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Enhancement of Green Leaf Yield in Tea [*Camelia sinensis* (L.) O Kuntze] as a Function of Pigments by Foliar Application of Triacontanol

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Abstract

Tricontanol is a natural plant growth regulator that possesses growth promoting activity and it is also able to increase leaf pigment and thereby improving yield of various crops. Plant pigments particularly leaf chlorophyll contents have widely been appraised as the most significant indicator of photosynthesis. Tea is one of the most important leverage in the world but its productivity needs to be increased to meet up the ever increasing demand of tea in coming years. Thus in the present experiment the effect of foliar application of triacontanol on green leaf yield as a function of chlorophyll and carotenoids contents of field grown mature tea was evaluated. Total six numbers of triacontanol (0.1% EW) treatments @ 0.3, 0.4, 0.5, 0.6, 0.8 and 1.0 ml l^{-1} of water, besides two control treatments, *viz*. untreated control and water spray were used. Total chlorophyll content in the various leaves viz. bud, 1st, 2nd and matured leaves were estimated during each plucking which was continued up to fourth round. It was observed that triacontanol exerted a markedly positive effect on leaf pigment contents and green leaf production of tea. The results further indicated that the total chlorophyll contents of matured leaves were positively associated with green leaf yield at fourth round of plucking. The application of triacontanol *i.e.* @ 0.5 ml l^{-1} at three weeks interval may be recommended for tea since this treatment was found to produce more green leaves as compared to others irrespective of plucking rounds.

Keywords: Triacontanol, boosts, tea leaf, yield

1. Introduction

Triacontanol (l-hydroxytriacontane), a saturated lipid alcohol with 30 carbon atoms ($C_{30}H_{61}OH$)of plant origin possesses growth regulator and yield promoting properties. It had long been recognized as plant growth regulator by Ries et al. (1977) and naturally found in the plant cuticle waxes, in bee wax and tea wastes. It has been found as a potent plant growth promoting substance that improves the plant growth as well as productivity of various crops through effectively improving the rate of cell division resulting in increase in length of stem and root as well as several physiological processes like photosynthesis, CO_2 accumulation, nutrient absorption etc. (Misra and Srivastava, 1991; Shahbaz et al., 2013). It was also reported to be plant growth regulator without any residual toxicity effect (Samui and Roy, 2007).

Tea [*Camellia sinensis* (L.) O Kuntze] is the most widely consumed

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beverage after water in the world. It is economically most important among the plantation crops, under large scale cultivation in several South-East Asian and Eastern- and Southern Africa countries (De Costa et al., 2007). Tea is manufactured by using the tender apical shoots consisting of a bud and 2-3 leaves plucked periodically from the perennial shrubs of cultivated tea species. Among the beverages, tea consumption is increasing at a faster rate in recent years due to its non-alcoholic nature and the possible benefits on human health. However, global tea productivity has remained stagnant during last few decades. Thus it calls for development of new technologies towards increasing yields and productivity in order to manage the present challenges of low productivity of existing old plantation, decreasing cost-benefit ratio, and by and large to meet up the increasing global demand for tea in coming years.

Several studies showed that application of triacontanol either to the root medium or to foliages had significantly enhanced yield of field crops, horticultural crops, and medicinal and aromatic plants (Kapitsimadi and Vioryl, 1995; Bhattacharya and Rao, 1996; Borowski et al., 2000; Khan et al., 2007). Earlier studies have also shown an increase in chlorophyll and carotenoids contents in crop leaves by application of triacontanol (Khan et al., 2009). Appraising plant pigments particularly chlorophyll content in leaves is significant as an indicator of photosynthetic activity (Larcher, 1995; Muthuchelian et al., 1997) and ultimately plant productivity. Besides, presence of carotenoids in the tea leaves is considered to influence the quality of tea (Venkatakrishna et al., 1977).

Many researchers have reported the influence of various plant growth regulators on different traits like breaking of bud dormancy, chlorophyll contents and quality of tea (Nandi et al., 1995; Chandra and Pandey, 1998; Pandey and Chandra, 2001; Pandey, 2009). But little information are available regarding the effect of triacontanol on productivity as a function of leaf pigment contents of this important plantation crop till date.

Thus the present study was aimed to assess whether the foliar application of triacontanol could enhance green leaf yield of tea bushes as a function of chlorophyll and carotenoids contents. The generated information would be handy tool for increasing productivity of the tea plantation industry.

