Research Article *Journal of Plantation Crops, 2013, 41(2): 196-201*

Impact of continuous mechanical harvesting on leaf leatheriness and possible alleviation measures

Jibu Thomas*, R. Raj Kumar[1], A.K.A. Mandal[2] and N. Muraleedharan[3]

School of Biotechnology and Health Sciences, Karunya University, Karunya Nagar, Coimbatore – 641114

[1]UPASI Tea Research Foundation, Tea Research Institute, Valparai- 642 127, Coimbatore

[2] Vellore Institute of Technology University, Vellore - 632 014

[3] Tea Research Association, Tocklai Experimantal Station, Jorhat-785008

(Manuscript Received: 01-02-13, Revised: 30-04-13, Accepted: 02-05-13)

Abstract

Mechanization in plucking has become imperative to improve the profitability and efficiency in tea industry. Continuous shear harvesting of tea shoots creates a stress on plant thereby changing the texture of the crop shoots termed as "leaf leatheriness". Objective of the study was to generate data on the formation of leaf leatheriness due to continuous shear harvesting and to propose the remedial measures. A factorial block design experiment was conducted with a 'Chinery' clone UPASI-9. Results indicated that continuous shear harvesting for a period of six months resulted in the accumulation of total wax content when compared to the hand plucked crop shoots which contributed to the leatheriness of crop shoots. Significant increase in the banji content in the harvest was also noticed due to continuous shear harvesting. Foliar applied chemicals influenced the reduction in banji shoots in the shear harvested treatments. Among the foliar applied treatments, reduction in the total wax content in the continuously shear harvested plots was obtained by the foliar application of KNO_3 (2%) + Urea (1%) followed by KNO_3 (2%) and $Ca(NO_3)_2$ (2%) when compared with control. Study concluded that foliar application of KNO_3 (2%) alone or in combination with Urea (1%) is beneficial in alleviating the leaf leatheriness caused due to continuous shear harvesting without deterioration of quality characteristics with a prophylactic effect to improve the yield of tea plants.

Keywords: Banji content, *Camellia sinensis*, KNO_3, leaf leatheriness, mechanization

Introduction

Tea, *Camellia sinensis* is a foliage crop. Efforts are concentrated to improve the productivity in tea plantations both in terms of available resources. Improvement in productivity and cost control are the two major factors contributing to the profit in any sector (Obanda and Owuor, 1995). Labour is scarce as well as expensive in tea plantations. In order to improve the land and labour efficiency, mechanization in field operations has become vital (Sharma *et al*., 1981, Ilango *et al*., 2001). Regular harvest of the economical crop as three leaves and a bud was practiced as hand plucking earlier. Harvesting of tea shoots accounts to about 70 per cent of labour deployment. Due to the periodical improvement in the productivity, shears have been implemented on integrated schedule to completely harvest the crop shoots. Even though the current recommendation is an integrated use of shears during the high cropping season in south Indian tea growing regions, unavailability of labours to meet the productivity has led to intermittent use of shears as and when desired (UPASI,1996). The implementation of continuous shearing leads to hidden stress on plant physiology and metabolic activities (Owuor *et al*., 1991, Jibu Thomas *et al*., 2008). Phenotypic expression of this stress invasive mechanism becomes evident in tea

*Corresponding Author: jibuthomas.t@gmail.com

plants *viz.*, banji formation, crow foot, clustering of leaves, low maintenance foliage, *etc*. due to imposing of continued shearing (Raj Kumar *et al*., 2010).

It was found that continuous implementation of shears for harvesting the crop shoots has led to the change in the texture of the crop shoots. This state of formation of "hardy and waxy" crop shoots is termed as "leaf leatheriness". The objective of the study was to generate data on the formation of leatheriness of crop shoots due to continuous shear harvesting and to propose the remedial measures to alleviate the leatheriness there by improving the quality of made tea.

