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Review Article

# *CAMELLIA SINENSIS* (L.) O. KUNTZE AND ITS BENEFICIAL SOIL MICROFLORA

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**ABSTRACT**

Since time immemorial, humans have been using leaves of tea plant (*Camellia sinensis* L.) O. Kuntze as medicinal beverage. Till date, one cannot determine the extent to which it can benefit us both medicinally as well as economically. Therefore, looking at the popularity of tea in global market, studying and collecting information on places where it grows and elements residing there become important. To achieve this, it is necessary to emphasize on seasons of the year, climate of the place and physiochemical properties of soil, and also to give equal importance to soil microbes as well for they are an important part of biogeochemical cycles of the earth and also possess many abilities such as degradation of synthetic chemicals, promoting plant growth, solubilize nutrients, fixes nitrogen, enzyme degradation, control of pests and diseases.

**Keywords:** *Camellia sinensis*, Microbes, Abilities, Biogeochemical.

## INTRODUCTION

Tea is the most widely and popularly used beverage produced from leaves and buds of tea plant, *Camellia sinensis* belonging to Theaceae family [1]. It is a perennial woody plant grown as one of the major cash crops in many developing countries in world and can be cultivated in different types of soil. *Camellia* was discovered about 2700 B.C., making tea, one of the world's oldest beverages. The discovery of this plant is attributed to great Chinese scholar and herbalist emperor Shen Nung [2]. Tea plant is said to be originated near river Irrawaddy in South-East Asia which is the meeting point of Assam, North Myanmar, South-West China, and Tibet [3]. Species of *Camellia* that contributes to entire genetic pool of cultivated tea worldwide are *C. sinensis* (L.) O. Kuntze, *Camellia assamica* ssp. *assamica* (Masters), C. *assmica* ssp. lasiocalyx (Planch MS) [4]. According to report given by International Tea Committee, [5] tea plant occupies about 2.72 million hectares of world's land. Due to its attractive color, special flavor and stimulating effect in human body, tea is considered as the favorite among beverages [6]. It is also considered as the hot topic for nutritional and therapeutic researchers as it contain crucible therapeutic compounds which are more stable and direct acting than compounds found in other plants [7]. Tea leaves provide the cheapest and most popular beverage to the world [8] possessing numerous beneficial effect, attributed to polyphenol and purine alkaloids present there [9]. Apart these, aroma forming substances, tanning substance, flavanols, amino acids, vitamins enzymes, proteins, minerals, and trace elements are also present in tea leaves [10]. Other beneficial effect of tea includes providing refreshing and mild stimulating effects to its consumers [11], possession of detoxifying properties [12], anti-obesity ability [13], providing preventive action against number of human ailments [14,15], such as reducing risk of cancer and heart disease [16,17], possessing antibacterial ability against urinary tract bacteria [18] and in treatment of oxidative, inflammatory, and immune disorders along with other medicinal plants [19]. Tea, therefore, cannot be considered as merely a plant or a beverage rather it should be cherished as healthy part of human diet and source of new chemical compounds [6]. Keeping these benefits from tea plant as foremost important, this review attempts to explore benefits provided by soil microflora to tea plant and its environment.

## REQUIREMENTS FOR PLANT GROWTH

Growth rates, quality and yield of *C. sinensis* depends on climatic and physical conditions of the place [20], however, problems that are being faced in tea gardens such as insects and disease attacks, improper growth of buds, decline in soil fertility effect both quality and quantity of tea production [21], therefore, conditions for proper growth of tea plant should be checked before clearing any area for plantation of this monoculture crop. It is said that growth and physiology of tea plant and chemical composition in fresh tea leaves are greatly influenced by differences in factors such as altitude, latitude, climatic conditions, soil of tea bushes, and land elevation of tea plantation [22,23]. Food and Agriculture Organization (Table 1) [24] has given ideal conditions required for growing tea plant. Quality of tea also depends on plant age as shown by Iori *et al.*, [25] through their study in tea plantations at Brazil where the best tea quality was reported from younger tea plantations. The unusual characteristic of tea plant is that, along with requirement of acidic condition of its soil for its growth, the plant further acidifies its soil [26,27]. Apart from contribution by tea plant in making its soil acidic, cycling of litterfall to the soil [28], use of chemical fertilizers in the form of ammonium sulfate and urea in tea garden increase acidic condition of tea garden soil [29-31].

