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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.

Effet de l'ombrage sur des plantes herbacées transplantées réciproquement entre trois types d'ombrage

Résumé. *L'effet de trois types et niveaux d'ombrage sur la production de la biomasse aérienne et sur la valeur alimentaire de la végétation herbacée a été étudié pendant deux années. Cette expérience a été conduite à Laggadia, située au nord de Thessaloniki en Grèce à proximité des frontières de FYROM. Trois traitements, 0% d'ombrage (parcours ouvert), 75% d'ombrage (densité moyenne de la superficie forestière) et 95% d'ombrage (densité élevée de la superficie forestière) ont été comparés. Pour chaque origine, 45 morceaux de terre 30 × 30 cm ont été prélevés et transplantés (15 par traitement). Le modèle expérimental adopté est le split plot avec trois origines d'ombrage correspondant aux plots et trois niveaux d'ombrage représentant les sub-plots. L'origine de l'ombrage n'a pas affecté la biomasse produite et les teneurs en matières azotées totales (MAT) et en lignocellulose (ADF). En revanche, la teneur en NDF a été plus élevée et celle d'ADL plus faible pour les morceaux de terre provenant des parcours ouverts. La production moyenne d'herbe et la teneur en ADL ont varié significativement avec le niveau d'ombrage. En effet, ces deux paramètres ont été plus élevés avec les parcours ouverts par comparaison à la densité forestière moyenne et élevée. Seul l'ombrage le plus important a été associé avec des teneurs élevées en MAT, alors que les teneurs en NDF et ADL n'ont pas été affectées avec les différents niveaux d'ombrage.*

Mots-clés. *Système agroforestier – Biomasse produite – Valeur alimentaire – Niveau d'ombrage.*

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 moesiacae*, 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

	Open grassland	Medium density forested area	High density forested area
1996	151.9 a	150.9 a	118.8 a
1997	850.5 a	846.3 a	972.2 a

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

	Shading treatment		
	0%	75%	95%
1996	254.0 a	115.6 b	51.9 b
1997	1810.1 a	642.1 b	118.9 c

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

Chemical constituents	Shading origin					
	Open grassland		Medium density forested area		High density forested area	
	1996	1997	1996	1997	1996	1997
CP	9.26 a	11.54 a	10.66 a	12.17 a	11.08 a	10.89 a
NDF	64.07 a	63.71 a	55.15 b	57.66 b	50.93 b	58.26 b
ADF	35.44 a	35.17 a	33.85 a	33.65 a	31.82 a	34.20 a
ADL	6.25 b	6.13 b	7.21 ab	10.15 a	9.08 a	8.55 ab

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

Chemical constituents	Shading treatment					
	0%		75%		95%	
	1996	1997	1996	1997	1996	1997
CP	8.59 b	9.93 b	9.70 b	11.03 b	12.70 a	13.65 a
NDF	56.45 a	63.75 a	55.85 a	57.75 a	57.84 a	58.12 a
ADF	32.47 a	36.72 a	33.41 a	34.07 b	35.23 a	32.24 c
ADL	6.71 a	9.98 a	7.89 a	6.52 a	8.94 a	8.32 a

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

Anderson G.W. and Moore R.W., 1987. Productivity in the first seven years of a *Pinus radiata* – Annual pasture agroforest in Western Australia. In: *Australian Journal of Experimental Agriculture*, 27. p. 231-238.

AOAC, 1990. *Official Methods of Analysis*, 15th edn. Washington DC, USA: Association of Official Analytical Chemists. p. 746.

Athanasiadis N., 1986. *Forest Phytosociology*. Thessaloniki, Greece: Giahoudi-Giapouli Press. 119 p. (in Greek).

Bergez J.E., Dalziel A.J.I., Duller C., Eason W.R., Hoppe G. and Lavender R.H., 1997. Light modification in a developing silvopastoral system in the UK: A quantitative analysis. In: *Agroforestry Systems*, 37. p. 227-240.

Bjorkman O., 1966. Comparative studies of photosynthesis and respiration in ecological races. In: *Brittonia*, 18. p. 214-224.

