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Variation of Mineral Matter Contents in Fresh Tea (*Camelia sinensis* L.) Leaf According to Sunshine Conditions and Harvest Periods

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Abstract: This study was carried out to determine the changing of mineral matter contents according to sunshine conditions and harvest periods in fresh tea leaves (*Camelia sinensis* L.). This study was planned at three tea orchards which sunny during the day (100 % PAR), sunny half-day (66 % PAR) and shady (41 % PAR), and at three harvest periods. Al, Ca, Cu, Fe, Mg, Mn, S and Zn analyzes were made in each orchard and every harvest period. Experiment was set up out in randomized blocks design with two factors and three replications. As a result of the study, it was determined that the mineral contents of the tea leaves changed according to the sunshine conditions of the orchards and harvest periods and this situation also showed a difference according to the mineral matter.
Keywords: *Camelia sinensis*, PAR, Mineral Matter, Sunshine, Fresh Tea Leaf

Yaş Çay Yaprağı Mineral Madde İçeriğinin Güneşlenme Koşulları ve Hasat Dönemlerine Göre Değişimi

Öz: Bu çalışma yaş çay yaprağının **(***Camelia sinensis* L.) verim, kalite parametreleri ve mineral madde içeriklerinin bahçelerin güneşlenme durumu ve hasat dönemlerine göre değişimini belirlemek amacıyla yürütülmüştür. Çalışma 2015 yılında, Rize'nin Güneysu ilçesinde gün boyu güneş alan (% 100 PAR), günün yarısında güneşli (% 66 PAR) ve gölgeli bahçede (% 41 PAR) ve 3 hasat döneminde yürütülmüştür. Her bahçede ve her sürgün döneminde alınan yaş çay yapraklarında Al, Ca, Cu, Fe, Mg, Mn, S ve Zn analizleri yapılmıştır. Deneme deseni tesadüf bloklarında 2 faktörlü ve 3 tekerrürlü olarak düzenlenmiştir. Çalışma sonucunda çay yaprağının mineral madde içeriklerinin bahçelerin güneşlenme durumları ile hasat dönemlerine göre değiştiği ve bu durumun mineral madde çeşidine göre de farklılık arzettiği belirlenmiştir.
Anahtar Kelimeler: *Camelia sinensis*, PAR, Mineral Madde, Güneşlenme, Yaş Çay Yaprağı

Introduction

Despite its southern and south-east Asian origin, the tea is grown in tropical and subtropical regions all over the world. Tea plants can be economically grown in areas with abundant rainfall (Anonymous, 2016).

For the normal development of the tea plant it is necessary that the annual temperature average does not fall below 14 ° C, the total annual rainfall is not less than 2000 mm and the distribution is regular according to the month and the relative humidity is at least 70% (Anonymous, 2013).

In Turkey, tea orchards that dominated by Chinese varieties are made up of a large number of genotypes with significant differences in terms of traits such as morphology, quality, vegetative and generative growth and adaptation to ecological conditions (Anonymous, 1976).

The most important factors affecting the growth of tea plants are climate and soil. It is sometimes harmful for bright solar ray to come directly to the tea plant. It is more beneficial for the solar rays to be intermittently scattered among the clouds after a continuous rainfall. This situation is considered important because of its positive effect on the quality of tea. When shading is not applied appropriately, positive effects as well as adverse effects can be seen in tea plant (Kacar, 2010).

Mineral matters are also important for physiological, chemical and biochemical functions in plants as well as in the growth of tea plants (Kacar, 2010). Mineral matters show an increase or decrease depending on the genetic properties of the plant, on the season, the age of the tea plant, the position of the leaf, the vegetative and cultural factors such as fertilizer, pruning and climatic factors, soil properties, location, rainfall, altitude etc. (Kacar, 2010; Streeti et al., 2006).

This study was carried out to determine the changing of mineral matter contents according to sunshine condition and harvest periods in fresh tea leaves (*Camelia sinensis* L.).

Materials and Methods

The study was carried out in 2015 in the village of Ortaköy of Güneysu district of Rize province, Turkey.

The PAR (active radiation in photosynthesis) values of the orchards were determined to determine the sunshine conditions of the orchards. The temperature, humidity and PAR data logger kit was used for determining of the orchards (Table 1).

