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Effect of mechanical plucking height on tea green leaf yield and its quality

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ABSTRACT

Tea is very important product in many countries due to huge consumption in the world and its valuable contains. The traditional harvesting method needs to be improved due to its effect on yield and quality. Mechanical plucking as a substitution to conventional method is spreading quickly and is necessary to be investigated for proper adoption. One of crucial factor has been noted to be the height of harvesting in this method, hence identifying the most appropriate height was aim of this study. The research was conducted in a research station of Fashalem located in the North part of Iran, Guilan province during last season. Treatments at four plucking height level of 5, 10 and 15 cm plus control (Plucking with secateurs) and their effects on tea hybrid bushes were considered. Regarding quality, parameters consisted revenue of total green leaf and the leaf standard, Tannin of green leaf and solid material contain in of green leaf were determined. Study was performed using randomized complete block design with three replications. The results indicated that plucking height of 5 centimeter, in total green leaf and standard leaf was significantly higher than other heights. Moreover 5 cm plucking height showed maximum amount of tannin and solid material compared to the other treatments. There. The effect of time was found to be significant for different parameters of quality.

Keywords: Tea, Height of Plucking, Green Leaf Yield.

1- INTRODUCTION

In northern Iran between 37^0N to 51^0E latitudes, tea fields with an area of over 34,000 hectares are extended on plains and mountainsides. More than 60,000 farmer families work in these fields and over 180 factories are active in producing and processing dried tea. Here, green leaves of tea are harvested from late April (at most, May 5) to late October (at most, November6) with the highest rate belonging to the first plucking (spring plucking) that has the best quality. Tea harvesting is usually coincided with cultivation procedures of other agricultural products such as rice. This situation along with the shortage of workers results in higher harvesting costs on one hand and lower tea quality on the other due to the increase of bush heights and the reduction of green leaves quality which happens because of not harvesting them on time. Generally, the use of non-standard tools, not enough-skilled workers and the

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wage increase are among factors responsible for increasing the rates of harvesting costs that lead to a higher price cost of the green leaves and finally, the increased price of the produced dried tea. As a whole, this process impairs the competitiveness of the domestic quality teas in comparison to the imported ones. Since tea harvesting costs constitute a large amount of the green leaves production expenditure (Hudson 1998), in order to retrench the latter and to have an on time harvest and increase the interest / cost ratio, using a harvesting machine to replace the workforce on the condition of maintaining the harvested green leaves' quality seems necessary (Satyanarayana, 1995). Also, with the small area of tea fields in Iran taken into account, applying a combination of mechanical and manual harvesting (Dalimoenthe 2004) to improve the yield and reduce the related costs is possible. In an experiment with the purpose of studying the effects of different manual harvest levels on the yield and quality of tea bushes, it was reported that harvesting from 5cm higher than the pruning level in better than other treatments with regard to the total yield of the green leaves and the standard ones and considering the bush extension level, 5 and 10cm levels are preferred over the controls (Hassanpour Asil, 2003).

A research was carried out in Kenya highlands showed that Machine harvesting almost doubled the yield and was at least 35 times faster than hand plucking. However, hand plucking resulted in better quality made tea. (Mwakha, 1990). An evaluated was carried out in India (UPASI Tea Research Institute) showed that A majority of estates surveyed (108 out of 140) used shear harvesting, with most of these integrating shear harvesting and hand plucking. A cost: benefit ratio of 1:34 was calculated for shear harvesting. (Satyanarayana, 1995). A research was carried out in India showed that Plucking with flat shears produced higher yields (3-year average) than with raised shears but the quality was greater with raised shears. (Barbora *et al*.,1996). A research was carried out in Japan showed that during a period of new shoot growth for the first crop in 1992, new shoots were harvested at 1 cm intervals (1-15 cm) above the last skiffing surface. Weights of leaves and stems were heavier from the lower layers than from the upper layers. The total N concentration was higher for the upper layers. The free amino acid concentration was higher for the middle layers from an early harvest, but higher for the upper layers from a late harvest. The neutral detergent fiber concentration was higher for the lower layers. The results showed that at the higher plucking height, yield decreased but quality was enhanced (Nakano *et al*., 1996).

An evaluated was carried out in Kenya showed that Catching levels in green leaf, total the aflavins, brightness, the arubigins, color, flavor index and sensory evaluation decreased with coarseness of the plucking standard. The sum of Group I volatile flavor compounds (which impart inferior aroma) and C6 aldehydes and alcohols, in particular, increased with coarseness of the plucking standard. The sum of Group II volatile flavor compounds (which impart a sweet flowery aroma) did not follow a particular pattern, but flavor index decreased with coarseness of the plucking standards (Owuor *et al*., 1998).

