Effects of shading on herbaceous plant patches transplanted reciprocally between three shading treatments

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Effects of shading on herbaceous plant patches transplanted reciprocally between three shading treatments

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Abstract. The effect of three shading origins and of three shading levels on the above-ground production and nutritive value of herbaceous vegetation were studied for two years. The experiment was conducted in Laggadia, north of the city of Thessaloniki, Greece close to the borders of the FYROM. Three treatments, 0% shading level (open grassland), 75% shading level (medium density forested area) and 95% shading level (high density forested area) were studied. From each origin 45 patches 30 × 30 cm were dug and then transplanted, 15 patches to each treatment. The experimental layout was a split plot design. It included the three shading origins as the whole pots and the three shading treatments as sub-plots. Herbage production, CP and ADF contents were not affected by the shading origin, while NDF content was higher and ADL lower for the patches originating from the open area. Average herbage production and ADF content were statistically different between shading levels: they were higher for the open area compared to medium and high density forest stands. Only high shading resulted in significantly higher CP values on average, while NDF and ADL content was not affected by shading levels.

Keywords. Agroforestry system – Herbage production – Nutritive value – Shading level.

I – Introduction

Trees affect the understory herbaceous vegetation primarily by intercepting light which is the critical factor for herbaceous plants growth (Sibbald et al., 1991; Braziotis and Papanastasis, 1995) although competition for soil, water and nutrients may also be important in this respect (Rao, 1998; Nissen et al., 1999). Shading though modifies the rate of photosynthesis and the water relations of herbaceous vegetation (Bergez et al., 1997). Some researchers have reported that herbage production decreases as shading intensity increases (Pase, 1958; Knowles, 1991), while other...
(Holland, 1979; Anderson and Moore, 1987; Kyriazopoulos et al., 1999, 2002) found a higher production of the understory vegetation under reduced light intensity. This might be attributed to the increased photosynthetic rate. Higher herbage production have been obtained under artificial shading of 50% (Koukoura and Nastis, 1989) compared to the control (full sun) or heavier shading (70%, 90%), and of 55% (Kyriazopoulos, 2001) compared to the control (full sun) and 85% shading. There is no doubt that natural shading under forest stands modifies not only light intensity but also relative humidity altering evapotranspiration rate and thus, soil water use efficiency as well as soil water availability. Etienne (1996) has reported that soil water loss was much lower in shaded areas of the dry Mediterranean region compared to open grasslands. It is not well documented whether under shading levels of natural forest stands herbage production would be increased due to more effective soil water use or would be reduced due to competition for soil, water and light.

Shading improves the nutritive value of the understory vegetation as it increases the crude protein (CP) content (Blair et al., 1983; Koukoura, 1987; Koukoura and Nastis, 1989; Kyriazopoulos et al., 1999) and decreases lignin content compared to non shaded vegetation (Iason and Hester, 1993). Thus, under natural shading, in addition to increased production, a higher nutritive value of the forage resource is expected.

The objective of this paper was to study the effects of different natural shading levels on the production and the nutritive value of the herbaceous vegetation and to define which shading level is the most pertinent to achieve higher production.

II – Materials and methods

The study was conducted in the area of Laggadia, Pella prefecture, 100 km north of the city of the Thessaloniki, in Macedonia, Greece close to the borders of the FYROM (40°45’N, 22°58’E at 600 m altitude). The climate of the area is classified as sub-humid Mediterranean, with a mean air temperature of 13.9°C and an annual rainfall of 453 mm. The soil of the study area is classified as chromic luvisol according to the FAO soil system classification (Kyriazopoulos, 2001). The area is situated at the lower limits where Fagus sylvatica L. occupies in the alliance of Fagion moesiaceae, association Fagetum submontanum (Athanasiadis, 1986). The experimental area was protected from grazing.

The shading levels, as measured by a liquor quantum sensor in two beech (Fagus sylvatica L.) forest stands, were 95% and 75%. The control treatment was adjacent open grassland (0% shading level). From each origin 45 patches 30 × 30 cm were dug and then transplanted, 15 patches to each treatment, in late October 1995.

Herbage production from each patch was determined for two consecutive years by clipping all vegetation at 1 cm above ground at the end of the growing season (late June) and oven-drying at 65°C for 48 h. The nutritive value of the vegetation was determined as: (i) crude protein (CP) content by Kjeldahl method (AOAC, 1990); (ii) neutral detergent fiber (NDF) by using the method of van Soest et al. (1991); and (iii) acid detergent fiber (ADF) and acid detergent lignin (ADL) by using the method of Goering and van Soest (1970).

The experimental layout was a split plot design (Snedecor and Cochran, 1989). It included the three shading origins as the whole plots and the three shading treatments as sub-plots. The data were subjected to analysis of variance using the MSTAT program (Freed, 1991). Differences among means were determined by the Duncan’s New Multiple Range Test at P < 0.05 level of significance.

