Phytomass dynamics in the gaps of the low Macchia at “Castel Volturno” Nature Reserve, Southern Italy

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Aims and Introduction

The dense evergreen Mediterranean shrubland of Castel Volturno Nature Reserve (40° 57’ N; 1° 33’ E; Southern Italy) includes small gaps (covering about 20% of the low macchia area) dominated by herbs and bryophytes. The mosaic of plant cover is related mainly to frequent fires that have occurred in the Reserve especially in summer. Aboveground biomass of the shrubs, constituted by *Phillyrea* sp. pl., *Myrthus communis*, *Arbutus unedo*, *Pistacia lentiscus*, *Rhamnus alaternus*, *Cistus* sp.pl., *Quercus ilex*, has been estimated to be 2 and 4 kg m^{-2} in the low- and high maquis respectively and is of the same order as that observed in other Mediterranean shrubland (see for details De Marco et al., 2005). The soil is a Calcaric Arenosol (FAO, 1988) with a subalcaline pH and contains in the surface layer (0-5cm) of the gaps 3.95 kg m^{-2} organic matter. Herbs occurring in the gaps are mainly annual, germinating with the first rain after summer drought, fast growing in spring and concluding their life cycle in early summer. Their abundance as well as the fraction of the components legumes, grasses and forbs vary from year to year. Studies on the contribution of gaps dominated by herbs, to carbon flux into Mediterranean shrubland ecosystems are scanty. The aim of this research was 1) to determine the herbs biomass, aboveground and belowground, 2) to determine the relative contribution of the three functional groups, leguminous, grasses and forbs, to total aboveground biomass, 3) to understand the year to year variation of total biomass as related to the main climatic conditions and the relative abundance of the three functional groups of herbs.

Materials and Methods

Aboveground biomass was harvested from two 20x20 cm quadrats in each of nine 50x50 m plots in the experimental area. The underlying roots were directly sampled, where possible, and wholly recovered by sieving from soil cores. Two soil cores were taken at a depth of 10 cm in each of the quadrats. Shoots were separated and sorted into three groups: legumes, grasses and forbs. The number of harvests was 4 for the years 2004, 2005 and 2006 (March, April, May, June) and 1 for the year 2007 (May). Only for 2006 biomass was also determined in September, October, November and December. Soil water content was determined gravimetrically, soil organic matter by loss of ignition at 550°C and total nitrogen by a CNS gas cromatograph. The differences between years for phytomass and soil characteristics were evaluated by one way ANOVA followed by Tukey Test. Climatic variables (rainfall, number of days without rains or with less than 2 mm rain in a day, and mean maximum-daily- temperature) are reported for periods concerning the different harvests. In order to identify the factors responsible for the year to year variability, multivariate analysis was applied to the data. A matrix of 3 or 4 columns (years) and 11 rows (variables reported in Table 1, except aboveground phytomass) was processed by Hierarchical Cluster Analysis and Principal Component Analysis (Sin-tax 2000). Separate analyses were performed for distinct periods in order to avoid biomass underestimate of the early-growing plant groups; besides, as the peak standing crop was reached in May, data of the June harvest were not considered in the statistical analyses.

Results

Table 1 presents values of phytomass, soil characteristics and climatic variables for the early growth period (November- March) and the whole growth period up to the peak standing crop (November-May). According to ANOVA a significantly higher phytomass is produced in the gaps in the year 2004 as compared to the other study years. Significant differences between years have also been found for the relative contribution of the functional groups, legumes, grasses and forbs, to total aboveground phytomass. Legumes are the most abundant fraction in year 2004 and the least abundant in the subsequent year 2005 when grasses become the most abundant fraction. Forbs are the main part of the total aboveground phytomass in years 2006 and 2007. The belowground biomass shows the lowest values in the years 2005 and 2006 that were more wet than the years 2004 and 2007. When comparing the amount of belowground biomass measured in March to that measured in May it is evident that no increase of belowground pythomass occurs in the period March-May contrary to the relevant increase of aboveground biomass in the same period.
Measurements of biomass made in the period October 2006-January 2007 (not showed in Table 1) reveal that: i) with the first rain after summer drought, forbs regrow, reach biomass amount very near to those measured in May and then dye; ii) annuals herbs germinate in November, establish in early winter and grow very slowly up to March.
The cluster analysis allocates the study year 2004 well separated from the other three years which form three distinct groups with 2005 and 2006 characterized by higher similarity as compared to 2007 (Fig. 1). The principal component analysis orders the years on the basis of the variables considered (Fig. 1) and allows to define the percentage of variance due to single variables. Thus the highest percent variance (48%) is due to legumes; 19% of variance is due to rainfall; 16% variance to belowground biomass, 10% to

forbs and 7% to grasses. In the period November-March, as indicated by Cluster Analysis and PCA (not showed) 70% of the variance is attributable to rainfall,16% to belowground biomass and 12% to legumes.

