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Herbage Growth and Fodder Yield Characteristics of Kermes Oak (*Quecus coccifera* L.) in a Vegetation Period

[1]Ahmet Tolunay, [2]Veysel Ayhan, [2]Elif Adiyaman, [1]Ayhan Akyol and [2]Duygu Ince
[1]Faculty of Forestry, [2]Faculty of Agriculture, Süleyman Demirel University,
Eastern Campus, 32260 Isparta, Turkey

Abstract: This study investigates, the growth characteristics (growth of shoot length, number of leaves on terminal shoots, herbage yield) of herbage samples taken from kermes oak at 6 time intervals (April 15, May 15, June 15, July 15, August 15, September 15) as well as the seasonal change of certain nutritional contents (dry matter, water content, crude ash, organic matter) within the biomass obtained from these samples. The vegetation period started on March 15 and the shoots displayed their fastest development on April 15, May 15 and June 15 (4.25 7.48 and 8.77 cm, respectively). On July 15 and on subsequent intervals, the shoots did not display any growth in length. On April 15, the average number of leaves on main shoots was 10.17 and this figure was 13.42 on May 15. On June 15 and on subsequent intervals, a loss was recorded in the number of leaves on shoots. On April 15, when the first recordings were taken at the beginning of the vegetation season, the average amount of herbage obtained from an area of 1 m^2 was 241.00 g. The amount of herbage, marked its greatest increase between intervals on May 15 and reached an average of 441.83 g m^{-2}. The average herbage amount obtained on June 15 was 574.66 g m^{-2} and on July 15, this figure was 635.00 g m^{-2}. The amount of herbage did not mark any significant increase on August 15 and on September 15 ($p<0.05$). According to laboratory analyses, the average amount of dry matter in biomasses was 32.03% on April 15 and this ratio marked an increase on May 15 and June 15, reaching 56.85% on July 15 and no subsequent increase was recorded following this date. The ratio of organic matter in the first biomass sample that was taken on April 15 was 30.49%. This figure marked its greatest increase among the intervals on May 15, reaching 41.61%. On June 15, the organic matter ratio was 51.70%. The amount of organic matter in the analyses that were performed on July 15 was 54.48%. On August 15 and September 15, this figure increased in small increments and reached 55.60 and 56.07%, respectively ($p<0.05$). The herbage yield obtained from an area of one hectare during the vegetation period varied between 2 410.0-6 366.6 kg ha^{-1}, dry matter yield between 772.0-689.4 kg ha^{-1}, crude ash yield between 37.1-150.5 kg ha^{-1} and organic matter yield between 734.9-3 569.8 kg ha^{-1}. Herbage yield, dry matter, water content, crude ash and organic matter production values for diverse land coverage or mixed scrub species kermes oak scrublands can be calculated by utilizing the data of the study and research results can be adapted for diverse land conditions.

Key words: Herbage growth, fodder yield, vegetation period, kermes oak, scrubland, pure hair goat, Mediterranean region, Turkey

INTRODUCTION

Kermes oak is native to the Western Mediterranean region, from Morocco and Portugal to Turkey in the east. It is a large shrub, on rare occasions, a small tree, ranging between one and 6 m in height (on rare occasions up to 10 m) and a trunk diameter of 50 cm. It is an evergreen, with spiny, serrated leaves ranging between 1.5-4 cm in length and 1-3 cm in width. The acorns range between 2-3 cm in length and 1.5-2 cm in diameter. The acorns mature about 18 months after pollination and are retained within a cup that is densely covered in elongated, reflexed scales. Kermes oak grows very thickly on the hottest and driest hills throughout the Mediterranean region. In the spring, the bush sprouts fluffy, yellow catkins and acorns which ripen every second year among the old foliage (Davis, 1979).

The kermes oak scrublands constitute a grazing range, covering more than 2.4 million ha in Turkey. This area makes up 10% of the country's general forest land.

Corresponding Author: Ahmet Tolunay, Faculty of Forestry, Süleyman Demirel University, Eastern Campus, 32260 Isparta, Turkey

The land provides grazing ground for hair goats whose population is approximately at 6.5 million in the country (TUIK, 2008). Goat husbandry depends both on the grazing range and the herbage provided by kermes oak scrubland.

