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Physiological Pattern of Leaf Growth at Various Plucking Cycles Applied to Newly Released Clones of Tea Plant (*Camellia sinensis* L. O. Kuntze)

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Abstract

An experimental research to study the effect of plucking cycles on the physiological pattern of leaf growth of tea plant of newly-released tea cultivated varieties (clones) was conducted at Plantation of the Research Centre for Tea and Quinine Trees of Gambung of Bandung, Indonesia from April 2012 to July 2012. The leaf growth of tea are dependent on several genetic and environmental/agronomic factors The location of the Research Centre for Tea and Quinine tree is 1300 m above sea level. The experiment was conducted by using Split Plot Design to examine two factors, they are various of Gambung clones as the main plot with three levels, they are c1 = Gambung 4; c2 = Gambung 7; c3 = Gambung 9. And plucking cycles as the sub-plot factor with 5 levels, they are: 5 days; 7 days, 9 days; 11 days; and 13 days. So, there are 15 combinations with are repeated 3 times. The plant physiological factors as responses to the treatments measured in leaf growth consisting of: Number and quantity of leaves measured in dry weight (g); number of pecco; Pecco weight; number of burung/banjhi (dormant top) in g; weight of burung/banjhi in g; number of P+3 leaves; weight of P+3 leaves; number of P+2 leaves; and weight of P+2 leaves. Result of the experiment showed that the 13 days cycle allowing the further growth of leaves causing increasing of wet weight of leaves, and the Gambung 9 clone showed the best physiological growth of leaves.

Keywords: Clones, Dormant (burung/banjhi), Pecco, Physiological, Plucking

Introduction

Tea (*Camellia sinensis* L. O.Kuntze) plant needs constant temperature and humidity to grow well (Burgess and Carr, 1999; Islam *et al*., 2005; De Costa *et al*., 2007). Such the climatic conditionis found in tropical and subtropical regions. Balamurugan and Nandagopalan (2012) said that high land plantation produces better leaves quality, while medium and lowland plantations produce more in leave quantity.

Pruning is regularly conducted to maintain good physiological growth resulting to sound leave

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production, and to keep the height of shrub canopy reachable by tea peckers, so it is an important practice of tea cultivation (Mahes Kulkarni, 2012; Krisnaraj Thirugnasambantham *et al*., 2013). Pruning is the one important part of the development of the tea plant after plantation (NTRI, 2010; Rehman *et al*., 2012).

Tea plant grows in physiological condition to have the harvesting applied by plucking its sprout. Tea plantharvest is conducted by plucking young leaves. This practice of cutting leaves will affect the pattern of leaf physiology. Nisanka *et al*., (2004); Wen-Yan Han *et al*., (2007) said that pecco or the active youngest leave is plucked for highest quality, while the normal quality production obtained by plucking the pecco plus two or three young leaves. Tea plant has a periodicity of active growth and a dormant/retarded growth (called burung in Indonesia or called Banjhi in India) leaves. This periodicity is dependent on agronomic practices, climatic condition and genetic factors. Agronomic practices among other are pruning management, fertilizer application, and plucking cycles applied as stated by Ziyad and Zoysa (2006). Kamau *et al*. (2008) said that shoot extension rate was highest at the first year of the pruning cycle for both clones.

Climatic condition are determined with the plantation Elevations and Latitudes, and micro-climatic is also determined by agronomic practices as the management of plant shading, weeding practicing, apllying fertilizer, and the building of warm air trap of holes or pattern of soil tillage. And the genetic is in accordance with the clonal factors (Dalimoenthe, 1990; Astika, 1997). Applying fertilizer is a must in agronomic point of view, especially in soil with lest fertile and the removal of nutrient due to the harvest (Subandi, 2012c).

The growth of young leave will be affected by plucking cycle. Astika *et al*. (2004) stated that period and pattern of growth (periodicity of tea growth) of a cultivated clone varies among clones.Gambung Research Centre for Quinine and Tea has released several new cultivated varieties (clones), three of them are the clones of Gambung 4, Gambung 7 , Gambung 9, andother clones.