Materials and methods

A factorial block design experiment was conducted with a 'Chinery' clone UPASI-9 after second year of pruning. Experiment was carried out at the experimental farm of UPASI Tea Research Foundation located in the Anamallais (1050 m above MSL) for a period of two years. Experimental area was divided into two blocks and one half was continuously harvested using shears while other half remained to be hand plucked throughout the experimental period. Harvesting was carried out once is every 15 to 20 days interval. Continuous hand plucking and continuous shear harvesting were considered as the main treatments (MT). The sub treatments (ST) included foliar application of (i) GA_3 (50 ppm), (ii) each of GA_3 (50 ppm) and IAA (10 ppm) and (iii) KNO_3 (2%). The foliar application was carried between January and September (once in every fifteen days) using a hand operated knapsack sprayer was applied. A spray fluid volume of 200 liters per hectare was applied after plucking the harvestable shoots so that the targeted maintenance leaves are exposed to retain the foliar applied chemicals. Pre-treatment yield was monitored for three months before initiating the experiment.

Based on the results obtained from this experiment, foliar application of KNO_3 was found to be beneficial in continuously shear harvested plants and hence, further refinement of the chemicals and their concentration was attempted only in the shear harvested plots with inclusion of new treatments to identify their effect as well. The modified treatment details are as follows. (i) Unsprayed control - hand plucked (T1), (ii) Unsprayed control - shear harvested (T2), (iii) Foliar application of KNO_3 (1%) (T3), (iv) KNO_3 (2%) (T4), (v) KNO_3 (1%) and Urea (T5), (vi) KNO_3 (2%) and Urea (1%) (T6),(vii) Urea (1%) and MOP (T7), (viii) $Ca(NO_3)_2$ (2%) (T8) and (ix) KNO_3 (2%) in alternate spraying rounds (T9). Foliar application of these chemicals were carried out during October 2007 to September 2008 and successive monitoring of the yield till December 2008.

Determination of total wax content

Total wax content of the crop shoot was determined using gravimetric method. A known weight of the physiologically uniform leaf sample (two leaves and a bud) was collected from field and brought to the laboratory and subjected immediately to gravimetric estimation. Sample was washed thoroughly in 50 ml of chloroform for 45 sec in a conical flask. The shoots were removed and the solvent was transferred into a pre-weighed china dish with continuous washing of the conical flask with another 50 ml of chloroform. Solvent was dried on a hot plate programmed at 100 ^{o}C kept in a fume hood. Dry weight of the china dish was noted after attaining room temperature for calculating the wax content (Trdan *et al*., 2004). The wax content was expressed in per cent basis.

Yield observation

Crop shoots were harvested according to the treatments as either hand plucking or shear harvesting throughout the experimental period (January 2007 to December 2008). Samples collected from the individual experimental plots were weighed separately and total yield observed for each treatment during the experimental period was converted into made tea adopting the standard procedure (assuming 22.5% out turn during manufacture) and reported as made tea kg ha^{-1}.

Banji content documentation

Content of banji was documented in each harvest during the period of experimentation. Random samples were drawn from each treatment and brought to the laboratory for estimation. 100 g of crop shoots were picked randomly, and actively growing buds and dormant banji shoots were separated visually from the weighed shoots. Banji per cent by weight is computed using the formula, Banji (%) = (Wt. of banji shoots / Total wt. of shoots) x 100

Dry matter content

Approximately 5 g of crop shoot (two leaves and a bud) was collected and recorded the fresh weight. The sample was transferred to a brown cover and kept in a hot air oven maintained at 80 $\pm$ 5 ^{o}C for 16 hrs. The dry weight of the sample was recorded once after the sample was brought to room temperature. Dry matter content was calculated as 100-[(fresh wt – dry wt)/fresh wt x 100] and expressed as per cent.

Black tea manufacture and quality parameters of made tea

In order to establish the quality parameters of the harvest, miniature crush tear and curl (CTC) manufacture was attempted from the plucked three leaf and a bud. The made tea was assessed for its primary quality constituents and organoleptic scores. Quality constituents such as theaflavins (TF), thearubigins (TR), highly polymerized substances (HPS) and total liquor colour (TLC) were analyzed using spectrophotometric method (Thanaraj and Seshadri, 1990). Colour index and briskness index were computed with the values of TF, TR, HPS and caffeine (Ramaswamy, 1986). A portion of the made tea samples were sent to the professional tea tasters' at Coonoor, The Nilgris for organoleptic evaluation (infusion, colour, strength, briskness) which directly influences the market value realization of the produce.