Table 1. Average temperature, humidity and PAR values determined in research orchards between 01.07.2015-20.08 2015

Sunshine condition	Temp. (°C)	Humidity (%)	PAR (µmol)	PAR (%)
Sunny during the day (SDD)	23.11	91.20	263.43	% 100
Sunny half-day (SHD)	23.47	90.80	173.67	% 66
Shady (SH)	22.14	97.14	107.80	% 41

Soil characteristics of experimental sites are presented in Table 2.

Table 2. Soil characteristics of experimental sites

	SDD	SHD	SH
pH	4.83	5.35	4.58
Nitrogen	0.285 N	0.668 N	0.335 N
Phosphorus	33 ppm	62 ppm	33 ppm
Potassium	256 ppm	417 ppm	219 ppm
Organic Matter (%)	3.65	8.77	4.63

In 2015, mineral matter analyzes (copper, manganese, iron, zinc, calcium, magnesium, aluminum, sulfur) were made on leaf samples taken during the 3 harvest periods from May to September. The harvest was carried out in the 1st harvest period on 27.05.2015, in the 2nd harvest period on 26.07.2015, in the 3rd harvest period on 13.09.2015.

The mineral matter analysis of fresh tea leaves were carried out in the laboratory of Atatürk Tea and Horticultural Research Institute Directorate in the province of Rize (Turkey). Analyzes of mineral matters were made by nitric-perchloric acid mixture in the atomic absorption method according to wet burning technique (Kacar, 1991; Turan et al., 2016).

This study was planned at three tea orchards which sunny during the day (SDD, 100 % PAR), sunny half-day (SHD, 66 % PAR) and shady (SH, 41 % PAR), and at three harvest periods. Experiment was set up out in randomized blocks design with three replications.

Results and Discussion

As a result of the analysis of variance, it was determined that the Al content was significant for the sunshine conditions; Ca and Mg were significant for harvest periods; Cu, S and Zn were significant for the sunshine conditions and harvest periods; Fe and Mn were significant for the sunshine conditions, harvest periods and the orchards*harvest periods interaction (Table 3).

The maximum values of mineral matter contents of fresh tea leaves were found in the SDD, SH and SHD orchards for Al; at the third, second and first harvest periods for Ca; at the first, second and third harvest periods for Mg; in the SDD, SH and SHD orchards, and at the third, first and second harvest periods for Cu; in the SDD, SHD and SH orchards, and at the second, third and first harvest periods for S and Zn; in the SDD orchard*first harvest period, SHD orchard*third harvest period interactions for Fe; and in the SDD orchard*first harvest period, SDD orchard*third harvest period interactions for Mn, respectively.

Kacar et al. (1979) stated that the Cu content increased in parallel with the increase in harvest periods, and that Fe and Mn contents of the tea leaves were mostly in the second harvest period. In our study, the copper content of tea leaves fluctuated according to the period of harvest, but it was most found in the third harvest period. On the other hand, the highest iron content in our study was determined as the first and the highest Mn content was determined in the third harvest period. According to Kacar (2010), it is stated that the tea plants grown in the shade are higher than the other mineral content except Mg. However, in our study, the highest values were determined in the first exile period. It is thought that the differences between the studies can be caused by ecology, orchard conditions, soil structure and tea genotypes differences. In fact, Matsumoto et al. (1796) stated that there may be changes in the content of nutrients of tea leaves according to sunshine condition and harvest periods.

In our study, the Ca content increased as the periods of harvest increased. Also, Taban et al. (2000 and 2001) stated that while the amount of Cu, Fe, Mn and Zn concentrations of leaf decreased, the Ca concentrations increased in accordance with harvest periods. On the other hand, Kacar (2010) also stated that calcium accumulates more in old leaves because it is immobilized and this situation varies according to varieties and soil Ca content, and Sud et al. (1995) stated that high temperature and high atmospheric evaporative demand assisted calcium uptake whereas high humidity and high rainfall reduced it.

In our study, the Cu content of the tea leaves showed irregular changes according to the sunshine condition and harvest periods. Kacar (2010) also stated that there are indeterminate relationships between the age of tea plant leaves and Cu contents. On the other hand, high weekly evaporation, weekly relative humidity and accumulated rainfall depressed the uptake of copper, iron and zinc in green tea shoots (Sud et al., 1995).

In our study, iron content showed change with sunshine condition and harvest periods. On the other hand, Horuz and Korkmaz (2006) stated that iron content changes irregularly according to harvesting periods.

In our study, magnesium content decreased gradually according to harvest periods. Kacar (2010) states that the Mg content of tea leaf shows an interesting change and it is more in old leaves, and the amount of Mg was higher in the second harvest than in the first harvest period, but there were no significant differences between the harvest periods.