As an estate crop, tea has been contributing considerable amount of income for many nations including Indonesia. China and India are two countries dominate the world production. In 2011 Indonesia ranks the eighth of tea producing countries with its production as much as 142,400 metric tonnes. Seven other big tea producing countries are; China (1,640,310 m tonnes), India (966,733 m tonnes), Kenya (377,912 m tonnes), Sri Lanka (327,500 m tonnes), Turkey (221,600 m tonnes), Vietnam (206,600 m tonnes), and Iran (162,517 m tonnes) (FAO, 2012 quoted by Van der Schaar Investment, 2013).

Estate crop is a Subsector of agriculture had showed important fund collector for Indonesian nation in time of national economic turmoil in 1997 and on. At that period Indonesian government faced a serious difficult economic situation. The value of Indonesian currency (IDR) downed to minimum rate in its history. Indonesian importers were not able to import any raw material or spare-parts for replacing the parts of machineries used in their factories and plants.

Textile industries were collapse due to the raw material (cotton fiber) have to be imported from abroad producing cotton countries (Subandi, 2012c). Electronics industries were unable to maintain their production activities. Most electronic element were still imported, Indonesian industries in this sector of economic were just the assembling process. No current currency were available to fund the imported material, and no industries were running in normal condition. Many worker are homed for permanently. This economic turmoil ignited the succession of national Indonesians leadership. No economic sectors were running well except the agricultural sector. For executing this economic sector of the agriculture, there are no exported raw material and components.

Unlike rice which has still to be imported to meet the national consumption requirement (Subandi, 2012a), the tea production together with other commodities (rubber, coffee, Palm oil, sugarcane, coconut, etc.) was able to contribute collecting fund in supporting the healing of economic crisis. Without which Indonesian monetary crisis would furlong unsettled.

Cycles of plucking or the activity to harvest tea plant may vary based on the external condition as the seasonal growth, rain intensity, elevation of plantation location, system of agronomy (fertilizer application/pruning policy /shading plant), quality of leaves wanted/ plucking formulae, the available of pickers, and of course the internal or genetic characteristic of clone of plant. The theories of Plucking or picking of tea had been developed since the Dutch colonial established the tea plantation in Indonesia in 19 centuries. In line with the advanced finding in plant physiology theory, the theories and the practices of plucking have been experimenting by the researchers both in Research Centers and Universities as said by Subandi (2012b) as time goes and human culture developes, scientific theories as the product of human intelligence have change from time to time.

Indonesian tea plantation production is only at the most 1,006 kg $ha^{-1}year^{-1}$. This low production is due to the ageing of plants, that is why the management of plantation has to consider the replanting with new cultivated variety (Astika, 1997). Other effort to increase the production is by applying new agronomical practices among other is the plucking cycle of tea leaves. The interaction effects between plucking cycles and the clonal characteristic was searched in this experiment.

Method

Site of the experiment is the tea plantation cultivated in the experimental field of the Research Centre for Tea and Quinine Plants. In Ciwidey Subdistrict of Bandung Regency around 20 km in Southern Bandung city of West Java, Indonesia. The site is on the elevation of 1,300 m above sea level with Andisol soil classification, and soil acidity (pH.4.5 to 5.5).

Experimental design was Split Plot Design, the Main Plot was Gambung clones with three levels, they are c_1 = Gambung 4; c_2 = Gambung 7; c_3 = Gambung 9. And plucking cycles as the sub-plot factor with 5 levels, they are: 5 days; 7 days, 9 days; 11 days; and 13 days. There are 15 combinations with three replications. The plant physiology responses (growth) and yield consist of: Dry weight of leave production (g); number of pecco; Pecco weight (g); number of burung (dormant top); Dry weight of burung(g); number of Pecco+3 leaves; Dry weight of Pecco+3 leaves (g); number of Pecco+2 leaves; and dry weight of Pecco+2 leaves (g).

Environmental condition were monitored at the time of experiment as the elements of climate: rainfall, wind, the sun radiation, temperature and the atmospheric humidity. The health crop condition was also noted through the analysis of starch content of plant roots. And the soil fertility is noted based on the latest data of soil analysis of the garden block. Shading system of high cover crops was in good condition filtering the sun shine (Fig. 1 and 2).