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) and mean values of replicates were presented with critical difference (CD) at five per cent probability and coefficient of variations (CV) wherever applicable (Gomez and Gomez, 1984).

Results and discussion

Results showed that continuous shear harvesting for a period of six months imparted leaf letheryness of the crop shoots. Visual observation done for a period upto six months showed significant change in the texture of the crop shoots. It was observed that continuous shear harvesting resulted in the accumulation of total wax content when compared to the hand plucked crop shoots which contributed to the leatheriness of crop shoots. Significant increase in the banji content in the harvest was also noticed due to continuous shear harvesting. Foliar applied chemicals as phytohormones or KNO_3 influenced the reduction in banji shoots in the shear harvested treatments. All the treatments in the shear harvesting were able to reduce the wax content when compared to control. Among the foliar applied treatments, KNO_3 application at 2 per cent revealed significant reduction in wax and banji. Marimuthu *et al*., (2001) studied the impact of shear harvesting on the basic physiology and health of tea bush. It was reported that net photosynthetic rate significantly reduced and a significant increase in respiratory loss was observed when the plants were indiscriminately harvested with shears. Shear harvesting throughout the year depleted the root reserves as well. Observations on biometric parameters revealed that the number of shoots per unit area increased with increasing duration of shear harvesting while weight of shoots declined significantly. Bushes under continuous shear harvesting registered higher number of banji shoots as well.

Even though improvement in yield was noticed due to foliar application of gibberelic acid (50 ppm) in combination with indole acetic acid (10 ppm), only the foliar application of KNO_3 was beneficial in reducing the leatheriness of leaf (Table 1 & 2). Physical examination of the harvested crop

Table 1. Variation in tea yields (kg ha^{-1}) with reference to style of plucking

Sub Treatment (ST)	Main Treatment (MT) Hand plucking	Shear harvesting	Mean
Control	5639	5548	5594
GA_3 (50 ppm)	5731	5718	5725
GA_3 (50 ppm) + IAA (10 ppm)	6376	5337	5857
KNO_3 (2%)	5763	5897	5830
Mean	5877	5625	
	SE ($\pm$)	CD (P≤0.05)	CV (%)
MT	231	495	7.36
ST	326	700	
MT x ST	462	990	

Table 2. Variation in biometric parameters with reference to style of plucking

Treatments	Wax Banji	Dry matter content (%)	Banji (%)
Control (hand plucking)	0.12	28.16	69
GA_3 (50 ppm)	0.15	27.64	69
GA_3 (50 ppm) + IAA (10 ppm)	0.29	29.25	70
KNO_3 (2%)	0.14	29.33	66
Control (shear harvesting)	0.26	23.69	80
GA_3 (50 ppm)	0.28	28.75	77
GA_3 (50 ppm) + IAA (10 ppm)	0.21	29.18	75
KNO_3 (2%)	0.14	27.16	72
CD ($P \leq 0.05$)	0.10	1.03	2.0
CV (%)	3.31	5.63	7.2

substantiates these results on wax content. Since foliar application of KNO_3 was found to be a better treatment in shear harvesting plots, all further experiments were concentrated with KNO_3 or related chemicals at various doses to achieve soft and succulent crop shoots. A study on shear harvesting confirms the importance of maintenance foliage and strengthens the mother leaf addition while plucking (Raj Kumar *et al.*, 2010).

Foliar application of revised treatments in the experimental plots confirmed the influence of KNO_3 in the reduction of total wax content with prominent reduction in banji when compared to the control plots of shear harvested treatments. Highest reduction in the total wax content in the continuously shear harvested plots was obtained by the foliar application of KNO_3 (2%) + Urea (1%) followed by KNO_3 (2%) and $Ca(NO_3)_2$ (2%) compared with control. Physical observation of the crop shoots collected from the experimental plots inferred no typical difference with the continuously hand plucked crop shoots. Reduction in the banji content of the harvest was evident in all the treatments of shear harvesting when compared to control. Foliar application of KNO_3 (2%), KNO_3 (2%) + Urea (1%), $Ca(NO_3)_2$ (2%) and Urea and MOP (1%) each significantly reduced the banji in the harvest (Table 3).