Various studies have been conducted to investigate grazing in forest meadows and forage yield in Turkey (Defne, 1955; Alpay, 1972). Furthermore, there are also studies regarding the utilization of forest tree leaf fodders (Mol, 1982; Sevimsoy and Sun, 1987). These studies have highlighted the damage inflicted on forests and trees by pure hair goats (*Capra hircus* L.) and requests have subsequently been made to keep these animals away from forests. However, countries located in the Mediterranean Region have noticed the importance of the kermes oak (*Quercus coccifera* L.) in goat breeding and tried to develop their breeding system (Papachristou, 1997; Aldezabal and Garin, 2000; Boyazoglu and Morand, 2001; Ainalis and Tsiouvaras, 2004; Ainalis *et al*., 2006; Zarovali *et al*., 2007).

In Turkey, kermes oak is considered a lowly shrub variety due to the perception that it is unable to yield a productive forest. Despite the fact that it is a significant source of fodder for feeding pure hair goats, herbage growth and fodder yield characteristics of kermes oak are not known. This study determines, the herbage growth and fodder yield characteristics of kermes oak during the vegetation period.

MATERIALS AND METHODS

Study area: This study was conducted at Süleyman Demirel University, Research and Implementation Forest Areas, Province of Isparta in the Western Mediterranean region of Turkey. The study area is located between 37°83'50"-37°83'3'1"N latitude and 30°51'72"-30°51'94"E longitude, at an elevation of 1,250 m. Its aspect is towards the southwest.

According to the data, provided by the closest meteorology station, Isparta meteorology station, the long-term average annual rainfall is 600.4 mm and the average air temperature is 12.1°C. During the winter (December-March) and summer (June-September) seasons, average air temperature ranges between 1.7 and 5.8 and 19.7-23.1°C, respectively and average rainfall ranges between 90.0, 100.0, 9.6 and 36.6 mm, respectively. The climate of the area is characterized as semi-arid with cold winters (SMSI, 2008). The soil texture is clay to wet clay, derived from conglomerates of the Mesozoic Era and colluvials from the river or torrent bank deposits (Atalay, 2006). A range of organic matter content between 2.60 and 3.20%, a pH of 7.5 are considered average.

The shrub variety that has demonstrated the sturdiest distribution within the area of study is kermes oak (*Quercus coccifera* L.). Up until 7 years ago, this area served as grazing ground for pure hair goats. It was subsequently allocated by the university as a research and implementation forest and was closed to all types of grazing. Land coverage of kermes oak varies between 70 and 90%, shrub height varies between 50 and 150 cm. Due to its pebbly surface, the site is not amenable to industrial plantation. The presence of herbaceous species such as spurge (*Euphorbia* L.) and dark mullein (*Verbascus* L.) in the area points to a low site index.

Experimental procedure

Field measurements: An area of 3 ha in the university research forest with a uniform environment of growth characteristics (aspect, altitude, slope, soil, etc.) has been selected. Kermes oak shrubs that have spread over an area of at least 6 m^2 in this zone were identified and 30 shrubs with these characteristics were randomly selected. A sampling quadrangle was created around the sampling site by using wood sticks of 1×1 m. At each vegetation interval, 30 different sites were selected for determining the amount of herbage yield and shoots and leaves that grew during each vegetation period within an area of 1 m^2 at these selected sites were collected. Representative, hand-picked forage samples (Cook, 1964) similar to those consumed by animals were collected. Samples from the experimentation site were taken on April 15, May 15, June 15, July 15, August 15 and September 15 of 2008. Green herbage samples that were collected were weighed and at each interval, numerical data for samples taken from 30 kermes oak shrubs were recorded. In addition, 10 shoots within a sample site of 1 m^2 were randomly selected. The lengths of the shoots were measured and the number of leaves on each shoot was counted. The average of 10 shoot lengths and 10 leaf numbers that were obtained within the sample site of 1 m^2 was calculated and recorded. Therefore, at each interval, 30 average shoot lengths and leaf numbers were recorded.