Discussion on Plantation Environment

Analysis of Climatic condition in the time of experiment (April 2012 to July 2012): In general, in all Java island was dry season, April was the end of rainy season with a very little of rainfall. May-June- July were dry season with very little rainfall.Rainfall record during the experiment shows in April total rainfall was 8,147 mm and total rainy days was 15. In May total rainfall was 5,831 mm total rainy days were 12 rainy days. In June total rainfall 1,488 mm with 6 rainy days, in July up to days 12th there was no rainfall at all.

Daily temperature which was measured at Climatology Observation Center of Gambung Research Centre indicated a constant at the average 20^0C, and the average night temperature was 15^0C. Minimum night temperatures occur usually in the months of August and September of the year. These months are the peak of dry season in most Indonesian regions. And frost happening in the months sometimes destroys tea plant in high land plantations. In the months of the experiment the atmospheric temperature was higher than normal but it was normalized by the existence of shading trees (shown in Fig. 1 and 2), and it was not reaching the minimum at night.

Fig 1: Leaves is waiting for plucking

Fig 2: Other Main Plot (growing under the shading plants

Fig 3: Pecco Leaves Grows out of the Previous Plucking

Analysis of soil before the experiment was conducted. The soil is in good; texture sandy silt (23.72 % of clay; 62.71% of silt; 13.57% of sand). C/N ratio 9, and 75.1 ppm of available P_2O_5. Agronomical record shows that the plantation is well maintained (weeding, applying fertilizer, trimming, and plant protection).

Discussion on Physiological Plant

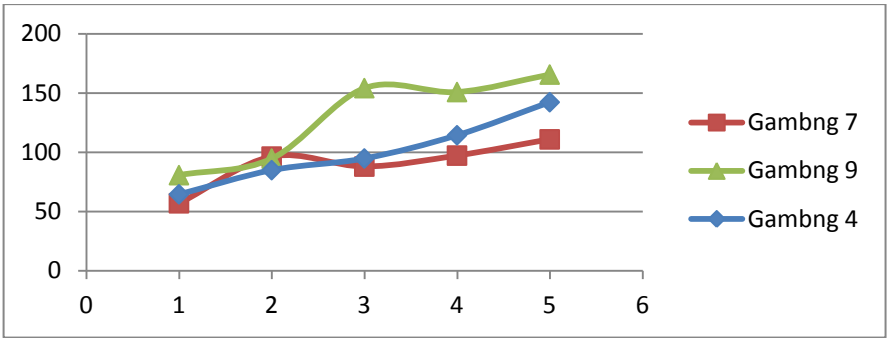
Total Leaf Growth.

Result of analyses of variance showed that subplot (plucking cycles) affected the growth of tea resulting in significant effect, and there is significant interaction between plucking cycle and various clones as shown in the graphic 1. Here is the Table of Dry-weigh of Leaves $Plot^{-1}$, Dry weight is accumulation of weight of several leave grades and categories.

Tabel 1: Dry Weight of Leaves per-Plot at Various Plucking Cycles and Clones

Clones	Plucking Cycles				
	----------gram----------				
	p1	**p2**	**p3**	**p4**	**p5**
c1	64,51 B	84,88 A	94,74 B	114,33 B	142,22 B
	a	B	c	d	E
c2	56,95 A	96,33 B	87,92 A	97,18 A	110,86 A
	a	C	b	c	D
c3	80,67 B	94,68 B	154,11C	150,81C	165,57 C
	a	B	c	c	D

Notes. Figures indicated with the same capital at the same column, and figures indicated with the same italic of the same row, are not significantly difference based on Duncan test at 5%.