A research was carried out in India showed that yield was highest with tipping 5 cm above the pruning mark (1247 kg made tea/ha). Yield decreased as the distance from the pruning mark increased (tipping 25 cm from the pruning mark resulted in 1053 kg made tea/ha). (Sharma *et al*., 1998). A study was conducted at Valparai, India showed that the chemical quality parameters and sensory evaluation of black teas changed with method of plucking. Hand-plucked teas were very rich in their green-leaf biochemical precursors and had higher contents of made-tea quality constituents than shear-plucked teas. The quality deterioration was mainly due to mechanical injury and non-selective plucking with shear plucking. However, tea obtained by shear plucking from a field continuously sheared over a prolonged period (5 years) was found to be superior to that obtained by shear plucking from a field previously under hand-plucking (Ramaswamy *et al*., 1998). An evaluated was carried out in India showed that Plucking accounts for around 20% of the total cost of tea production in

India, and significant wage increases since 1990 combined with escalating costs for other inputs are having a negative impact on the profitability of tea. There is a need to increase the productivity of tea and the efficiency of pluckers. Factors affecting the plucking average, and which should be addressed when looking at ways to improve productivity, include: plucking interval; mechanical harvesting; lane plucking; plucker deployment; organization of pluckers; time of plucking; standard of plucking; length of pruning cycle; height of pruning; bush height; weighments; supervision; and human resource development (Hudson, 1998).

An evaluated was carried out in Kenya showed that a higher plucking speed with the hand-held machine and hand plucking was obtained 8601 and 4360 kg green leaf/day, respectively. Shoots obtained by hand plucking were found to have better quality than the mechanically harvested ones. (Bore *et al*., 1998)

An experiment was conducted in Elappara, Vandiperiyar, Kerala, India to investigate the effect of different harvesting methods on the incidence of grey blight (Pestalotia spp.) on tea. Grey blight incidence was lowest with hand plucking with breaking back (6.8%) and highest with continuous shearing (22.2-23.7%). (Sanjay *et al*., 2003)

A research was carried out in Indonesia and recommends the adoption of mechanized plucking during high cropping seasons and of intervening hand plucking during low cropping seasons. The potential of shears-pluckers and machine-pluckers versus that of hand plucking is emphasized. The advantages of mechanizing the harvesting operation and of combining hand and shears plucking are also mentioned (Dalimoenth, 2004). In this study, by evaluating these machines in the existing conditions of tea fields in Iran and determining the best height for the planted bushes to be harvested, maximum productivity in the harvest of green leaves while maintaining the dried tea quality can be achieved.

2- OBJECTIVES

Objectives of the study were: 1- To study the effect of four harvesting heights on quality factors of tea 2- To determine the most appropriate height for tea harvesting with the highest yield.

3- MATERIAL AND METHODS

This research has been conducted in Shahid Eftekhari Tea Research Station of Fashalam located in 12km of Rasht-Fouman road. The station was established in 1956 and its first productive bushes were planted between 1959 to 1964.Based on the latest survey, the total area of the used plots was 8.48 hectares. Station situated at $37^{\circ} 25^{/}$ N latitude, longitude $49^{\circ} 25^{/}$ W and altitude 3m above mean sea level. The research was done in the 4th plot with an area of 1593 m^2.

The agricultural processes including pruning, fertilization, irrigation, etc were performed in accordance to the traditions of the station. The selected plot was divided into 12 equal subplots (4 treatments and 3 replications) each of which having 80 m^2 as area. Harvest was done by using a flat two-seated plucking machine with 800mm as its blade width, weighing 12.3 kg and having an engine capacity of 41.5 cm^3. To determine the green leaf yield, the total annual harvest of each experimental plot was collected and weighed separately. After an accurate weighing, harvest samples of spring, summer and autumn plucking indexes were immediately transferred to the National Center of Tea Researches located in Lahijan, to have their dry matter and Polyphenol level determined.

