Herbage production and number of plant species in subalpine meadows of two mountains with different geological background and soil characteristics in Northern Greece

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Abstract

In this study, the effect of soil macro-nutrient concentrations on herbage production and number of plant species in subalpine meadows of Jenna Mountain and Belles Mountain were investigated. In each study area, 9 sampling plots (4x4 m) were placed and herbage production was collected, and the number of plant species was recorded monthly from May to September 2011. The texture of soils was determined, and the concentrations of organic matter, total Nitrogen, Phosphorus, exchangeable potassium were measured. A total of 129 species were recorded on Mt Jenna while 161 species were recorded on Mt Belles. The average herbage production was significantly higher ($p<0.05$) on Mt Belles. A positive correlation between herbage production and soil N, K and OM were observed on Mt Belles while no such correlations were observed on Mt Jenna. On both mountains there was a negative correlation between the number of species and herbage production. Results from soil analysis showed that the concentrations of total N and OM were higher ($p<0.05$) in the 0-10 cm depth compared to the 10-20 cm depth. Exchangeable K was higher ($p<0.05$) on Mt Belles, however total N was higher ($p<0.05$) on Mt Jenna. It seems that the climatic conditions as well as the geological background may have affected these findings.

Key words: subalpine meadows, biomass, plant species, potassium, nitrogen

Introduction

There has been a lot of research in recent years focused on the factors that affect the floristic diversity of meadows. Especially for subalpine meadows, where human intervention is kept to a minimum as compared to farm meadows, the most important factors are forage production and soil parameters (De Deyn et al. 2004).

It is known that forage production depends on soil fertility (Tallowin et al. 1994). Several researchers noted that increased soil nitrogen, after fertilization, decreases the number of species in the plant community (Elisseou et al. 1995, Willems et al. 1996). Also other soil nutrients, such as phosphorus and potassium, can result in a decrease to floristic diversity

(Bobbink et al. 1991, Aerts et al. 2003). Usually, pH determines the species in a plant community and shows high correlation to plant diversity but, in some temperate regions of southwest Europe, it was not correlated with pH at all (Janssens et al. 1998). Moreover, Koerselman and Meuleman (1996) stated that the ratio N/P is a significant determining factor for floristic diversity and they concluded that when it ranged between 10 and 14, the highest floristic diversity was achieved. However, other researchers (Marrs 1993, Smith1994) reported that grasslands with higher biodiversity are found on soils with a low nutrient status.

The aim of the study was to determine the effects of soil characteristics of two distinct areas with different geological background, on the herbage production and the number of plant species.

Materials and methods

The study was conducted in 2011 at Mt Jenna and Mt Belles which have different geological backgrounds, in Greece. A subalpine meadow area was selected on each mountain to investigate herbage production as well as the number of plant species. On Mt Jenna (longitude 22° 13′, latitude: 41° 09′) the sampling sites were located at an altitude of 1770m – 1900m. The parent material is of volcanic origin, mostly trachyte, and sandstone. On Mt Belles (longitude 22° 53′, latitude: 41° 20′) the sampling sites were located at an altitude of 1680m-1790m. Mt Belles has a uniform geological background with metamorphic rocks, mostly gneiss. The mean temperature during the growth period was 24.5°C and 10.06°C and precipitation was 40 mm. and 25.7mm for Mt Belles and Mt Jenna, respectively.

Nine sampling plots (4x4m) were selected to determine herbage production and samples were taken at monthly intervals from May to September of 2011 coinciding with the growing period, of each subalpine meadow. Plant species were collected and identified using the Treatises Mountain Flora of Greece (Strid 1986, Strid and Tan 1991) and Flora Europaea (Tutin et al. 1964-1980).

Soil cores were collected from two different depths, 0-10 cm and 10-20 cm, with 3 replications in each plant sampling plot in the two study areas. Percentage of clay (Bouyoucos 1962), sand and silt, organic matter (Walkley and Black 1934), total Nitrogen (Kjeldahl), Phosphorus (Olsen) and exchangeable potassium (Page et al 1982) were measured.

Statistical analysis was done using JMP ® 8 (Sall et al. 2007). The average, standard deviation and correlation coefficients were determined. ANOVA analysis (students'–*t* test) was used to determine significant differences

(p≤0.05) between the two different depths as well as between the two study areas for the nutrients' content, herbage production and number of species.

