Research Article

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# Influence of biochemicals on regulation of bud break, green leaf yield and crop distribution in tea

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## Abstract

Tea (*Camellia* sp.) undergoes winter dormancy for a period of 3 to 4 months in north east India. An attempt was made to hasten the bud break and regulate crop distribution by exogenous application of certain biochemicals *viz*. Jibika (a commercial mixture of $GA_3$+$GA_4$+$GA_7$), indole-3-acetic acid, cycocel, thiourea, methanol, succinic acid and sucrose besides deionised water as control. It was observed that the bud break was hastened by 11 days and the bushes reached 50% bud break stage by 9.3 days earlier due to Jibika treatment as compared to control. The number of primary shoots (158.0) and dry weight of tipped-in primaries (22.1 g/bush) were the highest in Jibika treated bushes while shoot (25.3 cm) and internodal (4.3 cm) length was maximum in thiourea treated bushes. The mean monthly green leaf yield showed a significant variation due to treatments and the total annual green leaf yield was higher (816.8 g/bush) due to sucrose application. Significant increase was recorded in terms of crop distribution by sucrose treatment during early (12.4 %) and mid (18.6 %) season while cycocel treatment produced 27.3 % increase in green leaf during end season with respect to control. Early season crop is important from quality point of view and it was effectively enhanced by sucrose. It seems that besides phytohormones, other chemicals can also regulate growth and green leaf yield and thus, could have a great potential in the tea industry.

*Keywords:* Biochemicals, bud break, *Camellia sinensis*, crop distribution, green leaf yield

## Introduction

Tea is a widely consumed non-alcoholic beverage in the world and is made from tender apical vegetative shoots of the perennial shrubs of cultivated *Camellia* species. Tea growing area is spread all over the continents except North America within the latitudinal and longitudinal range of 45°N to 35°S and 150°E to 60° W, respectively. However, tea cultivated near the equator produces almost the same yield every month, but farther from the equator, winter harvest gradually declines and tea plants experience winter dormancy (Barua, 1969). In North East India, in general, and Assam in particular, tea bush undergoes 3 to 4 months of winter dormancy between December and March (Barua, 1989).

Earlier reports revealed that environmental factors, particularly temperature and photoperiod, are known to influence winter dormancy (Barua, 1969; Matthews and Stephens, 1998). Tea bushes undergo dormancy when the night temperature falls below 12°C for a period of about 3 to 4 months and the day length drops below 11 h (Das and Barua, 1988). The interactions between climatic variables result in hormonal imbalances which impose dormancy (Wareing and Phillips, 1970). Various studies have been conducted to ascertain the role of endogenous levels of growth regulators in relation to dormancy in tea (Kakkar and Nagar, 1997; Nagar and Kumar, 2000; Nagar and Sood, 2006). However, exogenous application of growth regulators and some other chemicals have been shown to break bud dormancy in tea bushes (Kulasegaram and Kathiravetpillai, 1974; Sarkar *et al*., 1986; Nandi *et al.*, 1995).

Attempts have been made in the past to regulate winter dormancy by using plant growth regulators (PGRs) like NAA, ABA, $GA_3$ and BAP (Manivel *et al.*, 1988;

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Nandi *et al.*, 1995) and crop distribution (Manivel, 1986) in tea. Besides PGRs, other compound such as Dormex (hydrogen cynamide) was evaluated in Taiwan and Sri Lanka (Chen *et al.*, 1993; Kathiravetpillai *et al.*, 1997) and its efficacy was reported on increasing yield and early bud break and harvest than the control. Trials were also conducted in southern India with Dormex by spraying on pruned frames of tea bushes on the same day of pruning which effectively hastened and improved bud break resulting in early recovery, tipping and increased crop without affecting the health and productivity of the bushes (Anon., 1993).

In the present experiment, an attempt was made to study the effect of some biochemicals along with a few PGRs to remove winter dormancy hastening bud break, crop distribution and green leaf yield in pruned tea in North East India.