2. Materials and Methods

2.1. Experimental plot and treatments

The experiment was conducted in the Cooch Behar Tea Estate, Falakata present in the Terai Zone of West Bengal. Average 30 years aged tea bushes planted with Tocklai released clonal selection, TV-9 at a spacing of 4.5'2.5' in single hedge pattern were used for the present study. The section was kept unpruned during preceded winter season during time 2015 to 2016. The experiment was laid out in randomized block design with three replications for each treatment. Single spraying of total six numbers of triacontanol(0.1% EW) treatments including T_1: 0.3, T_2: 0.4, T_3: 0.5, T_4: 0.6, T_5: 0.8, T_6: 1.0 (ml $^{-1}$ of water), besides two control treatments, *viz*. T_7: untreated control, T_8: water spray, was doneat afternoon period following the plucking of leaves on that particular day.

2.2. Chlorophyll and carotenoids estimation

Freshly harvested tea shoots were brought to the laboratory and separated into bud, 1st leaf, 2nd leaf, and matured leaf which immediately preceded the *janam*.Total chlorophylls and carotenoids contents in the leaves were extracted by 80% (v/v) acetone following percolation method of Hiscox and Israelstam (1978) and determined spectrophotometrically at 663, 645 and 470 nm to determine total chlorophyll and carotenoids content, respectively using a UV-VIS spectrophotometer (Shimadzu UV-1800). The amount of plant pigments were calculated according to the Lichtenthaler and Wellburn (1983) formulae.

2.3. Observation on green leaf yield and dry weight

Tender tea leaves preferably containing a bud and two leaves, were harvested for a total of four rounds at seven days interval after spraying. The weight of plucked leaves of ten pre-tagged bushes was recorded for each treatment separately for each round of plucking. Fresh harvested ten shoot tips for each treatment were taken to the laboratory and dried in hot air oven at 60±1 °C temperature for 72 hours. Average green leaf yield and average dry weight were computed and expressed as gram bush^{-1} and gram shoot tip^{-1}, respectively.

Statistical analysis was done following the methods of Panse and Sukhatme (1989) and analysis of variance was carried out by using SPSS Statistics 17.0 at p<0.05 level of significance.

3. Results and Discussion

As can be seen from the graphs presented in Figure (1A-1D), the application of triacontanol exerted positive effect on both total chlorophyll and carotenoids contents of leaves at different position in all the plucking rounds. In most of the

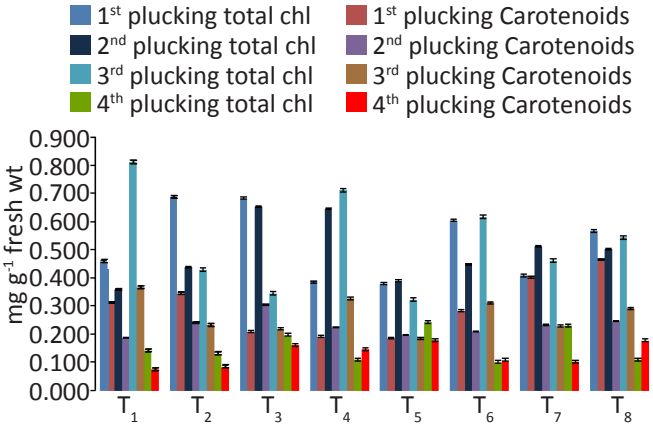

Figure 1A: Total chlorophyll and carotenoids content in buds at different plucking dates after spraying, Error bars (±) show SE

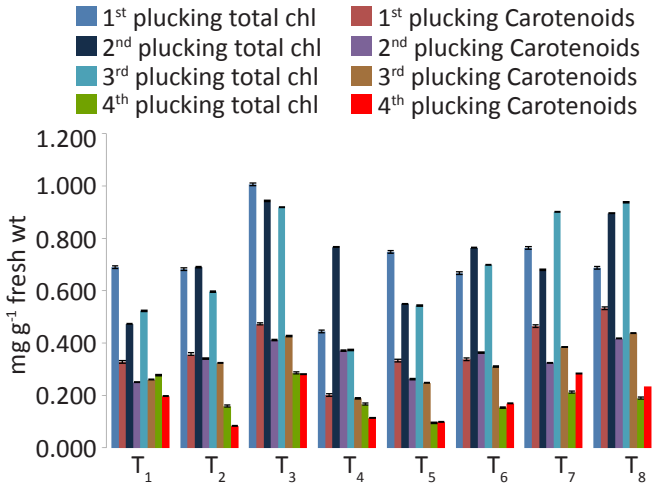

Figure 1B: Total chlorophyll and carotenoids content in 1st leaves at different plucking dates after spraying, Error bars (±) show SE