Results and Discussion

A total of 129 species consisting of 33 families and 83 genera were recorded in the subalpine meadows of Mt Jenna. Most of the taxa of this area belong to Caryophyllaceae (14), Asteraceae (12), Rosaceae (11), Poaceae (10) and Fabaceae (9) family. On Mt Belles,161 species consisting of 34 families and 107 genera were recorded. Most of the taxa belong to Caryophyllaceae (19), Asteraceae (19), Lamiaceae (12), Poaceae(14), Fabaceae (9), Rosaceae (9) and Scrophulariaceae (8) family. 25 species were common in both study areas.

Mean average herbage production was higher on Mt Belles (Table 1). The peak of herbage production on Mt Jenna was in August while on Mt Belleswas in July. There were differences (P<0.05) in herbage production between the two mountains for May, June and July, while no such differences were observed for August and September.

Table 1. Herbage production in Mt Jenna and Mt Belles

Herbage production kg/ha	Study area	May	June	July	August	September	Average
	Jenna	314^{a}±212	974^{a}±461	1939^{a}±1180	2062^{a}±1006	1195^{a}±398	1296^{a}±721
	Belles	899^{b}±216	1720^{b}±746	2496^{b}±1289	1889^{a}±951	1288^{a}±722	1658^{b}±606

Data are average values ±S.D. (n=9). Different letters in columns indicate significant differences between study areas (*P*<0.05).

Soils on Mt Jenna are classified according to USDA (1951) as Sandy loams and on Mt Belles as Loamy sands. Soil analysis results showed that the concentrations of K, total N, and organic matter were higher (p<0.05) in depth 1 compared to depth 2, while there was no difference in the concentration of P (Table 2). Exchangeable K was higher (p<0.05) on Mt Belles, while the opposite was observed for total N.

For the area on Mt Belles there was a positive correlation between herbage production and K, OM and N content of the soil while there was no correlation between herbage production and P (Table 3). These findings are in accordance with the results of other researchers (Van der Woude et al. 1994, Koerselman and Meuleman 1996, Aerts et al 2003). In contrast, there were no correlations for the area on Mt Jenna. This may be due to the fact that for the period of May to early June low temperatures prevailed on Mt

Jenna accompanied by snowfalls which resulted in low biomass accumulation.

Table 2. Soil characteristics in two depths on Mt Jenna and Mt Belles

	JENNA		BELLES	
	Depth 1	Depth 2	Depth 1	Depth 2
OM%	8.91^{a}±3.17*	4.11^{b}±1.76	8.31^{a}±3.51	4.93^{b}±1.21
N_t%	$0.56^{a,c}$±0.17	$0.32^{b,c}$±0.09	$0.39^{a,d}$±0.16	$0.27^{b,d}$±0.06
P mg/kg	10.34^{a}±8.27	6.18^{a}±6.15	10.33^{a}±5.91	6.97^{a}±3.89
K_{ex} mg/kg	153.97^{c}±96.4	82.94^{c}±66.30	200.68^{d}±144.38	163.84^{d}±113.60

* Data are average values ±S.D. (n=18 for JENNA and n=9 for BELLES). Different letters in columns indicate significant difference between study areas (*P*<0.05). Depth 1: 0-10 cm, Depth 2: 10-20 cm

Table 3. Correlation coefficients (r) of measured parameters on Mt Jenna and Mt Belles

	BELLES		**JENA**	
	Number of species	Herbage production	Number of species	Herbage production
Number of species	-	-0.50*	-	-0.42*
Herbage production	-0.50*	-	-0.42*	-
N	-0.24	0.26	0.02	-0.14
K	-0.06	0.41*	0.02	-0.12
P	-0.28*	0.19	0.08	0.06
OM	-0.32*	0.28*	0.04	0.02

Level of significance: * p<0.05

The statistical analysis showed a negative correlation between herbage production and number of species for Mt Belles as well as for Mt Jenna. The results are in accordance with Grime (1979), Tilman et al. (2001) and Poldini et al. (2011). On Mt Bellesa negative correlation was observed between the number of plant species and soil OM, P and N concentration. Janssens et al. (1998) have reported a correlation only with P and K, while Marrs (1993) and

Mountford et al. (1993) only with N. On Mt Jennano such correlations were observed.

Conclusions

The concentrations of soil macro-nutrients (N, P and K) had a positive effect on the herbage production of Mt Belles, while there was a negative effect on the number of plant species. No such relations were observed for Mt Jenna. On both mountains a negative correlation was found between the number of plant species and the herbage production. It seems that the climatic conditions as well as the geological background may have affected the results.

References

Aerts R., H. de Caluwe and B. Beltman. 2003. Is the relation between nutrient supply and biodiversity co-determined by the type of nutrient limitation. *Oikos*, 101: 489–498.