Foliar application of $Ca(NO_3)_2$ (2%) recorded significant highest yield followed by KNO_3 (2%) and Urea + MOP (2%) each when compared with the shear harvesting control treatment. Even though none of the treatments recorded a significant improvement in yield over hand plucked control, positive treatments showed a marginal improvement than the hand plucked control treatment. Thus, it was proved that the regular shear harvesting of the crop shoots under prevailing conditions drastically reduced the yield of the plants (Table 3).

Quality parameters of the made tea manufactured form the crop shoots of different treatments were assessed to ascertain the impact of foliar applied chemicals on quality of the produce. It was evident from the study that none of the applied chemicals had any deleterious effect on the made tea. All the treatments registered values of TR, TR, HPS and TLC on par with the control hand plucked samples with minor deviations. Foliar application of KNO_3 in combination with Urea at various dosage and $Ca(NO_3)_2$ (2%) improved the values of TR, HPS and TLC in comparison with control of hand plucked and shear harvested samples. Among the treatments alternate round spraying did not impart more significance (Table 4).

Scores given by the professional tea tasters revealed that the liquor characteristics of the made

Table 3. Yield and biometric parameters in relation to the foliar application of KNO_3 and related chemicals

Treatments	Wax (%)	Banji (%)	Yield (kg ha^{-1})
T1 Hand plucked - control	0.291	58	2964
T2 Shear harvested - control	0.443	76	2498
T3 Foliar application of KNO_3 (1%)	0.413	65	2796
T4 Foliar application of KNO_3 (2%)	0.342	61	3282
T5 Foliar applications of KNO_3 (1%) + Urea (1%)	0.375	61	3065
T6 Foliar applications of KNO_3 (2%) + Urea (1%)	0.293	57	3188
T7 Foliar applications of Urea (1%) + MOP (1%)	0.403	59	3273
T8 Foliar application of $Ca(NO_3)_2$ (2%)	0.326	56	3319
T9 Foliar application of KNO_3 (2%) in alternate spraying rounds	0.450	73	2753
CD ($P \leq 0.05$)	0.10	11.80	646.90
CV (%)	12.93	16.07	12.36

Table 4. Quality parameters of hand plucked and shear harvested samples in response to foliar applied chemicals

Treatments	TF	TR	HPS	TLC	TR/TF
T1 Hand plucked - control	1.63	12.98	10.11	4.45	8.26
T2 Shear harvested - control	1.88	12.39	10.08	4.67	6.58
T3 Foliar application of KNO_3 (1%)	1.63	12.94	10.08	4.44	8.25
T4 Foliar application of KNO_3 (2%)	1.57	13.19	14.55	5.64	8.41
T5 Foliar applications of KNO_3 (1%) + Urea (1%)	1.70	13.93	13.17	5.30	8.18
T6 Foliar applications of KNO_3 (2%) + Urea (1%)	1.69	11.01	11.42	4.83	6.53
T7 Foliar applications of Urea (1%) + MOP (1%)	1.65	13.33	11.84	5.86	8.10
T8 Foliar application of $Ca(NO_3)_2$ (2%)	1.62	13.49	11.35	5.77	8.35
T9 Foliar application of KNO_3 (2%) in alternate spraying rounds	1.85	12.65	11.38	5.39	6.84
CD ($P \leq 0.05$)	0.07	0.43	1.03	0.36	0.32
CV (%)	3.27	5.83	5.36	4.89	6.73

Table 5. Organoleptic evaluation of made tea samples manufactured from hand plucked and shear harvested samples in response to foliar applied chemicals

