International Journal of Environmental and Ecology Research
www.environmentaljournal.in
Online ISSN: 2664-7117, Print ISSN: 2664-7109
Received: 11-05-2021, Accepted: 26-05-2021, Published: 10-06-2021
Volume 3, Issue 2, 2021, Page No. 20-23

Prospects of organic tea cultivation in Uttarakhand hills, India

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Abstract
Tea (*Camellia sinensis L.*) is one of the most popular drinks worldwide due to its pleasant taste and health promoting effect. In recent years, with the growing awareness about health related benefits of tea, organic tea is emerging as a special niche product globally. However, environmental pollution and residue left over by chemicals applied in tea cultivation are looked into seriously. Also, use of fertilizers cannot be promoted in the biodiversity rich and environmentally sensitive mountain ecosystem. Therefore, attempts are required for using organic fertilizers and locally made FYM that could be adopted by the peasants without compromising the yield of tea significantly. Uttarakhand (a mountainous state in north India) has a rich history of tea cultivation that dates back to about 150 years when the first consignment of 20,000 tea seedlings from Kolkata reached this region in 1835, at the same time when tea was also planted in the hills of H.P., Darjeeling, Assam and South India. However, with the departure of British the tea industry in Uttarakhand degenerated considerably due to several reasons. Uttarakhand Government reintroduced tea in Uttarakhand hills in 1987, by reviving abandoned tea gardens of the British period and focused on organic tea cultivation in over 1000 ha land. Considering the above we conducted research in the experimental plantations of UPASI-9 variety of tea (*Camellia sinensis L.*) under three fertilizer treatments viz., NPK, bio-fertilizer and farm yard manure (FYM) as per the recommended doses for nutrient poor soil in the mid-hills of Uttarakhand (Distt. Almora). A comparative account of plant growth and tea yield under various fertilizer treatments after three years shows that the FYM treated plots were significantly better in tea yield as compared to fertilizer treated plots (640 vs 444 kg/ha green leaves), which is about three-fold lower than recorded in Darjeeling hills, India. Thus the poor hill farmers can cultivate organic tea profitably using FYM prepared by them in cattle-sheds replacing the costly and environmentally hazardous inorganic fertilizers in Uttarakhand.

Keywords: Tea (*Camellia sinensis L.*), fertilizer, organic farming, FYM, tea yield, Uttarakhand hills

Introduction

Tea (*Camellia sinensis L.*) is one of the most popular drinks worldwide due to its pleasant taste and health promoting effect. In India, tea accounts for over 90% in terms of consumption of stimulants (tea, coffee, and cocoa beans) and the average annual consumption of tea in India (0.72 kg per person) is comparable to world average (0.75 kg) but still lower than Ireland, Pakistan, Sri Lanka, Turkey and UK (1.0–2.96 kg per person). India is the second largest producer of tea in the world, and accounts for about one-third (i.e., 1390 million kg) of the global tea production (http://www.teaboard. gov.in), and has significant share in the international tea market. The Indian tea industry directly employs more than a million people, mostly backward and tribal (of which 70% are women), and directly or indirectly generates income and livelihood for over 2 million people (including 4.15 lakh families of small tea growers having < 10 ha tea plantations) and contributes significantly to the socio-economic development of our country (Muraleedharan, 2005 [1]; Abdul Hanan; http://www.sikkimuniversity.in). Tea is a fertilizer and labour intensive crop. Nutrient management in tea plantations, especially the supply of N, P, K, Mg and S is essential for the growth and development of tea plants that affects the quality of tea. Tea being a foliage crop, the shoots are harvested at regular intervals removing nutrients from the plant-soil system. Production of 1000 kg dry tea removes 40 kg N, 4 kg P_2O_5, and 19 kg K_2O (Othieno, 1981) [2]. Thus, nutrient deficiency in soils and poor fertilization are most likely the two important reasons for low yield and quality of tea. In recent years, sustainable agriculture has become a prime concern due to increasing fertilizer costs and increased focus on environmental protection. Further, with the growing awareness about health related benefits of tea, organic tea is emerging as a special niche product globally. Continuous use of chemical fertilizers and pesticides disrupts the biological eco-balance of 'soil-plant system', and integrated nutrient management is being increasingly practiced to sustain the soil fertility and crop productivity and promote biological diversity. Thus, fertilizers or organic manure alone cannot sustain tea production. Chemical fertilizers initially boost up the tea yield, but gradually causes decrease in fertilizer use efficiency indicating that the application of organic fertilizers stimulates the activity of soil micro-organisms, improves soil structure/texture and increases the availability of plant nutrients (Singh *et al*. 2011) [3]. Today, environmental pollution and residue left over by chemicals applied in tea cultivation are looked into seriously. The application of organic manures and bioinoculants could minimize these problems as they are advantageous over chemical fertilizers to improve soil fertility, and would also reduce the use of fossil fuel based inorganic fertilizers harmful for the environment. The beneficial effects of combined application of chemical fertilizers with organic manures viz., farmyard manure, vermicompost, biofertilizers and other such materials is universally known. In India, the deleterious impact of continuous use of chemical fertilizers alone in agriculture is being realized now.