## Materials and Methods

### Experimental plot and treatments

The experiment was conducted in the Experimental Garden for Plantation Crops, Assam Agricultural University, Jorhat, India. Eleven year old tea bushes of a Tocklai released clone, TV18 (Cambod type), grown under moderate stand of shade were used for the study. Tea bushes were planted at a spacing of 105 x 75 x 60 cm in a staggered double hedge pattern and each plot measured 2.47 $m^2$ with four bushes. Bushes were light pruned at 55 cm above the ground level in mid January. There were eight treatments and replicated four times in Randomized Block Design. Treatments included were Jibika (a commercial mixture of $GA_3$+$GA_4$+$GA_7$ supplied by Thea Chem Pvt Ltd., Kolkata, India) 5.0 ml $l^{-1}$, indole-3-acetic acid (IAA) 0.2 g $l^{-1}$, cycocel 0.5 ml $l^{-1}$, thiourea (TU) 15 g $l^{-1}$, methanol 300 ml $l^{-1}$, succinic acid (SA) 0.1 g $l^{-1}$ and sucrose 20.0 g $l^{-1}$ besides deionized water sprayed as control. In all the cases, 'Teepol' was included at 100 µl $l^{-1}$ as surfactant. Spraying was done three times at four months interval. First spray was done on the pruned sticks and after cleaning the bushes during mid January. Second spray was done in mid May followed by a third one in mid September. Each experimental plot was isolated by providing guard rows to reduce the drift of chemicals to other plots at the time of spraying.

### Observations on growth and green leaf yield

Number of days required for bud break was counted from the day of pruning and the 50 % bud break was counted from the day of pruning when about 50 % of the lateral buds unfolded the leaf appendage. Average monthly green leaf yield was recorded and crop distribution throughout the cropping season was computed.

Total number of primary shoots which grew out from the pruned sticks were counted and expressed as number of primary shoots per bush. Tipping of the primaries was done at a height of 20 cm above the pruning level. A total of four rounds of tipping beginning early March (where bud break appeared early) were carried out in the experimental plots. The weight of tipped shoot and the number of primaries tipped in each round were recorded for individual plots. Cumulative data on tipping, dry weight of tipped material and number of primaries tipped per bush were computed. The fresh weight of young shoots harvested, preferably two leaves and a bud was recorded at weekly intervals from each plot. Cumulative green leaf yield was calculated month-wise and season-wise and expressed as g fresh weight per bush. Crop harvested during the whole growing period was divided into three main seasons *viz.* early (April, May and June), mid (July, August and September) and end (October and November).The shoot and internodal lengths of individual primaries were measured by sampling ten shoots per bush. The data were subjected to one-way analysis of variance (ANOVA) (Gomez and Gomez, 1984).

## Results and Discussion

### Regulation of bud break and growth by biochemicals

All the applied biochemicals had significant effect on hastening bud break in pruned tea bushes as compared to control (Table 1). Jibika promoted early bud break by 10.7 days (d) while TU, SA and sucrose resulted in 9.6 , 9.3 and 9.2 d, respectively, as compared to that of control. Number of days required for 50 % bud break was markedly reduced in all the treatments, except IAA, over control (Table 1). Jibika treated bushes attained 9.3 d earlier in terms of the 50 % bud break stage followed by cycocel and sucrose. Application of IAA prolonged the bud break by 3.9 d when compared to that of control.

A chemical compound ascribed as growth regulator should have potential to break winter dormancy in tea, and it should reduce the number of days required for unfolding the leaf appendages without affecting the quantity or quality. As mentioned earlier, winter dormancy is imposed by climatic conditions (Omae and Takeda, 2003), which in turn, affects the endogenous hormonal balance. During winter, endogenous level of abscisic acid is higher than that of GA and tilted promoter: inhibitor ratio towards inhibitor side. Exogenous