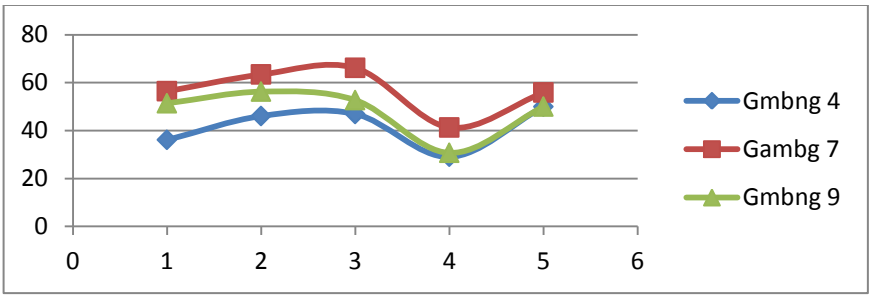
Graph 1: Graph of leaves weight (g) of Somes Clones of Plucking Cycles

The longer plucking cycle the more leaves have period to physiological development of vegetative organ and in return will affect to tea quality in view of production. Plucking cycle of 13 day gives the plant to develop fully its leaves compared to shorter cycles. The plant bear more leavess and leaves ofmore in morphological weight. At that period plants bear more young leaves, and these leaves develop gradually to maturity. Older leaves weighs more. As shown in the graph, a significant interaction between Plucking Cycles and Clones happened. Maintenance leaves is mature in 13 days old in view of chlorophyll formation and development. The condition when a leaf is no more sink status or parasitic condition (measured comparatively between photosynthesis and respiration rates), because its function as a active photosynthetic organ. The leaf color is already full green and since then the texture is developing hard and rigid for further fiber formation, and in consequently decrease the leaf quality . The tea leaves plucked at 13 days cycle mostly has a pecco and two or three young leaves, the oldest leaf is 13 days old. This full developed leaf contributed to the weight of leaves.

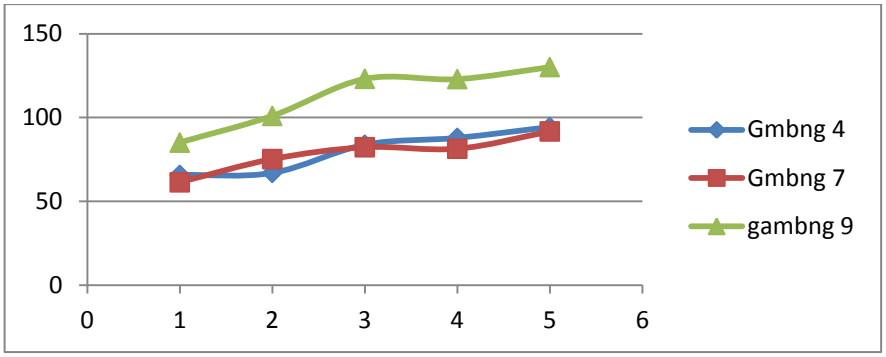
Number of Pecco and Burung/Banjhi

Tea plant growth is characterized with the presence of active leaves and dormant (retarded growth) in its plucking table (canopy). Active leaves (pecco) and dormant leaves or retarded growth (burung/banjhi) growing in the plucking tableare harvested. Influenced with genetic, health condition of plant, and the environment as the climate and the soil, plants bear active and dormant leaves in a certain proportion of period. A better condition of environment induces a cultivar or a clone of tea to grow more active leaves and less dormant leaves.

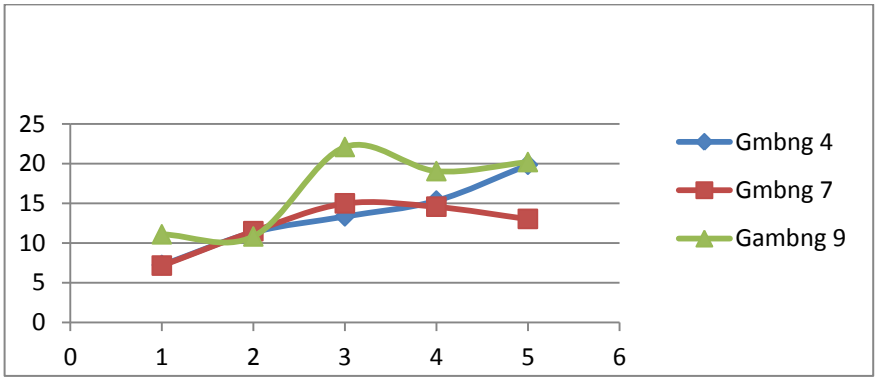
Scarce Supply of rain-water in the experiment time caused the tea plant grow slower as a result of the plant lack of available nutrition (water as solvent), and eventually caused the less production of pecco. Kigalu and Mike Carr (2006) noted differences in yield responces to density and irrigation and drought. Graph 2 and 3 show the condition of more burung appear. Longer period of dormant notes the graph of burung higher than of the pecco.