## IMPORTANCE OF MICROFLORAL ASSOCIATION WITH TEA SOIL

Soil microbial communities influence environmental quality and plant growth [32] by breaking down organic and inorganic substance, releasing enzymes, that play an important role in nutrient cycling and thereby, enhancing growth of higher plants [33,34] studying their abundance and diversity is necessary so that economically important plant like tea can be grown without an aid of synthetic fertilizers that are very much detrimental to environment. Other beneficial effects of soil microbes on plants as stressed by Lynch [35] includes -nutrient and water uptake enhancement, dinitrogen fixation, phytohormone production, symbiosis, disease and pest control, and soil enhancement. Thus, soil and its microbial communities are necessary for biogeochemical cycles of soil nutrients, crop quality improvement and agroecosystem sustainability [36,37]. Soil of tea garden like any plantation provides ideal place for large number of microflora which interacts among themselves or with plant roots, resulting in benefitting or harming the plant. During such plant root and soil microbe interactions, root secretes exudates which may have stimulatory or inhibitory effect on soil microflora. In case of tea garden soil, occurrence of negative rhizospheric effect and antagonist's microbial colonization that possess antibiosis, competition, parasitism and predation are some of the important characteristic features [38] making tea soil microbes beneficial for growth of tea plant [39]. Another important feature associated with tea soil is its acidic nature which further increases as the age of tea plant increases and this factor according to Pandey and Palni [40] is one of the important factors responsible

**Table 1: Ideal conditions for growth of tea plant**

| Parameters | Ideal condition |
|---|---|
| Climate | Hot, moist climate |
| pH | Acidic soil |
| Temperatures | 10-30°C |
| Annual precipitation | 1250 mm (minimum) |
| Slopes | 0.5-10° |
| Elevations | 2000 |

for suppressing microbial communities in tea rhizosphere. Despite all these, all biogeochemical cycles necessary for plant survival occurs in tea growing area attributing to role of microbial communities residing there and hence, exploitation and conservation of beneficial microbes in tea soil are necessary as these microbes have potentials to make soil mineral nutrients available for plant usage, degrade synthetic fertilizers, antagonize target organisms, and conserve our environment [41].

**Dominant microflora**

Among bacteria of tea soil, genus *Bacillus* dominate tea rhizosphere with *Bacillus subtilis* and *Bacillus mycoides* comprising major part of the bacterial population, which was attributed to their antifungal activity and tolerance of stress under unfavorable environmental condition [42]. These dominant *Bacillus* species were reported to exhibit strong *in vitro* antagonistic activity against fungal population such as species of *Trichoderma* and *Penicillium* residing in the same tea growing are thereby, showing that plant-microbe and microbe-microbe interactions, and environmental factors are the most important factor favoring or suppressing microbial communities in tea rhizosphere [43]. Among fungi of tea soil, *Penicillium* (reported species were *Penicillium erythromellis*, *Penicillium funiculosum*, *Penicillium janthinellum*, and *Penicillium raistrickii*) and *Trichoderma* (reported species includes *Trichoderma koningii* and *Trichoderma pseudokoningii)* dominate tea rhizosphere and these dominant fungi also showed antagonism against dominant bacteria in the tea rhizosphere [44].

**Nitrifiers**

At low pH level, even as low as 2.9, (reported to be the lowest level of pH for nitrification in the tea soil) nitrification occurs in tea soil due to presence of acid-tolerant autotrophic nitrifying bacteria like *Nitrosococcus* [29]. Other microfloras that make nitrification possible in low pH level of tea gardens are species of *Nitrosomonas* and *Nitrosospira* [45]. Nitrous oxide was observed to be emitted from 100 years old tea orchard soil due to involvement of acidophilic denitrifiers [46].