**Table 1. Effect of biochemicals on early bud break and growth related parameters**

| Treatments | Concentration of biochemicals (per litre) | Days to initial bud break | Days to 50% bud break | No. of primary shoots/ bush | Primaries tipped (number/ bush) | Dry wt. of tipped primaries (g/bush) | Shoot length (cm) | Internodal length (cm) |
|---|---|---|---|---|---|---|---|---|
| Control | -- | 47.6 | 59.3 | 132.3 | 50.0 | 19.4 | 20.7 | 3.8 |
| Jibika | 0.5 ml | 36.8 | 50.0 | 158.0 | 52.3 | 22.1 | 23.9 | 4.3 |
| IAA | 0.2 g | 44.7 | 63.2 | 135.7 | 49.0 | 20.1 | 18.2 | 3.4 |
| Cycocel | 0.5 ml | 43.8 | 51.5 | 156.0 | 49.7 | 20.3 | 21.2 | 3.9 |
| Thiourea | 15.0 g | 38.0 | 52.8 | 142.0 | 53.3 | 21.1 | 25.3 | 4.3 |
| Methanol | 300 ml | 44.0 | 53.0 | 142.3 | 49.0 | 19.9 | 23.1 | 4.2 |
| Succinic acid | 0.1 g | 38.3 | 56.0 | 130.0 | 43.3 | 16.9 | 20.8 | 3.6 |
| Sucrose | 20.0 g | 38.3 | 51.8 | 135.7 | 49.3 | 20.2 | 21.9 | 3.9 |
| Mean | | 41.4 | 54.7 | 141.5 | 49.5 | 20.0 | 21.9 | 3.9 |
| S.E.(d) | | ±0.76 | ±1.07 | ±3.52 | NS | ±0.49 | ±0.48 | ±0.07 |
| CD (P=0.05%) | | 2.41 | 3.37 | 11.08 | NS | 1.55 | 1.51 | 0.23 |
| CV (%) | | 3.19 | 3.39 | 4.30 | 10.91 | 4.26 | 3.79 | 3.16 |

NS = Not Significant

application of growth regulating substances restores hormonal balance and promoters early bud break. In this study, Jibika was found effective in promoting bud break which substantiated the earlier report (Rahman, 1971). It has been reported that TU effectively breaks winter dormancy in mango (Tongumpai *et al.*, 1997). The well known effect of TU on releasing bud dormancy in grapevine was reported due to reduced catalase activity resulting in a transient disruption of respiratory metabolism induced by hydrogen peroxide (Nir *et al.* 1986; Arora *et al.*, 2003). Reduction in number of days to attain 50 % bud break in treated bushes was due to the early bud break which might be because of stimulation of internal hormones that resulted in faster growth. However, further investigation is necessary to ascertain the role of these substances in breaking the dormancy.

Maximum number of primary shoots (158.0) was produced in bushes treated with Jibika followed by cycocel (156.0). However, all other biochemicals applied did not enhance the number of primary shoots significantly (Table 1). Number of primaries tipped per bush did not show significant difference in response to applied chemical substances. Increase in the total number of primary shoots with Jibika might be due to the early bud break as reported earlier by Sarkar *et al.* (1989). In general, GA hastened the shoot growth by unfolding of leaf primordia that are already present in the dormant bud (Pandey and Chandra, 2001). Bushes treated with cycocel, a growth retardant, also produced significantly higher number of primaries per bush. This is in confirmation with the findings of Barbora *et al.* (1989). It is well established that cycocel affect the transport of auxin and gibberellin and thereby retarding apical growth and inducing more number of laterals.

The dry weight of tipped primaries per bush (Table 1) was significantly higher in Jibika (13.8 %) treated bushes when compared to control. This may be because the dry weight of individual primary shoot was higher due to Jibika treatment as reported earlier (Pandey and Chandra, 2001). Nandi *et al.* (1995) found a significant increase in fresh and dry weight of shoot due to $GA_3$ application in tea.

Significant increase in the length of primary shoot was obtained with TU application (22.4 %) followed by Jibika (15.8 %) and methanol (11.8 %) while increase in internodal length was higher with Jibika (13.6 %) followed by TU (12.0 %) and methanol (9.2 %) (Table 1). Similar results were obtained with GA in other tree species besides tea (Sarkar *et al.*, 1989; Nandi *et al.*, 1995; Pandey and Chandra, 2001). Since GA is known for causing cell elongation and utilization of food materials, increased internodal and shoot length in comparison to control are explainable.