Blair R.M., Alcaniz R. and Harrell A., 1983. Shade intensity influences the nutrient quality and digestibility of southern deer browse leaves. In: *J. Range Manage.*, 36. p. 257-264.
Blenkinsop P.G. and Dale J.E., 1974. The effects of shade treatment and light intensity on ribulose-1,5-diphosphate carboxylase activity and fraction I protein level in the first leaf of barley. In: *J. Experimental Botany*, 25. p. 899-912.
Braziotis D.C. and Papanastasis V.P., 1995. Seasonal changes of understorey herbage yield in relation to light intensity and soil moisture content in a *Pinus pinaster* plantation. In: *Agroforestry Systems*, 29. p. 91-101.
Delvin R.M., 1966. *Plant Physiology*. Reinhold Books in the Biological Sciences. p. 226-276.
Etienne M., 1996. *Research on Temperate and Tropical Silvopastoral Systems*. Paris, France: INRA Editions. p. 5-19.
Freed R.D., 1991. *MSTATC: Microcomputer Statistical Program*. *Experimental Design, Data Management and Data Analysis*. Michigan State University, USA.
Goering H.K. and van Soest P.J., 1970. *Forage Fiber Analyses.* Agricultural Handbook, No. 379. Washington DC, USA: Agricultural Research Service, USDA.
Holland V.L., 1979. Effect of blue oak on rangeland forage production in Central California. In: Ecology, management and utilization of California oaks. USDA For. Serv. Pacific Southwest Forest and Range Exp. Sta. Gen. Tech. Rep. PSW-44.
Iason G.R. and Hester A.J., 1993. The response of heather (*Calluna vulgaris*) to shade and nutrients – Predictions of the carbon-nutrient balance hypothesis. In: *Journal of Ecology*, 81. p. 75-80.
Knowles R.L., 1991. New Zealand experience with silvopastoral systems: A review. In: *Forest Ecology and Management*, 45. p. 251-267.
Koukoura Z., 1987. Composition of kermes oak browse as affected by shade and stage of maturity. In: *Anim. Feed Sci. Techn.*, 21. p. 1-9.
Koukoura Z. and Nastis A.S., 1989. Effect of shade on production and forage quality of herbaceous species. In: *Geotechnical Scientific Issues*, 1. p. 17-25 (in Greek, English summary).
Kyriazopoulos A.P., 2001. Effects of shading and livestock grazing on the herbaceous vegetation to agrosilvopastoral systems. PhD Thesis: Aristotle University of Thessaloniki. 147 p. (in Greek, English summary).
Kyriazopoulos A.P., Koukoura Z. and Nastis A.S., 1999. Effects of wild cherry (*Prunus avium*) and grazing on the herbaceous understorey and its crude protein content. In: *Grassland Science in Europe*, 4. p. 187-190.
Kyriazopoulos A.P., Koukoura Z., Tsiouvaras C. and Nastis A.S., 2002. Interactions between trees and herbaceous vegetation in the early establishment stages in an agroforestry system. In: *Geotechnical Scientific Issues*, 2. p. 10-16 (in Greek, English summary).
McEwen L.C. and Dietz D.R., 1965. Shade effects on chemical composition of herbage in the Black Hills. In: *J. Range Manage.*, 18. p. 184-190.
Nissen T.M., Midmore D.J. and Cabrera M.L., 1999. Aboveground and belowground competition between intercropped cabbage and young *Eucalyptus torelliana*. In: *Agroforestry Systems*, 46. p. 83-93.
Pase C.P., 1958. Herbage production and composition under immature ponderosa pine stands in Black Hills. In: *J. Range Manage.*, 11. p. 238-243.
Phares R.E., 1971. Growth of red oak (*Quercus rubra* L.) seedlings in relation to light and nutrient. In: *Ecology*, 52. p. 669-672.
Rao M.R., Nair P.K.R. and Ong C.K., 1998. Biophysical interactions in tropical agroforestry systems. In: *Agroforestry Systems*, 38. p. 3-50.
Sibbald A.R., Griffiths J.H. and Elston D.A., 1991. The effects of the presence of widely spaced conifers on understory herbage production in the UK. In: *Forest Ecology and Management*, 45. p. 71-77.
Snedecor G.W. and Cochran W.G., 1989. *Statistical Methods*, 8th edn. Ames, Iowa, USA: The Iowa State University Press.
van Soest P.J., Robertson J.B. and Lewis B.A., 1991. Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. In: *J. Dairy Sci*., 74. p. 3583-3597.
Wolters G.L., 1973. Southern pine overstories influence herbage quality. In: *J. Range Manage.*, 26. p. 423-426.