**Pesticide degarders and bioremedies**

In agricultural practice, fertilizers, pesticides, and herbicides are being used extensively which results in deterioration of our environment [47] and also causes lethal effect to humans especially when insecticides made from organophosphates are used as the latter has been reported to cause muscarinic, nicotinic, and central nervous system manifestation [48]. Thus, importance must be given to biodegraders of these chemicals that remove contaminants without compromising environment. Kawai *et al.*, [49] showed the presence of acid and aluminum tolerating microbes from tea fields at Japan through enrichment culture technique and microbes identified were yeast such as *Cryptococcus humicola*, *Rhodotorula glutinis* and fungi such as *Aspergillus flavus*, *Penicillium janthinellum* and other species of *Penicillium*, *Trichoderma asperellum*. Other aluminum resistant microbes reported from tea soil were species of *Neurospora* capable of growing in aluminum containing environment and further decreasing concentrations of aluminum there [50]. Aluminum resistant and acid tolerant yeasts in soil sample collected from tea garden at Kagoshima, Japan were reported by Kanazawa *et al.*, [51] and basing on morphology and phylogeny, strains were identified as *Cryptococcus* species and *Candida palmioleophila*. Species of *Cryptococcus* and *C. palmioleophila* in addition to acid tolerance were also found to resist heavy metals in cadmium, copper, cobalt, mercury, iron, zinc, silver, manganese, and nickel [52]. Apart from these, fungi isolated from tea gardens such as *Emericellopsis* sp., *Paecilomyces lilacinus, Mortierella ramanniana* var. *angulispora, Sporothrix inflata, Penicillium glabrum, Metarhizium anisopliae, Chaetospharia inaeqalis,* and *Aspergillus fumigatus* were also reported to be acid and aluminum tolerant [53]. Pesticides imidacloprid effect bacterial, fungal and actinomycetes population of both rhizosphere and nonrhizosphere of tea garden, however, microfloras were able to recover with time from this initial inhibitory effect [54]. Species of *Aspergillus, Trichoderma, Curvularia, Penicillium,* and *Alternaria* when treated with selected fungicides *in vitro* showed recovery from toxic effects of fungicides with time [55]. Strains of *Pseudomonas* isolated from tea rhizosphere have been found to be effective in degrading triazole fungicide propiconazole [56]. Species of *Pseudomas* were also able to antagonize other fungal pathogens due to their ability to produce siderophore and hydrogen cyanide. They were able to produce phytohormones exhibit tolerance to agrochemicals and showed synergistic activity with other beneficial bioinnoculants [33]. Such works indicates microfloral potential in bioremediation and reclaiming acid contaminated sites.

**Biological agents**

Tea plants are being affected by diverse pests and diseases [17], therefore, pesticides are being used to control them and to increase crop yield [57]. However, problems like cost of pesticides and resistance by pests along with comprise environment and human health makes them undesirable solution [58]. In such scenario, needs arises for seeking solutions that eradicate these problems and also yielding quantity and quality tea [59]. As rhizosphere of tea provides an excellent site for isolation of microbes that possess biocontrol properties [38] solutions for mentioned problems can be procured from tea garden microflora itself. Species of *Trichoderma* isolated from tea soil were reported as effective biocontrol agents due to their ability to inhibit the growth of fungal pathogen *Macrophoma theiocola* up to 82% [60] and *Phomopsis theae* petch [61]. *Pseudomonas corrugata* and *B. subtilis* isolated from established tea bushes showed biocontrol potential by producing diffusible and volatile compounds which inhibit the radial growth of two phytopathogenic fungi namely *Fusarium udum* and *Alternaria solani* [62]. Species of *Pseudomonas* from tea soil were able to antagonize tea fungal pathogen [53] by producing antifungal compounds such as siderophore and hydrogen cyanide [58,63]. Mazumdar *et al.,* [64] observed antagonistic activity exhibited by five bacterial isolates of *Bacillus* against fungal pathogen *Fusarium oxysporum. Glomus mosseae,* an arbuscular mycorrhizal (AM) fungus isolated from tea soil showed positive response in suppressing tea root pathogen *Ustulina zonata* [6]. Species of Streptomyces isolated from tea soil were found to control tea pathogens by producing secondary metabolites thereby, showing the potentiality of these microfloras as antagonists against tea pathogens [65].