## Crop distribution

Sucrose treatment resulted in significant increase in green leaf yield during early (12.4 %) and mid (18.6 %) seasons while cycocel treatment produced 27.3 % increase in green leaf during end season with respect to control (Table 2). Besides cycocel, sucrose (13.2 %) and Jibika (12.6 %) also recorded significant increase in crop during end season compared to control. Cycocel treatment resulted in significant suppression (6.7 %) of crop during mid season over control. However, succinic

**Table 2. Crop distribution in tea throughout the growing season as influenced by application of biochemicals**

| | | Crop distribution (g/bush) | | | | | |
|---|---|---|---|---|---|---|---|
| **Treatments** | **Concentration of biochemicals (per litre)** | **Early season** | **% change over control** | **Mid season** | **% change over control** | **End season** | **% change over control** |
| Control | -- | 265.1 | - | 314.9 | - | 128.6 | - |
| Jibika | 0.5 ml | 281.7 | 6.3 | 356.9 | 13.3 | 144.8 | 12.6 |
| IAA | 0.2 g | 247.6 | 6.6 | 323.4 | 2.7 | 140.2 | 9.0 |
| Cycocel | 0.5 ml | 269.1 | 1.5 | 293.8 | -6.7 | 163.7 | 27.3 |
| Thiourea | 15.0 g | 275.3 | 3.8 | 341.8 | 8.5 | 134.2 | 4.3 |
| Methanol | 300 ml | 272.4 | 2.8 | 362.7 | 15.2 | 133.2 | 3.6 |
| Succinic acid | 0.1 g | 229.2 | -13.5 | 274.2 | -12.9 | 124.8 | -2.9 |
| Sucrose | 20.0 g | 298.0 | 12.4 | 373.6 | 18.6 | 145.6 | 13.2 |
| Mean | | 267.3 | | 330.2 | | 139.4 | |
| S.E.(d) | | ±5.75 | | ±6.90 | | ±2.38 | |
| CD (P=0.05%) | | 18.13 | | 21.75 | | 7.51 | |
| CV (%) | | 3.73 | | 3.62 | | 2.96 | |

acid treatment resulted in reduction in crop yield throughout the cropping season over control. Irrespective of the treatments, per cent distribution of green leaf yield recorded during early, mid and end seasons were 36.3, 44.8 and 18.9, respectively, with a mean value of 267.3, 330.2 and 139.4 g/bush.

Winter dormancy is usually followed by a very heavy cropping summer. This necessitates adequate provision of labour and machinery to gather and manufacture the crop on peak summer days which needs over-capitalization. But during the end season, the tea-processing unit is under-utilized. Therefore, regulating the crop throughout the cropping season is an important aspect in tea industry. In this study, the desired crop distribution throughout the season was obtained with cycocel treatment which resulted in significantly higher amount of end season crop. It has been reported that GA increased early crop while the growth retardants like cycocel, alar-85 (SADH) and ethepon (CEPA), suppress early crop and produce more crop during the later part of the year, thus, compensating the early suppression (Anon., 1977).

The early crop is considered to be important in the market from quality point of view which was effectively enhanced by sucrose. But application of cycocel was found effective in crop regulation without reducing the total output. Results obtained at Tea Research Association, Tocklai, India also confirms the present finding (Anon., 1985). Single spray of chlormequat during peak growing season suppressed the growth for 2-3 weeks followed by vigorous growth following a couple of weeks. It has been reported that there was no crop loss and these biochemical had no adverse effect on quality aspects (Chandra and Pandey, 1998).