III – Results and discussion

1. Herbage production

The very low herbage production during the first year of the experiment (Table 1) can be attributed
to the transplantation shock which reduced the root system length. However, during the second year of the experiment herbage production was five times higher as the plants had recovered from the transplantation shock. The shading origin did not affect the total herbage yield.

Table 1. Herbage production (kg DM/ha) of the three shading origins during the two years of the experiment

<table>
<thead>
<tr>
<th></th>
<th>Open grassland</th>
<th>Medium density forested area</th>
<th>High density forested area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>151.9 a</td>
<td>150.9 a</td>
<td>118.8 a</td>
</tr>
<tr>
<td>1997</td>
<td>850.5 a</td>
<td>846.3 a</td>
<td>972.2 a</td>
</tr>
</tbody>
</table>

a: means in the same row followed by the same letter are not significantly different (P ≥ 0.05).

During the first year herbage production was significantly higher under the full sun, while no significant differences were detected between the two shading levels (Table 2). During 1997, the limitation of light intensity resulted in a progressively significant reduction of herbage production. Lower herbage production found under the 75% and 95% shading levels is attributed primarily to the reduced photosynthetic rate under low light (Blenkinsop and Dale, 1974).

Table 2. Herbage production (kg DM/ha) in the shading treatments during the two years of the experiment

<table>
<thead>
<tr>
<th>Shading treatment</th>
<th>0%</th>
<th>75%</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>254.0 a</td>
<td>115.6 b</td>
<td>51.9 b</td>
</tr>
<tr>
<td>1997</td>
<td>1810.1 a</td>
<td>642.1 b</td>
<td>118.9 c</td>
</tr>
</tbody>
</table>

a, b, c: means in the same row followed by the same letter are not significantly different (P ≥ 0.05).

2. Nutritive value

The highest nutritive value of the herbaceous vegetation was found in the sods originated from the wider spaced tree area (Table 3). Forage from sods originated from the open area had the higher NDF and the lower ADL content. CP and ADF contents were not affected by the shading origin. These results can be probably explained by the different species composition in each shading origin.

CP content of herbage was significantly higher when light intensity decreased at the highest level (i.e. 95% shading treatment, Table 4). This increase could be associated with the stage of maturity. Under reduced light intensity plants reach maturity later in the season. Similar results have been reported by McEwen and Diets (1965), Bjorkman (1966), Phares (1971), Wolters (1973), Blair et al. (1983), Koukoura (1987), Koukoura and Nastis (1989) and Kyriazopoulos et al. (1999). According to Delvin (1966), chlorophyll decolorizes partly under high light intensity and some enzymes that participate in the composition of the proteins hibernate. ADF content was higher for the open area (0% shading) and statistically different between shading levels, but only for the second year of the experiment. NDF and ADL content was not affected by shading levels.
Table 3. Chemical constituents (% DM) of herbaceous vegetation of the three shading origins during the two years of the experiment

<table>
<thead>
<tr>
<th>Chemical constituents</th>
<th>Shading origin</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open grassland</td>
<td>Medium density</td>
<td>High density</td>
</tr>
<tr>
<td>CP</td>
<td>9.26 a</td>
<td>11.54 a</td>
<td>10.66 a</td>
</tr>
<tr>
<td>NDF</td>
<td>64.07 a</td>
<td>63.71 a</td>
<td>55.15 b</td>
</tr>
<tr>
<td>ADF</td>
<td>35.44 a</td>
<td>35.17 a</td>
<td>33.85 a</td>
</tr>
<tr>
<td>ADL</td>
<td>6.25 b</td>
<td>6.13 b</td>
<td>7.21 ab</td>
</tr>
</tbody>
</table>

a, b: means in the same row within each year followed by the same letter are not significantly different (P ≥ 0.05).

Table 4. Chemical constituents (% DM) of herbaceous vegetation of the three shading treatments during the two years of the experiment

<table>
<thead>
<tr>
<th>Chemical constituents</th>
<th>Shading treatment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>75%</td>
<td>95%</td>
</tr>
<tr>
<td>CP</td>
<td>8.59 b</td>
<td>9.93 b</td>
<td>9.70 b</td>
</tr>
<tr>
<td>NDF</td>
<td>56.45 a</td>
<td>63.75 a</td>
<td>55.85 a</td>
</tr>
<tr>
<td>ADF</td>
<td>32.47 a</td>
<td>36.72 a</td>
<td>33.41 a</td>
</tr>
<tr>
<td>ADL</td>
<td>6.71 a</td>
<td>9.98 a</td>
<td>7.89 a</td>
</tr>
</tbody>
</table>

a, b, c: means in the same row within each year followed by the same letter are not significantly different (P ≥ 0.05).

IV – Conclusions

Shading origin had no effect on herbage production and it slightly affected its nutritive value. Herbage production significantly decreased as shading level increased. Reduced light intensity increased the nutritive value of the herbaceous vegetation.

References


Nutritional and foraging ecology of sheep and goats