**Enzyme degraders and nutrient cyclers**

Microbes involved in secreting enzymes, such as nitrate reductase and alkaline phosphatase, were reported from tea garden soil [34] thereby, promoting plant growth by making organic phosphates accessible for plant usage. Variety of enzymes were reported from actinomycetes isolated from tea soil whose population correlate positively to soil nutrients including total N, available P and exchange K content [51]. Diazotrophic bacteria belonging to genera such as *Azospira, Bacillus, Brevundimonas, Burkholderia, Delfia, Herbaspirillum, Paenibacillus, Pseudomonas, Rhizobium, Mesorhizobium, Stenotrophomas, Ralstonia* were reported from tea roots [66] indicating the diversity nitrogen-fixing bacteria in tea soil. Microbes belonging to genera such as *Bacillus, Pseudomonas, Burkholderia, Chryseobacterium, Acinetobacter, Enterobacter, Serratia,* and *Micrococcus* were observed to bring about nutrient cycling in tea soil [67].

**Biofertilizers**

Many microorganisms in soil act as biofertilizers by mobilizing soil nutrients and make them available for uptake by plants thereby answering problems of expensive fertilizers cost and also making our earth free of contaminants. In tea soils, deficiency of macronutrients potassium was found to be possibly overcomed by the presence of potash solubilizing bacterial strains [68]. Tea garden rhizobacteria such as *Bacillus amyloliquefaciens, Bacillus pumilus,* and *Serratia marcescens* isolated were able to solubilize phosphorus [69]. Rhizospheric soil of tea plant showed presence of phosphate solubilizing bacteria which converts inorganic insoluble phosphate into soluble form and were also able to produce indoleacetic acid in the presence of tryptophan under *in vitro* condition [70]. Mycorrhizal fungal species belonging to genera such as *Glomus*, *Gigaspora*, *Acaulospora*, *Scutellospora* were isolated from tea rhizosphere [71]. During active growth and dormancy period of the plant, fifty-one AM fungal morphotypes were observed in tea rhizosphere [72]. Vesicular AM were able to infect the tea roots up to 17% thereby, helping in uptake and utilization of phosphate by tea plants [73]. Tea soil thus, harbor varieties of phosphate solubilizing microfloras and mycorrhizal fungal species which are beneficial for soil as well as for plant because a root system forming mycorrhizal will have greater effective surface area for acquisition nutrients and also they can explore great volume of soil [74], and thus, can be employed as potent biofertilizers.

## CONCLUSION

Tea is one of the cash crops of many countries in the world, earners of foreign exchange and provider of employment to millions of people throughout the world so, from the economic point of view, there is need to focus on growth promoting, stress tolerant and degraders of toxic chemicals to increase the tea yield. Chemicals applied to the soil in the form of fertilizers, fungicides, pesticides, etc., enhances growth tea plant and control its pathogen only to limited extend. Most of the fungicides and pesticides apart from inhibiting the growth of pathogens also, kill beneficial microbes in the soil. Chemical applications inhibit the pathogen growth only for limited period after which the microbes become resistant to it. Therefore, exploration of beneficial microflora especially those showing biological control potential becomes very much necessary to save the good microbes.

Human regards the present century as an age of information technology, but there is no doubt that, the present age is also an age of pollution where every organism falls prey to the deleterious effects of pollutants. Hence in this scenario, studies on beneficial microbes become very important to develop effective bioremediation strategies and fight against the problems of pollutants disrupting the environment.

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