History of Tea Cultivation in Uttarakhand

Although Uttarakhand hardly figures in the tea growing states of India, but it has a rich history of tea cultivation that dates back to about 150 years when the first consignment of 20,000 tea seedlings from Kolkata reached this region in 1835, at the same time when tea was also planted in the hills of H.P., Darjeeling, Assam and South India (Rawat, 1996) [4]. In Uttarakhand 63 tea gardens (spread over an area of 4428 ha) existed in 1880, registering a production of 770,270 kg by 1897 (Joshi, 1995) [5]. Some of the largest tea gardens in Uttarakhand measured up to 158 - 486 ha in Kumaun hills. The Chaukouri and Berinag tea gardens (122 ha) were in peak production during 1940–1965, and alone employed 500 persons. Dehradun Tea Company Ltd. Arcadia, today manufactures 70,000 kg of green tea every season still today (Joshi, 1995) [5]. In spite of the glorious past, tea industry in Uttarakhand faced steady decline due to several socio-economic and political reasons. Apparent labour problem, shortage of adequate fuel for tea processing, and cost of packaging and transportation to Calcutta (now Kolkata) were some of the problems faced by the tea industry of Uttarakhand. Many of the tea gardens in the area slowly got converted to growing temperate fruits (apple, peaches, plums, pears, apricots, citrus, *etc*.) during 1925–1950 leading to decline in number of tea gardens from 63 to 20 in 1911 (858 ha), and the production declined to 47,250 kg in 1908 (Joshi, 1995; Anonymous, 1996) [5,6]. Falling production levels, lack of expert labour and increased operational costs collectively forced owners to sell their tea estates. After independence, rampant encroachments, outmigration of skilled labour in search of jobs, market competition due to availability of tea from outside, lack of local tea factories, poor technical knowledge amongst the locals about tea cultivation and processing, absence of good transport facilities, careless attitude of the garden owners and lack of silvicultural management of tea gardens, fast spread of invasive weeds like *Lantana* were some of the reasons of failure of tea industry in this region (Negi and Bisht, 2012) [7].

Revival of Tea Gardens in Uttarakhand

Uttarakhand Government reintroduced tea in Uttarakhand hills in 1987, by taking culturable wastelands of rural communities on lease and reviving abandoned tea gardens of the British period. In 2004, Uttarakhand Tea Development Board (UTDB) was formally set up to develop tea gardens in the state (www.utdb.gov.in) and tea varieties such as Takdah-78, Ambari AV2, Upasi-9, TS-378, TS-520, Assam BSS etc. with their specific cultivation practices (spacing and number of tea bushes per/ha) for four altitudinal zones in Uttarakhand following recommendations of Dr. M.B. Tamang, a tea specialist of Palampur (H.P.) (Tamang, 2008) [8]. The yield of made tea in plantations of various ages thus raised up to 646 kg ha–1 (2810 kg ha^{-1} green leaf) for 11-year-old plantation (Tamang, 2008) [8]. The best quality orthodox tea produced from the region was valued at Rs. 9,000 per kg and also attracted inquiries from buyers abroad. Thus far approximately 1000 ha land has been put under tea cultivation by UTDB, and about half of this has been converted into organic tea in the state (Parihar, 2018) [9] and the Govt. aims to promote eco-friendly, organic and quality tea plantations in 9000 ha area to generate employment and income to the rural people in Uttarakhand. In 2002 a tea factory was also established at Kausani under PPP mode. Later on, with the establishment of tea gardens in small pockets in different areas viz., Champawat, Ghorakhal (Nainital), and Nauti (Chamoli), small tea factories have been established by UTDB (www.utdb.uk.gov.in).