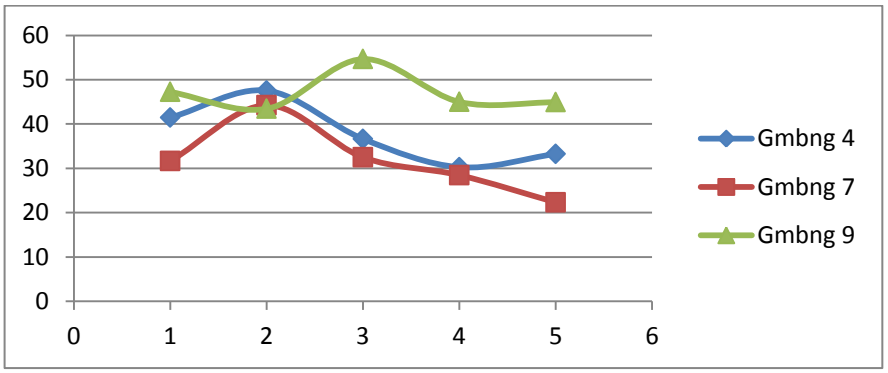
Graph 2: Number of Pecco (leaves)



Graph 3: Number of Burung/Banjhi (leaves)



Graph 4: Number of Pecco + 3 (leaves)



Graph 5: Number of Pecco + 2 (leaves)

Measuring number of pecco plus is to know the rate of growth at certain period. The graph 4 and 5 show their differences. Pecco + 2 was more than Pecco+ 3. Leaves was low in its rate due to lack of water. Pecco +3 is derived from Pecco + 2. More time was required to bear one more leaf, that is why, in the canopy more Pecco + 2 were in existence. Balamurugan and Nandagopalan (2012) said under continued plucking without pruning orskiffing , the plucking table become inconveniently high and growing apices gradually lose vigour. Pruning at this stage becomes necessary, this important practice in tea cultivation which involves removal of certain amount of growth of the bush.

The rate of apices growth to attain 2 leaves or 3 leaves before the top (pecco or burung/banjhi) were different among the treatments of plucking cycles and clones as shown in Graph 4 and 5. The pattern of graph drawn by the number of Pecco+2 leaves and Pecco+3 leaves indicated there were interaction between the plucking cycles and the clones. Different characteristic of growth rate of the clones and different plucking cycles yielded in different number of pecco and leaves. It means plucking as the action to cut the leaves can be considered as a minor/light pruning action to the tea bush, and it affects the growing rates.And it also means that the clones pattern of growth were different, and they were revealed in this experiment.

Conclusions

Plucking cycles affected significantly the physiological leavesgrowth as appeared in weight, number of pecco and burung/banjhi, and numberof pecco+2 leaves and pecco+3 leaves. Plucking cycle of 13 days affected faster growth of leaf as measured with the leaves number and weight, more time allowing more time for leaves to develop. Gambung 9 clone was the best physiological growing pattern showed the best growth of leaves in term of characteristic of harvest. There were interaction effects between the plucking cycles and the clones revealed in different growing characteristic of clones and also revealed in different effect of cultivation practices (plucking can be considered as minor or light prunning. Also in this experiment report said that atmospheric condition as the effect of the timing (season) affected the temperature and in turn affected the physiological growth of tea, and shading plants growing in tea plantation can normalize the micro-climate. And pruning is important practice for tea cultivation as it will affect the physiology of plant, it related to the rate of growth.

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