In our study, the content of manganese has changed with the sunshine condition and harvest periods as in the iron content. The amount of manganese in the soil on the manganese amount of leaves, the climate, plant variety, the position of the leaf, the time of sampling is influenced by many factors and it is seen more in the old leaf (Kacar, 2010). Low temperature and high humidity reduced manganese uptake (Sud et al., 1995).

The useful zinc content of the soil may vary depending on factors such as climate, cultivar and leaf age (Kacar, 2010). Tsushida and Takeo (1977) reported that the Zn content of young organs is higher than that of the older organs. Kacar et al. (1979) determined that according to the harvest periods, Zn contents were 45 ppm in the first period, 33 ppm in the 2nd second and 41 ppm in the third period. Our results are consistent with these literature.

It was found that the different clones varied significantly ($p \leq 0.05$) in their micronutrient levels when planted in a single location under similar agronomic practices and this did not follow a similar pattern when the clones were planted in different locations (Nyaigoti Omwoyo et al.2014). Ferrera et al. (2001) stated that the variation of mineral composition are linked to different origins of the tea plant. In addition, Wong et al. (1998) stated that distributions of Al, Cu and Zn in different parts of the tea plant and in the different provinces varied.

Conclusion

According to these results, it can be said that the content of mineral matter in fresh tea leaf may change according to the sunshine conditions of the orchards and harvest periods and this situation also showed a difference according to the mineral matter. Thus there is need to identify the micronutrient content of tea plants according to regions and environmental conditions.

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Table 3. Changing of mineral matter contents (ppm) of fresh tea leaves according to sunshine conditions and harvesting periods

Sunshine Condition	**Harvest Periods**			**Mean**
	First	**Second**	**Third**	
		Al		
SDD	957.833	1262.700	1318.117	**1179,550 A**
SHD	861.667	860.743	935.743	**886.051 B**
SH	1349.617	998.087	1089.753	**1145.819 A**
Mean	**1056.372**	**1040.510**	**1114.538**	
		Ca		
SDD	3479.083	4219.100	4231.933	**3976.706**
SHD	3615.670	4096.783	4085.477	**3932.643**
SH	3420.950	4212.477	4245.820	**3959.749**
Mean	**3505.234 B**	**4176.120 A**	**4187.743 A**	
		Cu		
SDD	10.450	8.137	10.743	**9.777 A**
SHD	6.030	7.060	10.410	**7.833 B**
SH	9.187	7.220	12.230	**9.546 A**
Mean	**8.556 B**	**7.472 B**	**11.128 A**	
		Fe		
SDD	187.000 a	170.187 ab	120.653 c	**159.280 A**
SHD	163.500 b	122.547 c	80.417 e	**122.154 B**
SH	122.583 c	92.077 de	114.293 cd	**109.651 B**
Mean	**157.694 A**	**128.270 B**	**105.121 C**	
		Mg		
SDD	1559.793	770.190	750.460	**1026.814**
SHD	1467.987	844.320	826.037	**1046.114**
SH	1575.860	836.217	805.373	**1072.483**
Mean	**1534.547 A**	**816.909 B**	**793.957 B**	
		Mn		
SDD	1464.750 a	1008.410 bc	1464.000 a	**1312.387 A**
SHD	897.153 bc	950.270 bc	1032.120 b	**959.848 B**
SH	555.660 d	847.843 c	884.987 bc	**762.830 C**
Mean	**972.521 B**	**935.508 B**	**1127.036 A**	
		S		
SDD	3559.377	3965.710	3898.857	**3807.981 A**
SHD	3397.437	3615.147	3483.357	**3498.647 B**
SH	3192.317	3604.733	3555.983	**3451.011 B**
Mean	**3383.043 B**	**3728.530 A**	**3646.066 A**	
		Zn		
SDD	38.667	24.083	29.167	**30.639 A**
SHD	26.000	22.167	25.500	**24.556 B**
SH	26.167	22.817	23.500	**24.161 B**
Mean	**30.278 A**	**23.022 B**	**26.056 B**	

	Al	Ca	Cu	Fe	Mg	Mn	S	Zn
$LSD_{Sunshine\ condition}$:	193.585	-	1.355	13.232	-	94.954	11.340	3.596
$LSD_{Harvesting\ periods}$:	-	155.092	1.355	13.232	124.727	94.954	11.340	3.596
$LSD_{Interaction}$:	-	-	-	22.918	-	164.465	-	

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