Laboratory analyses: At each interval, 30 herbage samples that were obtained were mixed and formed into one single sample which was then ground at a hummer mill with a sieve of 3 mm. A sample was taken from this biomass in order to identify its dry material and water contents. All samples were oven-dried at 105°C for 24 h and weighed. Percentage ratios of the dry material and water contents of the samples were thus determined. Biomass samples were oven-dried at 550°C for 24 h in order to determine their raw ash contents. The raw ash

figure that was obtained was subtracted from the dry material figure and the percentage ratio of organic material was obtained. These procedures were conducted in the laboratory and consisted of 3 parallel and 4 repeated analyses at each interval.

Statistical analyses: All data sets were subjected to repeated ANOVA measurements in order to test their statistical significance across the 6 intervals. The Tukey test was used in order to measure statistical differences between means (Steel and Torrie, 1980). The statistical analyses were carried out using SPSS 16.0 software for Windows. All tests were performed at a significance level of $p<0.05$.

RESULTS AND DISCUSSION

Field measurements results: Results of ANOVA on growth of shoot length (cm), number of leaves on terminal shoot (piece), herbage yield (g m^{-2}) are presented in Table 1. Differences among the interval means as a result of variance analysis are statistically significant. Results of the Tukey test are shown in Latin letters above the averages.

Growth of shoot length: After the beginning of the vegetation period in mid-March, the first measurement of kermes oak shoot length was taken on April 15. The average shoot length on this date was 4.25 cm. The increase in shoot length continued until May 15 and the average shoot length during this period was 7.48 cm. The average shoot length on June 15 was 8.77 cm. The increase in shoot length between April 15 and May 15 (7.48-4.25 = $^{+}$3.23 cm) was lower than the increase in shoot length between May 15 and June 15 (8.77-7.48 = $^{+}$1.29 cm). Shoot length growth came to a stop after June 15. No variance ($p<0.05$) was found among measurements taken during the periods from June 15 until September 15.

Number of leaves on terminal shoots: On April 15, the average number of terminal shoots was 10.17. On May 15, the average number of leaves was found to be 13.42. Measurements taken on June 15 revealed a very low level of increase in the number of leaves on shoots and the average leaf count was 14.84. Measurements taken after this period reveal a decrease in the number of leaves on shoots (the number of leaves on September 15 was 14.64) ($p<0.05$).

Yield of herbage: The amount of herbage obtained from an area of 1 m^2 on April 15 when the first measurements were taken at the beginning of the vegetation season was 241.00 g m^{-2}. On May 15, the average figure was 441.83 g m^{-2}, reflecting the highest monthly increase among the intervals (The amount of increase between April 15 and May 15 was 441.83-241.00 = $^{+}$200.83 g m^{-2}). The average amount of herbage obtained from an area of 1 m^2 at the next measurement interval, June 15, was 574.66 g m^{-2}. The amount of herbage increase between May 15 and June 15 was 574.66-441.83 = $^{+}$132.80 g m^{-2}. Measurements taken on July 15 revealed an increase of 60.34 g m^{-2} in the average herbage amount obtained from an area of 1 m^2, reaching 635.0 g m^{-2}, over measurements taken on June 15. Measurements taken on August 15 and September 15 revealed no variance between the intervals due to a lack of increase in the herbage amount ($p<0.05$).

Table 1: Field measurement results of the study

	Growth of shoot length (cm)		Number of leaves on terminal shoot (piece)		Herbage yields (g m^{-2})	
Date	Min.-Max.	Mean±SD	Min.-Max.	Mean±SD	Min.-Max.	Mean±SD
April 15 2008	3.48-5.13	4.25±0.42^{c,1}	7.60-12.40	10.17±1.360^{e}	80.0-410.0	241.00±98.830^{d}
May 15 2008	6.63-8.710	7.48±0.530^{b}	12.50-14.80	13.42±0.640^{d}	175.0-750.0	441.83±174.53^{c}
June 15 2008	7.48-10.74	8.77±0.910^{a}	13.50-16.00	14.84±0.700^{a}	260.0-890.0	574.66±196.84^{b}
July 15 2008	7.42-10.46	8.70±0.850^{a}	13.40-15.60	14.60±0.45^{a,b}	280.0-980.0	635.00±212.40^{a}
Aug. 15 2008	7.36-10.45	8.68±0.860^{a}	13.60-15.00	14.21±0.27^{b,c}	290.0-990.0	636.33±214.82^{a}
Sept. 15 2008	7.32-10.42	8.64±0.860^{a}	13.24-14.90	14.08±0.310^{c}	280.0-980.0	636.66±210.45^{a}