To measure dry matter the green leaf sample is poured in a weighing capsule and put in a 103-105 $^{\circ}$C AUTO. After reaching a fixed weight, it will be taken out of the AUTO and when cooled in a desiccator, the percentage of its dry matter is calculated by using the following equation:

$$Dry\ matter\ percentage = \frac{Capsuleweight - capsuleweightwiththesample}{Greenleafweight} \times 100$$

In order to measure tannin 2g of the prepared sample (grinded dry green leaves) is poured in a 400CC Erlenmeyer flask having sandpaper cover and mixed with 200CC boiled distilled water. Then, the Erlenmeyer is connected to an inverted or vertical cooler. Later, it is boiled on an electric stove for 30 minutes. The mixture is immediately filtered and the accumulated residue on the filter paper (which is in a funnel) is washed for a few times with boiling distilled water. Then, 50CC CH_3COOCu (copper acetate) (40g/l) is added to the filtered solution. After sedimentation, the solution is filtered while the sediment remains on the filter paper. The obtained sediment is leached with boiling distilled water. Following being dried at 600 $^{\circ}$C, it is burned for 30 minutes. The conversion coefficient for Tannin is 65.305.

$$Tannin\ Percentage = \frac{Se\,\mathrm{dim}\,entweightafterburning}{Originalsampleweight} \times conversioncoefficient$$

4- DATA AND RESULTS

Results of variance analysis for harvesting height in related yield have been indicated in Table 1. Results showed there are significant differences between harvesting heights (T_1 = 5 cm, T_2 = 10 cm, T_3 = 15 cm and T_4 = control) in producing tea yield at 1% level.

Table 1. The Variance Analysis of the normal data related to the yield characteristic carried out in a RCBD using the Factorial method

Source	Degrees of Freedom	Mean Square
Replication	2	119.688 ^{ns}
Plucking height	3	570.211 **
Error	6	10.638
Grand Mean		93.009
Coefficient of Variation		% 3.51

*,**, ^{ns} Respectively significant at 5% , 1% and non significant

Significant differences were found between harvesting heights in producing dry matter at 5% level. Also, it was observed that there is a significant difference between harvesting times in producing dry matter at 5% level. Besides, difference of interactions between harvesting times and height levels probability is significant (Table 2). The statistical analysis indicated that differences between harvesting height and times are significant at 1% level. Moreover,

Table 2. The Variance Analysis of the normal data related to the solid material characteristic carried out in a RCBD using the Factorial method

Source	Degrees of Freedom	Mean Square
Replication	2	0.427 ^{ns}
Plucking height	3	5.599 *
Error	6	0.846
Time	1	9.563 **
Time * Plucking height	3	2.350 *
Error	8	0.444
Grand Mean		24.171
Coefficient of Variation		% 2.76

* ,**, ^{ns} Respectively significant at 5% , 1% and non significant

The difference of interactions between harvesting times and height levels at 5% probability is significant (Table 3). The comparison of means plucking heights indicated that the lowest plucking height produced the highest tea yield among all plucking heights (Table 4).

Table 3. The Variance Analysis of the normal data related to the Tanin characteristic carried out in a RCBD using the Factorial method

Source	Degrees of Freedom	Mean Square
Replication	2	0.045 ^{ns}
Plucking height	3	10.822 **
Error	6	0.194
Time	1	10.822 **
Time * Plucking height	3	1.069 *
Error	8	0.203
Grand Mean		11.547
Coefficient of Variation		% 3.91

* ,** , ^{ns} Respectively significant at 5% , 1% and non significant

Table 4. Comparison of harvesting height averages by using the Duncan method with 5% probability of yielding characteristic

Plucking height (Treatment)	Mean	Ranked Order
T_1	109.9	A
T_4	98.22	B
T_3	84.57	C
T_2	79.35	C

T_1 = 5 cm, T_2 = 10 cm, T_3 = 15 cm and T_4 = control

The results of means comparison of harvesting times indicated in Table 5. Results showed that the highest dry matter percentage was obtained in summer. However, in a study that conducted in India it was found in spring and summer the Tanin and dry matter were increased (Sud and Badyal, 1989).

Table 5. Comparison of harvesting time averages by using the Duncan method with 5% probability of dry matter percentage characteristic

Time	Mean	Ranked Order	
D_1	25.178	A	
D_2	23.790		B

D_1 = Summer D_2 = Autumn

As observed in Table 6, the highest dry matter was obtained by treatment T_1 (5 cm plucking height). Also, obtained results form a research in Japan showed that at the lower plucking height, quality was increased (Nakano et al., 1996). Meanwhile, details of comparison of interaction between factors of harvesting height and time on dry matter percentage were shown in Table 7.