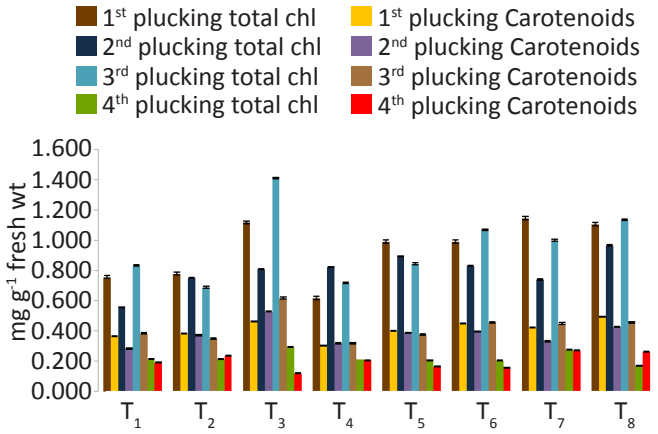

Figure 1C: Total chlorophyll and carotenoids content in 2nd leaves at different plucking dates after spraying, Error bars (±) show SE

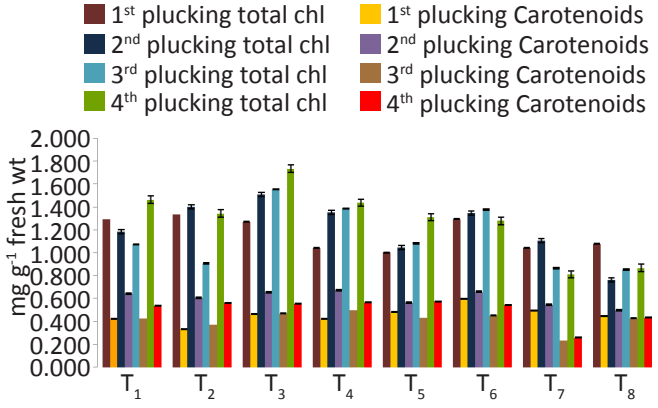

Figure 1D: Total chlorophyll and carotenoids content in matured green leaves at different plucking dates after spraying, Error bars (±) show SE

cases, the highest values of both pigments were recorded at treatment i.e. T_3 irrespective of plucking rounds. However, pigment contents followed a general trend of increasing upto third plucking round and declined thereafter in all treatments including control.

A significant positive effect of triacontanol on pigment contents of various crops were reported by many (Srivastava and Sharma, 1991; Chen et al., 2002; Naeem et al., 2011). Krishnapillai and Ediriweera (1986) reported that the greater content of chlorophyll in leaf tissues could greatly influence photosynthesis and thereby improve yield of tea.

Green leaf yield per bush was found to increase under most of the traicontanol treatments as compared to untreated control (Figure 2). However, most prominent enhancement of green leaf production was recorded during third plucking round after spraying. Highest green leaf yield per bush was found in T_3 treatment. Application of triacontanolhas been reported to enhance many physiological parameters like

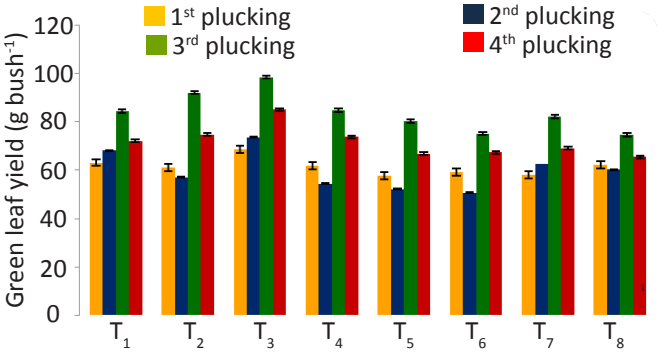

Figure 2: Total green leaf yield per plant at different plucking dates after spraying, Error bars (±) show SE

chlorophyll contents and photosynthetic rate (Misra and srivastava, 1991. Perveenet al., 2010; Krishnan and Kumari, 2008). Chlorophyll, undoubtedly being the most important of plant pigments determines the photosynthetic efficiency and productivity of the plant. Increase in plant growth might be due to triacontanol induced stimulation in photosynthetic rate as triacontanol has been found to be involved in the up-regulation of manygenes involved in the photosynthetic process (Chen et al., 2002, 2003).