[1]Means in the same column followed by the same letters are not significantly different at the 0.05 level; SD: Standard Deviation

Table 2: Laboratory analysis results of the study

	Dry matter ratio (%)		Water content ratio (%)		Crude ash ratio (%)		Organic matter ratio(%)	
Date	Min.-Max.	Mean±SD	Min.-Max.	Mean±SD	Min.-Max.	Mean±SD	Min.-Max.	Mean±SD
April 15 2008	31.75-32.38	32.03±0.32^{d,1}	67.62-68.25	67.97±0.32^{a}	1.48-1.49	1.54±0.050$_{d}$	30.16-30.84	30.49±0.34^{e}
May 15 2008	42.55-43.97	43.26±0.710^{c}	56.03-57.45	56.74±0.71^{b}	1.55-1.72	1.65±0.09$_{c,d}$	40.86-42.25	41.61±0.70^{d}
June 15 2008	53.07-54.80	53.83±0.880^{b}	45.20-46.93	46.17±0.88^{c}	2.03-2.28	2.13±0.13$_{a,b}$	50.98-52.52	51.70±0.77^{c}
July 15 2008	56.26-57.42	56.85±0.580^{a}	42.58-43.74	43.15±0.58^{d}	2.18-2.47	2.37±0.160$_{a}$	53.80-54.95	54.48±0.60^{b}
Aug. 15 2008	57.13-57.72	57.35±0.320$_{a}$	42.28-42.87	42.65±0.32^{d}	1.69-1.80	1.75±0.05$_{c,d}$	55.37-55.92	55.60±0.28^{a,b}
Sept. 15 2008	57.79-58.13	57.95±0.170^{a}	41.87-42.21	42.05±0.17^{d}	1.86-.1.91	1.88±0.02^{b,c}	55.93-56.22	56.07±0.14^{a}

[1]Means in the same column followed by the same letters are not significantly different at the 0.05 level; SD: Standard deviation

Table 3: Some forage yield characteristics of kermes oak

Date	Herbage yield (kg ha^{-1})	Dry matter yield (kg ha^{-1})	Water amount (kg ha^{-1})	Crude ash yield (kg ha^{-1})	Organic matter yield (kg ha^{-1})
April 15 2008	2410.0	772.0	1638.0	37.1	734.9
May 15 2008	4418.3	1911.3	2507.0	72.9	1838.4
June 15 2008	5746.6	3093.3	2653.3	122.4	2970.9
July 15 2008	6350.0	3610.0	2740.0	150.5	3459.5
Aug. 15 2008	6363.3	3649.3	2714.0	111.3	3538.0
Sept. 15 2008	6366.6	3689.4	2677.2	119.6	3569.8

Table 4: Biomass yields of kermes oak at different land coverage percentages

Date	10% (kg ha^{-1})	30% (kg ha^{-1})	50% (kg ha^{-1})	70% (kg ha^{-1})	100% (kg ha^{-1})
April 15 2008	241.0	723.00	1205.0	1687.0	2410.0
May 15 2008	441.8	1325.4	2209.1	3092.6	4418.3
June 15 2008	574.6	1723.0	2873.3	4022.2	5746.6
July 15 2008	635.0	1905.0	3175.0	4445.0	6350.0
Aug. 15 2008	636.3	1908.9	3181.6	4454.1	6363.3
Sept. 15 2008	636.6	1909.8	3183.3	4456.2	6366.6

Laboratory analyses results: Results of ANOVA on dry matter ratio (%), water content ratio (%), crude ash ratio (%), organic matter ratio (%) are presented in Table 2. Differences in averages among the periods as a result of the variance analysis are statistically significant. Tukey test results are shown in Latin letters above the averages.