Ecological Considerations in Tea Cultivation in Uttarakhand

Tea cultivation, on account of intensive cultural practices and fertilizer and pesticide inputs, needs to be looked into from the standpoint of ecological and socio-economic impacts, particularly on people, biodiversity (flora/fauna), soil, and water quality. In the tea gardens of Uttarakhand fertilizers such as ammonium sulphate, single super phosphate, murate of potash are used to raise soil fertility as per prescribed standards. Similarly, pesticides such as endosulphan, kalythene, phytolan, and thiodan are used to protect tea plants from the insects/fungal attacks and weeds (www.utdb.uk.gov.in). The reported use of pesticides containing sulphur, chlorine, and phosphate based chemicals is likely to result in accumulation of residue, if used indiscriminately (Chaudhary, 1993) [10]. Overuse of N fertilizer increases levels of nitrate–nitrogen in the ground and surface water (Negi and Bisht, 2012) [7]. Continuous tea plucking removed N (41.5 kg), P_2O5 (3.3 kg) and K_2O (21.5 kg) per 1000 kg dry tea from the tea garden soils of this region thus reduces the soil quality, and for the replenishment of soil fertility N fertilization rates (9–12 kg ha^{-1} per 100 kg of made tea) are recommended (Verma, 2012) [11]. Thus, nutrient deficiency in soils and poor fertilization are most likely the two important reasons for low yield and quality of tea faced by many tea gardens of this region. Fertilizer inputs generally surpass the crop nutrient demand (nutrient loss from harvest), and it may not be sufficient to balance total nutrient losses. Organic fertilizers can help to shape the microbial composition and recruit beneficial bacteria into the rhizosphere of tea, leading to improved tea quality (amino acid content in leaves) and reduced heavy metal contents (Cd, Pb and As) in tea leaves (Lin *et al.* 2019) [12]. Tea gardens being a monoculture is not a suitable habitat for biodiversity and frequent fertilizer applications and weeding promotes proliferation of non-palatable weeds such as *Ageratum conyzoides*, *Chrysanthellum americanum*, *C. crepidioides*, *Galinsoga parviflora*, *Lepidium sativum*, etc. in these tea gardens (Bisht *et al.* 2007) [13]. Among the positive impacts of tea gardens include: (i) payment of land lease rent by UTDB (@ Rs. 1000-1500 /ha/yr), and (ii) employment to women and their participation in tea cultivation in their own land that has helped them to improve their purchasing power and social respect, which has otherwise left uncultivated and become prone for soil erosion. However, cost:benefit ratio (1.86) points out that tea cultivation become profitable only after 5th year onwards of tea plantation. To make tea plantations sufficiently remunerative right from the initial years intercropping of tea with legumes, ginger, turmeric etc. may be opted that has been found to generate additional income ranging from 54–115% over the income from tea alone (Ghosh Hajra, 2001) [14].

Difficulties Faced in Tea Cultivation

In Uttarakhand, agro-climatic conditions for tea cultivation are not as suitable as in the north-east region of India. Tea requires a moderately warm and humid climate and grows best on well-drained fertile acidic soils on high lands as per Tea Research Association, Tocklai (Assam, India) (http://www.tocklai.net). In

Uttarakhand, tea plantations are raised between 1400 and 1700 m asl; majority areas contain soft brown, porous soil having silica and mica, pH 6.9, low in moisture, 29, poor in organic matter (1.64–2.82%), and total nitrogen in soil (0.098–0.167%) (Negi and Bisht, 2012; Negi and Bisht, 2018) [7, 18]. The wide temperature range (from 4–36ºC), relative humidity (40-80%), and inconsistent and less than one-fourth of the annual rainfall of about 1500 mm, during spring (as low as 5 mm in some years; e.g., March-May in 2002) when tea leaves are produced, become detrimental for tea growth. Thus, in the Uttarakhand state, growth and yield of tea plantations suffer from two major constraints: (i) poor soil fertility, and (ii) low soil moisture for most part of the year due to highly seasonal rainfall concentrated during July-September (Negi and Bisht, 2018) [18]. In this region tea plantations gain its full yield potential only after 7 years, and profitable yields are harvested only after 12 years (Tamang, 2008) [8]. Thus, supplementary soil moisture needs to be provided to tea plantations to support new leaf crop. Also, selection of suitable clones for agro-climatically diverse areas is essential for successful tea plantations (Joshi and Palni, 1998) [15].

The other problem relating to tea gardening is socio-economic in nature. In these tea gardens people get work for a few months only for leaf plucking between March and November and the wage payment is made on the basis of 8 hrs work and a worker should collect 12 kg leaves (Misra, 2006) [16]. STGs demand for increase in wages and lease rent, better management of tea gardens, capacity building of tea farmers on appropriate techniques of tea cultivation, and provision of facilities to labourers (such as medical, insurance, leave etc.). It should also be pointed out that sale and leasing land on large scale is not permissible to private entities from outside the state (leasing limited to 0.004 ha) under Uttarakhand Land Reform Act, 2003. This together with small holdings of farmers is a bottleneck for expansion of tea plantations in this region (http://www.downtoearth.org.in) (Misra, 2006) [16]. It is also notable that as many as 15 different brands of tea are sold in the local markets, and the locally produced Uttarakhand Tea (Nandadevi) has still to carve a market of its own. It appears that the other brands available in attractive packing with good liquor quality and odour, lower cost also compete with the local tea.