Treatments	Infusion	Colour	Strength	Briskness
T1 Hand plucked - control	7.3	7.7	7.0	7.7
T2 Shear harvested - control	7.3	7.3	7.4	7.5
T3 Foliar application of KNO_3 (1%)	7.1	7.6	7.6	7.8
T4 Foliar application of KNO_3 (2%)	7.3	7.3	7.3	7.3
T5 Foliar applications of KNO_3 (1%) + Urea (1%)	7.5	7.5	7.5	7.5
T6 Foliar applications of KNO_3 (2%) + Urea (1%)	7.3	7.6	7.6	7.3
T7 Foliar applications of Urea (1%) + MOP (1%)	7.8	7.5	7.5	7.0
T8 Foliar application of $Ca(NO_3)_2$ (2%)	7.6	7.6	7.3	6.9
T9 Foliar application of KNO_3 (2%) in alternate spraying rounds	7.4	7.3	7.1	7.3
CD ($P \leq 0.05$)	0.31	0.41	0.38	0.33
CV (%)	3.35	4.67	4.18	5.03

tea samples applied with chemicals did not show any deterioration of quality. Instead the application of Urea and MOP at 1 per cent each improved the infusion and strength of tea liquor followed by $Ca(NO_3)_2$ (2%). Foliar applications of $Ca(NO_3)_2$ alone or in combination showed only marginal variation from control hand plucked or shear harvested samples (Table 5).

Thus it is concluded from the study that foliar application of KNO_3 (2%) alone or in combination with Urea (1%) is beneficial in alleviating the leaf leatheriness caused due to continuous shear harvesting without deterioration of quality characteristics with a prophylactic effect to improve the yield of tea plants.

Acknowledgements

First author is thankful to Tea Technology Division for the analyses of quality parameters.

References

Ilango, R.V.J., Ajayakumar, K., Muraleedharan, N., Raj Kumar, R., Marimuthu, S. and Senthilkumar, R.S. 2001. Field evaluation of motorised harvesters in tea. *Bulletin of UPASI Tea Research Foundation* **54**: 1 -13.

Thomas, J., Raj Kumar, R. and Mandal, A.K.A. 2008. Impact of foliar application of KN03 for reduction of leaf leatheriness and banji in continuously shear harvested fields. *Newsletter of UPASI Tea Research Foundation* **18**(1): 2.

Marimuthu, S., Raj Kumar, R., Muraleedharan, N., Jayakumar, D. and Radhakrishnan, K.N. 2001. Physiological response of tea plants to shear harvesting. *Journal of Plantation Crops* **29**: 16-21.

Obanda, M. and Owuor, P.O. 1995. Clonal variations in the response of black tea quality due to plucking standards. *Food Chemistry* **53**: 381-384.

Othieno, C.O. and Anyuka, J.O. 1982. Preliminary performance of plucking methods. *Tea* **3**(2): 18-26.

Owuor, P.O. and Odhiambo, H.O. 1993. The response of quality and yield of black tea of two Camellia sinensis varieties to methods and intervals of harvesting. *Journal of the Science of Food and Agriculture* **44**: 261-264.

Owuor, P.O., Othieno, C.O., Robinson, and Baker, D.M. 1991. Changes in the quality parameters of seedling teadue to height and frequency of mechanical harvesting. *Journal of the Science of Food and Agriculture* **55**: 241-249.

Raj Kumar, R., Thomas, J. and Mandal, A.K.A. 2010. Impact of continuous shear harvesting on photoassimilate compartmentalization in mature tea. Extended Abstract. In: *PLACROSYM XIX*. *Abstracts*. Rubber Research Institute of India, Kottayam, Kerala. p. 22-24.

Ramaswamy, S. 1986. Improving tea quality in south India. *UPASI Tea Scientific Department Bulletin* **41**: 12-24.

Sharma, V.S., Haridas, P. and Venkataram, K.S. 1981. Mechanisation of harvesting in tea. *UPASI Tea Science Department. Bulletin*. **37**: 106-l 10.

Thanaraj, S.N.S. and Seshadri, R. 1990. Influence of polyphenol oxidase activity and polyphenol content of tea shoot on quality of black tea. *Journal of the Science of Food and Agriculture* **51**: 57-69.

Trdan, S., Znidarcic, D., Zlatic, E. and Jerman, J. 2004. Correlation between epicuticular wax content in the leaves of early white cabbage (*Brassica oleracea* L. var. *capitata*) and damage caused by *Thrips tabaci* Lindeman (Thysanoptera: Thripidae). *Acta Phytopathologica et Entomologica Hungarica* **39**(1-3): 173-185.

UPASI 1996. Annual Report. UPASI Tea Research Institute,Valparai, South India.