will power to resist the same.

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