Dry weight per shoot tip did not follow any general trend among the plucking rounds (Figure 3). But a marked increase

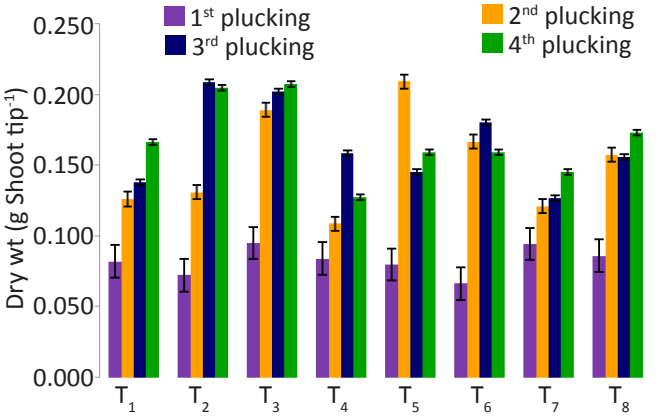

Figure 3: Dry weight per shoot tip at different plucking dates after spraying, Error bars (±) show SE

in shoot tip dry weight during later plucking rounds in some of the triacontanol treatments had been observed. Significant increase in dry weight of tea shoot primaries due to plant growth regulators had been reported by Nandi et al. (1995), and Chandra and Pandey (1998).

From the correlation studies it revealed that leaf pigment contents of buds and newer leaves had little association with green leaf production (Table 1). But pigments in particular total chlorophyll contents of matured leaves showed a greater positive association with green leaf yield especially during third and fourth rounds of plucking after foliar application of triacontal. However negligible association between green yield and shoot tip dry weight implied that higher green leaf production might be due to increase in number of plucking points per bush rather than more dry matter accumulation in individual shoot tips and this might be very useful as an increased numbers of plucking points per bush would be most desirable traits to produce quality tea without compromising with its quantity. Though pigment contents of buds and younger leaves showed less association with green leaf production but higher pigments in these leaves under triacontanol treatments would be implicated as quality traits because 'blackness' of tea depends on the content of chlorophyll and its transformation products Wickremasinghe and Perera (1966). Venkatakrishna et al. (1977) were also reported that carotenoids present in the tea leaves would influence the quality of tea.

Table 1: Simple correlation analysis between green yield and dry weight with plant pigments at different plucking dates after spraying

Parameters		Green leaf yield	Bud & 1st leaf		2nd leaf		3rd leaf		Matured leaf	
			Chl	Car	Chl	Car	Chl	Car	Chl	Car
1st plucking	Dry wt	0.441	-0.174	0.099	0.460	0.491	0.397	0.148	-0.387	-0.184
	Green leaf yield	1	0.539	-0.166	0.462	0.240	-0.001	0.166	0.455	-0.296
2nd plucking	Dry wt	-0.032	-0.113	0.188	0.162	0.027	0.501	0.703	-0.074	-0.146
	Green leaf yield	1	0.27 0	0.552	0.189	0.124	-0.438	0.300	0.158	0.055
3rd plucking	Dry wt	0.577	-0.333	-0.214	0.078	0.230	0.214	0.302	0.421	0.382
	Green leaf yield	1	-0.331	-0.325	-0.002	0.116	0.136	0.307	0.367	0.072
4th plucking	Dry wt	0.550	0.027	-0.059	0.338	0.114	0.218	-0.258	0.375	0.291
	Green leaf yield	1	0.116	-0.050	0.618	0.224	0.691	-0.490	0.754*	0.315

4. Conclusion

Triacontanol exerted an upbeat effect on leaf pigment contents and green leaf production of tea. Foliar application of Triacontanol (0.1% EW) @ 0.3 ml per litre of water would be recommended for tea, since T_3 has been found to produce more green leaves in most of the plucking rounds.

5. Acknowledgement

We convey our thanks to the garden management of Cooch Behar Tea Estate for their consent to conduct the field work.

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