Organic Tea Cultivation Shows the Way

In recent years, with the growing awareness about health related benefits of tea, organic tea is emerging as a special niche product globally. Also, environmental pollution and residue left over by chemicals applied in tea cultivation are looked into seriously. Integrated nutrient management in tea cultivation is being increasingly practiced to sustain the soil fertility and crop productivity and promote biological diversity. Chemical fertilizers initially boost up the tea yield, but gradually cause decrease in fertilizer-use efficiency, indicating that the application of organic fertilizers stimulates the activity of soil micro-organisms, improves soil structure/texture and increases the availability of plant nutrients (Singh, 2011) [17]. Also, use of fertilizers cannot be promoted in the biodiversity rich and environmentally sensitive mountain ecosystem. Therefore, attempts are required for using organic fertilizers and locally made FYM that could be adopted by the peasants without compromising the yield of tea significantly.

Considering the above we conducted research in the experimental plantations of UPASI-9 variety of tea (*Camellia sinensis L.*) established by us under three fertilizer treatments viz., NPK, bio-fertilizer and farm yard manure (FYM) as per the recommended doses for nutrient poor soil in the mid-hills of Uttarakhand (Distt. Almora) (Negi and Bisht, 2018) [18] (Plate 1). UPASI-9 variety has been recommended for warm valleys of Uttarakhand due to its drought tolerance, frost resistance, high yield and ability to withstand slightly high pH (Tamang, 2008) [8]. Plant mortality was replaced soon after mortality in the experimental plots from the stock of the plants (UPASI-9 var.) maintained nearby to the experimental plots. Tea crop yield in the experimental plantation in the following three years (April-October) was determined by counting number of leaf units (two leaves and a bud) and taking weight (fresh/dry) of the leaf crop after each plucking cycle. A comparative account of plant growth and tea yield under various fertilizer treatments shows that the FYM treated plots were significantly better in number of leaf production and tea yield as compared to fertilizer treated plots (640 vs 444 kg/ha green leaves) (Table 1). The plants treated with bio-fertilizer also compared well with the FYM treated plants with regards to tea yield and soil fertility. However, the tea yield we found here was about three-fold lower recorded in Darjeeling hills, India (Singh *et al.*, 2011) [17]. In the Uttarakhand tea growing areas situated at higher latitudes of 29º to 31º N compared 27º N lat. of Darjeeling, the leaf flushing commences late and ceases earlier, i.e., from end-March to early-November compared to mid-February to early-December in Darjeeling (eastern part of Himalaya). This reduces the crop yield due to reduced length of total cropping period (Tamang, 2008) [8].

Fig 1

Conclusion

Results from this experimental plantation proved that the poor hill farmers can cultivate tea profitably using FYM prepared by them in cattle-sheds. Cattle manure (FYM) contains high available K^+ and supplies to soil-plant system after mineralization and has the acid humus that helps in absorption of K^+ (Barbora, 1991) [19]. Therefore, FYM could be used in tea gardens than the use of scarce, costly and environmentally hazardous inorganic fertilizers. Organic tea farming apart from improving the tea quality, promote and enhances soil biological activity, nutrient cycling and biodiversity that restore and maintain ecological integrity while safeguarding the environmental concerns. It can be also suggested that planting of insect-pest repellent trees (*viz.*, *Melia azedarach*, *Adathoda vesica*, lemon grass and guatemala

grass, and shade trees those provide fuelwood, edibles, nectar for pollinators, *etc*. would enhance the overall returns from tea gardens. The use of growth promoting and soil mineral solubilizing microbial biofertilizers, arbuscular mycorrhizal fungi (Singh *et al.*, 2010) [20], and vermiculture would maintain the soil fertility. Certification of organic tea and training of the growers by tea experts will also needs to be taken up to promote sustainable tea cultivation in this region (Tolia, 2005) [21].

Table 1: A comparative account of various soil fertility, plant growth and yield parameters of tea planted under three fertilizer treatments (annual mean across two years of study).

Plant growth and soil fertility parameters	NPK	Bio-fertilizer	Farm-yard manure
Plant growth parameters			
Survival (%)	5.5±1.57	0.67±0.2	3.0±0.6
Leaf number / bush	192	241	254
Leaf fresh weight / bush	50	66	72
Leaf dry weight/bush	13	18	20
Yield (kg)/ha	444	590	640
Soil fertility parameters			
pH	5.25±0.05	5.28±0.09	5.41±0.05
Moisture (%)	18.5±2.9	15.6±1.9	18.8±3.1
Water holding capacity (%)	55.4±2.7	57.5±2.7	55.1±4.6
Total Nitrogen (%)	0.18±0.02	0.20±0.02	0.17±0.03
Total Phosphorus (%)	0.084±0.011	0.097±0.023	0.100±0.024
Organic carbon (%)	0.68±0.03	0.72±0.03	0.61±0.03

Acknowledgements
Authors are thankful to the Director, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora for providing necessary facilities and grants to carry out this study.

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