Discussion

The results show that phytomass production in the gaps of the Castel Volturno Macchia undergoes from year to year a variation in amount up to about threefold (701 to 244 g m^{-2}). Even higher (twenty folds) are the changes in amount of legume biomass. The higher total phytomass is associated to the higher fraction of legumes; this is consistent with the positive interaction of legumes with other species in many natural and agricultural ecosystems, since nitrogen fixation in their roots may increase nitrogen supply for other plants thus improving community productivity (Spehn et al., 2002). The higher soil nitrogen content (Table 1) has been measured in the year 2004 when legumes were most abundant and in the subsequent year 2005. After the decline in the year 2005, production increases again in the years 2006 and 2007 when also the legume fraction rises. That biomass production depends mainly on the contribution of legumes to total biomass is supported by the results of the PCA indicating that 48% of the variance is attributable to legumes.

Biomass allocation in the roots varies from year to year likely depending on rainfall as well as on the relative abundance of the three functional groups of herbs. It is interesting to note that roots growth occurs entirely in the early growth period (November-March) when herbs allocate a large proportion of new biomass belowground to cope with soil resources availability.

References

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Table 1 - Changes of aboveground and belowground phytomass (g m^{-2}) in gaps of the low Macchia at Castel Volturno Nature Reserve and main soil and climatic parameters.

Analised parameters	November-March			November-May			
	2004	2005	2006	2004	2005	2006	2007
Aboveground	150±10 ^{a}	58±8 ^{b}	132±12 ^{a}	543±55 ^{a}	169±22 ^{b}	202±25 ^{b}	324±55^{a,b}
Legumes	91±12^{a}	8±3^{b}	72±8^{a}	313±45^{a}	13±5^{b}	72±5^{c}	61±20^{b,c}
Grasses	38±10^{ab}	36±8^{a}	15±2^{b}	148±38^{a}	106±20^{a}	27±1^{b}	97±38^{a,b}
Forbs	22±4 ^{ab}	14±3^{a}	45±5^{b}	82±27^{a,b}	50±15^{a}	103±22^{a,b}	167±40^{b}
Belowground	148±17^{a}	108±24^{a}	52±5^{b}	158±22^{a}	75±8^{b}	85±8^{b}	241±47^{a}
pH	7.4±0.1^{a}	7.5±0.1^{a}	7.8±0.1^{b}	7.1±0.1^{a}	7.1±0.1^{a}	8.0±0.1^{b}	7.8±0.1^{b}
SOM (%)	9.3±0.7^{a}	7.4±0.2^{b}	6.0±0.3^{c}	8.3±0.2^{a}	6.8±0.2^{b}	5.8±0.3^{b}	6.9±0.4^{b}
SWC (%)	21.6±0.7^{a}	16.4±0.8^{b}	14.1±0.7^{c}	14.8±0.6^{a}	2.5±0.1^{b}	2.5±0.1^{b}	2.6±0.2^{b}
N (mg g^{-1})	3.7±0.4^{a}	2.7±0.4^{b}	2.5±0.4^{b}	3.1±0.4^{a}	3.3±0.2^{a}	2.6±0.5^{b}	1.5±0.3^{b}
P (mm)	488.4	682.4	626.4	659.2	804	695.4	602.8
T_{max} (°C)	14.7	13.9	15.3	17.8	18.2	20.2	18.2
Dry period	110	100	122	158	160	170	173

Values of biomass and soils parameters are means of 18 measurements at each harvest. P= rainfall in period; Dry period = number of days without or with rain < 2mm; T_{max} = mean-daily-maximum temperature. Means with different letters in apex differ from each other (Tuckey test, P<0.05).

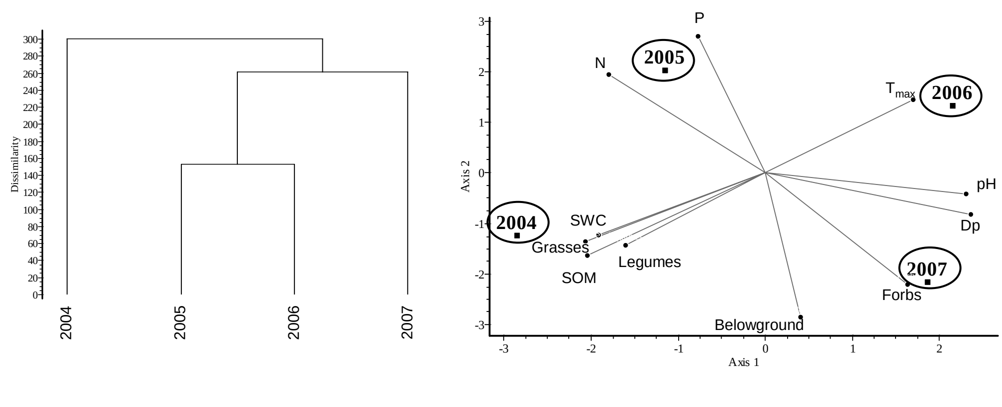

Figure 1 – Results of cluster analysis (left) and principal component analysis (right) applied to the parameters in table 1 (with exclusion of “Aboveground”, to avoid redundancy). Contribution to variance is 19 % for Rainfall, 48 % for Legumes, 16 % for Belowground phytomass, 10 % for Forbs and = 7 % for Grasses.