Bobbink R. 1991. Effects of nutrient enrichment in Dutch chalk grassland. *J. Appl. Ecol*., 28: 28–41.

Bouyoukos G.J. 1962. Hydrometer method improved for making particle size analysis of soil. *Agron. J.*, 54: 464-465.

De Deyn G.B., C.E. Raaijmakers and W.H. van der Putten. 2004. Plant community development is affected by nutrients and soil biota. *J. Ecol.*, 92: 824-834.

Elisseou G.C, D.S. Veresoglou and A.P. Mamolos. 1995. Vegetation productivity and diversity of acid grasslands in nothern Greece as influenced by winter rainfall and limiting nutrients. *Acta Oecol*.,16(6):687–702.

Janssens F., A. Peters, J.R. Tallowin, J.P. Bakker, R. Bekker, F. Fillat and M.J. Oomes. 1998. Relationship between soil chemical factors and grassland diversity. *Plant Soil*, 202: 69-78.

Grime JP, K. Thompson, R. Hunt, J.G. Hodgson, J.C.G. Cornelissen and I.H. Rorison. 1997. Integrated screening validates primary axes of specialisation in plants. *Oikos*, 79: 259-281.

Koerselman W. and A. F. M. Meuleman. 1996. The vegetation N:P ratio: a new tool to detect the nature of nutrient limitation. *J. Appl. Ecol*., 33: 1441–1450.

Marrs R.H. 1993. Soil fertility and nature conservation in Europe: theoretical considerations and practical management solutions. *Advances in Ecological Research*, 24: 241–300.

Mountford J.O., K.H. Lakhani and F. Kirkham. 1993. Experimental assessment of the effects of nitrogen addition under hay-cutting and aftermath grazing on the vegetation of meadows on a Somerset peat moor. *J. Appl. Ecol*., 30: 321–332.

Page A.L., R.H. Miller and D.R. Keeney (eds)., 1982. Methods of soil analysis, Chemical and Microbiological properties.Agronomy No 9 (Part 2) SSSA Inc.,Wisconsin, USA.

Poldini L., G. Sburlino, G. Buffa, and M. Vidali. 2011. Correlations among biodiversity, biomass and other plant community parameters using the phytosociological approach: A case study from the south-eastern *Alps. Plant Biosystems,* 145 No. 1: 131–140

Sall J., L. Creighton and A. Lehman. 2007. JMP® Start Statistics: A Guide to Statistics and Data Analysis Using JMP®, Fourth Edition. Cary, NC: SAS Institute Inc.

Smith R.S. 1994. Effects of fertilisers on plant species composition and conservation interest of UK grassland. In: Haggar, R.J., Peel, S. (Eds.), Grassland Management and Nature Conservation, Occasional Symposium No. 28. British Grassland Society, Reading, pp.64–73.

Strid, A. (ed.). 1986. Mountain Flora of Greece, Vol.1. Cambridge Univ. Press,Cambridge.819 p.

Strid, A. and K. Tan (eds.). 1991. Mountain Flora of Greece. Vol. 2. Edinburch University Press, Edinburch. 974p.

Tilman D., C. Lehman , and K.T. Thomson. 1997. Plant diversity and ecosystem productivity: theoretical considerations. Proc. Natl. Acad. Sci USA, 94: 1857–1861

Tilman D, PB Reich, J. Knops, D. Wedin, T. Mielke and C. Lehman. 2001. Diversity and productivity in a longterm grassland experiment. *Science*, 294: 843–845

Tutin T., V. Heywood, N. Burges, D. Valentine, S. Walters and D.Webb (eds.) 1964-1980. Flora Europaea, Vol. 1-5. Cambridge

USDA U.S. Dept. Agr. Soil Survey Staff 1951. Soil Survey Manual. U.S. Dept. Agr. Handbook #18, U.S. Gov. Print Office, Washington DC

Van der Woude B.J., D.M. Pegtel and J.P. Bakker. 1994. Nutrient limitation after long-term nitrogen fertiliser application in cut grasslands. Journal of Applied Ecology, 31: 405–412

Walkley A. and I.A. Black. 1934. An examination of the Degtjiareff method for determining soil organic matter and a proposed modification of chromic acid titration method. *Soil Sci*., 37: 29-38.

Willems J.H. and M.G.L. Van Nieuwstadt. 1996. Long-term after effects of fertilization on above-ground phytomass and species diversity in calcareous grassland. *Journal of Vegetation Science*, 7: 177–184.