## Green leaf yield

Higher quantum of green leaf was harvested due to sucrose treatment in the months of June, August and September (Table 3). Total annual green leaf yield recorded by sucrose treatment (816.8 g/bush) was significantly higher followed by Jibika (783.4 g/bush) and methanol (768.3 g/bush) as compared to control (708.6 g/bush). The yield potential depends upon the amount of green leaf plucked per unit area for a specific period. It has been reported that green leaf yield in tea is directly correlated with the level of nitrate reductase (NR) activity and the induction of NR activity depends not only on nitrate influx but also on sugars, which provide energy for protein synthesizing systems (Wickremasinghe *et al*., 1980; Aslam and Huffaker, 1984). Sucrose application increased NR activity in tea upto 321.3 and 105.9 µmol $NO_2^-$ reduced/g fresh weight/h during April-May and August-September, respectively (Pandey, unpublished). This could be a possible reason for increased crop yield due to sucrose as compared to rest of the chemicals.

Jibika treated bushes accumulated higher amount of dry matter in the shoots resulting in maximum dry weight of individual primary shoots which lead to increased green leaf yield (Pandey and Chandra, 2001). Production of markedly higher amount of green leaf due to methanol as compared to control might be because methanol application increased specific leaf area, which is a measure of leaf thickness, total leaf area and chlorophyll content in tea (Pandey and Chandra, 2001; Pandey, 2002). It has been reported that foliar application

**Table 3. Monthly green leaf yield as affected by application of biochemicals**

| Treatments | Concentration of biochemicals (per litre) | Monthly green leaf yield (g/bush) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | August | September | October | November | Total annual yield |
| Control | -- | 77.6 | 81.2 | 106.3 | 124.8 | 109.7 | 80.4 | 74.1 | 54.5 | 708.6 |
| Jibika | 0.5 ml | 98.1 | 78.8 | 104.8 | 141.9 | 113.3 | 101.7 | 82.3 | 62.5 | 783.4 |
| IAA | 0.2 g | 75.4 | 77.9 | 94.3 | 152.5 | 98.8 | 72.1 | 80.1 | 60.1 | 711.2 |
| Cycocel | 0.5 ml | 73.8 | 89.5 | 105.8 | 123.6 | 92.2 | 78.0 | 91.8 | 71.9 | 726.6 |
| Thiourea | 15.0 g | 93.5 | 74.8 | 107.0 | 145.1 | 101.7 | 95.0 | 77.1 | 57.1 | 751.3 |
| Methanol | 300 ml | 80.1 | 71.2 | 121.1 | 144.9 | 113.8 | 104.0 | 76.6 | 56.6 | 768.3 |
| Succinic acid | 0.1 g | 70.4 | 69.0 | 89.8 | 111.9 | 91.0 | 71.3 | 72.4 | 52.4 | 628.2 |
| Sucrose | 20.0 g | 85.6 | 79.3 | 133.1 | 139.6 | 121.7 | 112.5 | 82.8 | 62.2 | 816.8 |
| Mean | | 81.8 | 77.7 | 107.8 | 135.5 | 105.3 | 89.4 | 79.7 | 59.7 | 736.9 |
| S.E.(d) | | ±1.15 | ±0.52 | ±1.21 | ±0.93 | ±0.72 | ±0.73 | ±0.16 | ±0.36 | ±0.50 |
| CD (P=0.05%) | | 2.47 | 1.12 | 2.60 | 1.99 | 1.54 | 1.56 | 0.32 | 0.77 | 1.07 |
| CV (%) | | 12.10 | 0.89 | 12.48 | 9.62 | 10.00 | 16.77 | 7.21 | 9.65 | 8.16 |

of 30 % methanol on cotton resulted in increased turgidity, larger leaves and taller plants than controls after two weeks (Nonomura and Benson, 1992). They showed that the ratio of sucrose to glycolate is greatly increased by prior exposure to methanol, suggesting that long-term stimulation of growth may be related to inhibition of photorespiration. Further, they suggested that $C_3$ plants respond to high concentrations of methanol in two or more stages, first utilizing photorespiratory and other available metabolic pathways for detoxification and, thereafter, activating a mechanism that improves carbon fixation.

## Conclusion

This study has demonstrated that besides plant growth regulators, biochemicals could be used effectively to enhance early bud break in pruned tea bushes and/or reducing the winter dormancy and thereby achieve a higher level of productivity without affecting the quality. Certain chemicals like cycocel when used judiciously can be applied to regulate rush season crop in North East India effectively.

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