Table 6. Comparison of harvesting height averages by using the Duncan method with 5% probability of dry matter percentage characteristic

Plucking height (Treatment)	Mean	Ranked Order	
T_1	25.62	A	
T_3	23.72		B
T_2	23.68		B
T_4	23.67		B

Table 7. Comparison of interaction between two factors (harvesting height and time) by using the Duncan method with 5% probability of dry matter percentage characteristic

Time * Plucking height	Mean	Ranked Order			
$T_1 \times D_1$	26.47	A			
$T_4 \times D_1$	25.08	B			
$T_1 \times D_2$	24.77		B	C	
$T_2 \times D_1$	23.94		B	C	
$T_3 \times D_1$	23.72			C	
$T_3 \times D_2$	23.71			C	
$T_2 \times D_2$	23.42			C	D
$T_4 \times D_2$	22.27				D

The result showed that the highest Tannin percentage was in summer (Table 8). Also, in 1989 some researchers found that in spring and summer Tannin and Dry matter were increase (Sud and Badyal, 1989).

Table 8. Comparison of harvesting time averages by using the Duncan method with 5% probability of tannin percentage characteristic

Time	Mean	Ranked Order	
D_1	12.067	A	
D_2	11.026		B

Comparison of harvesting height treatments in producing tannin indicated that the highest tannin percentage obtained by treatment T_1 (Table 9). However, in 1986, Sivapalan *et al*., in a study indicated that high plucking (more than 2 leaves a bud or over 5 cm height) reduced the quality of green leaves and made tea. Meanwhile, details of comparison of interaction between factors of harvesting height and time on tannin percentage were shown in Table 10.

Table 9. Comparison of harvesting height averages by using the Duncan method with 5% probability of tannin percentage characteristic

Plucking height (Treatment)	Mean	Ranked Order		
T_1	13.19	A		
T_2	12.04		B	
T_4	10.79			C
T_3	10.17			C

Table 10. Comparison of interaction between two factors (harvesting height and time) by using the Duncan method with 5% probability of tannin percentage characteristic

Time * Plucking height	Mean	Ranked Order			
$T_1 \times D_1$	13.61	A			
$T_2 \times D_1$	13.17	A			
$T_1 \times D_2$	12.77	A			
$T_4 \times D_1$	10.95		B		
$T_2 \times D_2$	10.91		B		
$T_4 \times D_2$	10.63		B	C	
$T_3 \times D_1$	10.55		B	C	
$T_3 \times D_2$	9.79				C

5- DISCUSION

The results showed that plucking height of 5 centimeter, in total green leaf and standard leaf was significantly higher than other heights. More over 5 cm plucking height showed maximum amount of tannin and solid material compared to the other treatments. There. The effect of time was found to be significant for different parameters of quality.

Although an increase in green leaf height increases the yield amount in a harvest round, in a low height harvest due to the increase of the number of harvest rounds during plucking, harvesting from a lower height shows a better yield. It should be mentioned that green leaves harvested from lower heights have better qualities for producing black tea.

Usually, the Tannin level in soft shoots, buds and the first and second leaves is higher than other parts of tea bushes. Hence, with an increase in the harvesting height the Tannin level in green leaves decreases.

The results showed that harvesting from a lower height shows a better yield, in a similar experiment with the purpose of studying the effects of different manual harvest levels on the yield and quality of tea bushes, it was reported that harvesting from 5cm higher than the pruning level in better than other treatments with regard to the total yield of the green leaves and the standard ones and considering the bush extension level, 5 and 10cm levels are preferred over the controls. (Hassanpour Asil, 2003). Similarly in a research was carried out in Kenya showed that Machine harvesting almost doubled the yield (Mwakha, 1990). The results showed that harvesting in 5cm height shows a better Tannin and solid material characteristic in green leaves, similarly an experiment was conducted during 1989-90 in Kenya showed that for optimum yield, plucking speed and quality, medium plucking (2 leaves and a bud or about 5cm height) at 10- to 11-day intervals is recommended (Mwakha,1991). Again in a study was conducted at Srilanka showed that high plucking (over 2 leaves and a bud or over 5cm height) reduce the quality of green leaves and made tea (Sivapalan *et al.*, 1986).

6- CONCLUSION

The results of study indicated that an increase in green leaf height increases the yield amount in a harvest round, in a low height harvest due to the increase of the number of harvest rounds during plucking, harvesting from a lower height shows a better yield. However, it should be mentioned that green leaves harvested from lower heights have better qualities for producing black tea.

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