Dry matter ratio: Measurements taken on April 15 indicate an average dry matter ratio of 32.03% in biomasses. This ratio showed the largest increase among the periods on May 15 (an increase of $^{+}$11.23% in dry matter from April 15 to May 15) and reached 43.26%. The ratio of dry matter in biomass samples showed an increase of $^{+}$10.57 on June 15 over May 15 and reached 53.83%. On July 15, the dry matter ratio showed very little increase ($^{+}$3.02) and reached 56.85%. Results of analyses conducted on August 15 and September 15 after this period did not show a statistical difference from measurements taken on July 15 and no increase in dry matter ratio was recorded ($p<0.05$).

Water content ratio: Biomass water ratios taken at each period revealed results that were inverse to the dry matter ratios. Biomass water ratios showed a consistent decrease on April 15, May 15, June 15 and July 15 (67.97, 56.74, 46.17 and 43.15%, respectively). Measurements taken on July 15, August 15 and September 15 showed no variation among the periods ($p<0.05$).

Crude ash ratio: The crude ash ratio in biomass samples was found to be 1.54% on April 15. This ratio was found to have increased on May 15 and July 15-1.65 and 2.13%, respectively. The highest crude ash ratio during the vegetation period was found on July 15 (2.37%). The crude ash ratio fell on August 15-1.75% and showed a slight increase on September 15, reaching 1.88% ($p<0.05$).

Organic matter ratio: According to the laboratory analysis results conducted on samples taken throughout the 6 periods, the only item whose ratio showed a consistent increase in relation to the vegetation period was the ratio of organic matter. The first biomass sample taken on April 15 showed an organic matter ratio of 30.49%. The ratio of organic matter marked its largest increase among the periods between April 15 and May 15 with a rise of $^{+}$11.12%, reaching a ratio of 41.61% on May 15. Analysis of biomass/herbage samples on June 15 showed an organic matter ratio of 51.7%, an increase of $^{+}$10.09 over measurements taken on May 15. The amount of organic matter on July 15 was found to be 54.48%, an increase of $^{+}$2.78 and marked small increases on August 15 and September 15 ($^{+}$2.78 and $^{+}$0.47, respectively), reaching 55.60 and 56.07%, respectively ($p<0.05$).

Calculation of some forage yield characteristics of kermes Oak: Herbage yield measurements in this study, trial design were conducted using g m^{-2} as the unit of measurement. In other words, herbage values obtained from an area of 1 m^{2} at each period are measured in grams. These figures must be converted into kg ha^{-1} for practitioners who will prepare a grazing plan for kermes oak areas in any region. Furthermore, when biomass yield percentages as a result of laboratory analyses conducted over 6 periods during the vegetation period are compared with the herbage weights obtained over the same period, it is possible to convert dry matter, water content amount, crude ash and organic matter yields into kg ha^{-1}. The resulting calculations have yielded the following figures as indicated in Table 3.

The herbage amount obtained from an area of 1 ha during, the vegetation period varies between 2 410.0 and 6 366.6 kg ha^{-1}. The herbage amount obtained from an area of 1 ha from the beginning of the vegetation period until April 15 is 2 410.0 kg. This figure marked its steepest 1 month increase on May 15 and reached 4, 418.3 kg ha^{-1}. The average herbage amount obtained from an area of 1 ha on June 15 is 5 746.6 kg ha^{-1} and on July 6 350.0 kg ha^{-1}. No increase has been marked in the herbage amount on August 15 and September 15.

The figures provided in Table 3 are valid for circumstances where the land coverage percentage for kermes oak is 100%. However, under real land conditions, it may not be possible to find kermes oak scrubland with a coverage percentage of 100%. Furthermore, it may not be possible to locate vegetation where kermes oak is the sole native species. Therefore, Table 4 was prepared for kermes oak scrubland with varied land coverage and mixed scrub species. By taking this Table 4 as a reference point, it is possible to calculate

yield values appropriate for real land conditions according to the specific coverage and mixed species ratios.

The values provided in Table 4 are herbage yield values for kermes oak at varied land coverage and mixed species ratios. Similarly, by taking into consideration land coverage and mixed scrub species ratios ranging from 0-100%, it is possible to calculate dry matter yield, water amount, crude ash yield and organic matter yield.

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