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Quantitative and qualitative evaluation of tree and shrubby pasture species in Southern Italy[(1)]

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SUMMARY

The quantitative and qualitative results on 36 trees and shrubby species, compared in a pasture area in Southern Italy (Murgia) are reported. Among the species tested the best yield results in terms of biomass were provided by *Atriplex halimus* L. (Mediterranean saltbush). Among the tree crops, of high forage yield, *Robinia pseudoacacia* is noteworthy in consideration of the valuable forage quality.

Introduction

It is estimated that in the Mediterranean area about 7,000,000 ha are covered with trees and shrubs, used as forage species (Le Houérou, 1991, in press). Special emphasis was laid, over the 30 last years, to these species, as a result of the EEC agricultural policy which is aimed at reducing cereal crop growing (notably wheat) and developing agro-forestry and sylvo-pastoral system. In many Mediterranean areas, once covered with natural woodland including different oak species, as a result of a marked soil deterioration, reforestation is now being realized by coniferous trees which should be the precondition (pioneer species) for re-introducing more demanding crops such as oak. However, the indiscriminate use of conifers often reduces the underwood and rangeland productivity.

This necessitates a reforestation with tree and shrubby broad-leaved species to be used as food both for humans and animals or for the purpose of soil conservation and fertility.

Tree and shrubby crops usually have a beneficial effect on the production of the underlying herbaceous biomass compared to bare areas with increments which increase with soil deterioration (Le Houérou, 1980; Mann and Shankarnarayan, 1980; Vacher, 1984).

Many investigation revealed the good productive capacity (both in qualitative and quantitative terms) of many species as pasture plants, including *Atriplex nummularia, A repanda, A. halimus, Medicago arborea, Robinia pseudoacacia, Colutea arborescens,* etc.. for Mediterranean areas (Corleto *et al.*, 1980; Le Houérou, 1980; Papanastasis, 1985; Talamucci, 1985; Stringi *et al.*, 1987; Talamucci and Chaulet, 1989; Le Houérou, 1990; Corleto *et al.*, 1991; Corleto, 1992).

However, many other Mediterranean and exotic tree species need to be further studied to ascertain their adaptation and productivity as forage.

In this paper the first results about a comparative test on thirty-six tree and shrubby species in a poor pasture area in Southern Italy are reported.

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Some species among those tested have poor or no forage value but their adaptation to the environment was tested with a view to envisage their introduction in future protective forestation programmes or for other purposes (human food, wood production for industry, etc.).

Material and Methods

The research was started in February 1989 in a typical inland pasture area in the province of Bari (North-Western Murgia at 460 m a.s.l., characterized by shallow, stony soils, rock outcrops and a clay-sandy fraction, of good water holding power and cation exchange capacity but poorly supplied with total nitrogen, available phosphorus and organic matter.

Mean rainfall is about 570 mm and mostly occurs in autumn-winter The annual mean temperature is 14°C; minimum temperatures below 0°C are mostly recorded between November and March, with an absolute minimum value of -7.1°C.

Thirty-six tree and shrubby species, including non native Mediterranean species, were compared (Table 1)

Table 1 - List of trees and shrubs transplanted 15 February 1989 at the Altamura field (1).

Celtis occidentalis L.	(100)	*Prunus spinosa* L.	(67)
Robinia pseudoacacia L.	(100)	*Elaeagnus multiflora* L.	(63)
Coronilla emerus L.	(96)	*Prunus avium* L.	(63)
Ulmus pumila L.	(96)	*Ulmus campestris* L.	(63)
Amorpha fruticosa L.	(92)	*Caragana arborescens* Lamarck	(46)
Atriplex halimus L.	(92)	*Colutea arborescens* L.	(46)
Ailanthus glandulosa Desf.	(88)	*Fraxinus ornus* L.	(42)
Gleditsia triacanthos L. var. *inermis*	(88)	*Prunus cerasifera* Ehrh.	(42)
Kohlreuteria paniculata Laxm.	(88)	*Juglans nigra* L.	(38)
Elaeagnus sp.	(88)	*Acer campestre* L.	(37)
Amelancher canadensis Medic. Gesch.	(83)	*Acer pseudoplatanus* L.	(33)
Prunus mahaleb L.	(83)	*Fraxinus excelsior* L.	(29)
Prunus tomentosa L.	(83)	*Robinia hispida* L.	(25)
Elaeagnus umbellata Thumb		*Acer negundo* L.	(12)
var. *autumn* Glory	(75)	*Celtis australis* L.	(8)
Gleditsia triacanthos L.	(71)	*Acer saccharinum* L.	(4)
Cercis siliquastrum L.	(67)	*Alnus cordata* (Loisel.) Desf.	(0)
Juglans regia L.	(67)	*Tilia cordata* Miller	(0)
Morus alba L.	(67)		

(1) Number within brackets inticates the percentage of alive plants at August 20, 1992.

The randomized block experimental design was adopted with 2 replicates and plots made of a row of 12 plants, 2.5 x 2 m spaced. Before transplantation, soil ripping was carried and 40 cm x 40 x 60 holes were obtained.

On 15/2/1989 transplantation was carried using 18-month-old bare root seedlings except *Atriplex halimus* whose plants were obtained by cuttings from the existing spontaneous vegetation in the Basento valley (Basilicata). The whole experimental area was then enclosed.

During the three years, the weeds surrounding plants were controlled early in summer.

On August 20, 1992, three years and a half from planting, the following characters were determined: the green matter yield, removing the vegetation of the year including leaves and stems, on 3 plants for each replicate, using the whole biomass for the determination of the dry matter content and for qualitative analyses; the stem/leaf ratio and the mean plant height were also determined. A part of the biomass produced was used for the dry matter content determination by oven drying at 105°C for 48 hours. The remaining biomass was used for chemical analyses by oven drying at 65°C for 3 days. Samples of stems and leaves were ground together to a fine powder in a wiley mill. Crude protein was determined by Kjeldhal method (N x 6.25) and the N.D.F. (neutral detergent fiber) was analysed following Van Soest's methodology (1967) whereas the ash content was determined by oven ashing at 550°C. Moreover, for some species the qualitative characters were determined separately for stems and leaves.

The annual rainfall values in the period under consideration were respectively 387, 430, 487 and 191 mm in 1989, 1990, 1991 and from January to July 1992. In all cases, rainfall was far lower than the mean (570 mm).

Results

The species compared are reported in table 1 where the survival rates, observed at the determination of the biomass and of other qualitative characters, are also indicated.

The survival percentage observed ranges from 100% on *Celtis australis* L. and *Robinia pseudoacacia* L., to 0% on *Alnus cordata* (Loisel.) and *Tilia cordata* Miller. Survival values between 90 and 99% were found on *Ulmus pumila* L. (96%), *Coronilla emerus* L. (96%), *Atriplex halimus* L. (92%), *Amorpha fruticosa* L. (92%). Increasingly lower values were observed for the other species.

Quantitative characters

The yield analysis concerned only the species (25) which could supply a sufficient biomass for the determination of the qualitative characters scheduled.

The major yield characters studied are reported in table 2 (green and dry matter yield per plant, dry matter percentage, stem/leaf ratio, mean plant height).

Table 2 - D.M.Y., Green Matter Yield, D.M.P., stem/leaf ratio and plant height of different trees and shrubs (Altamura field, August 20, 1992).

Species	D.M.Y. (g/p.)	G.M.Y. (g/p.)	D.M.P. (%)	Stem/ leaf	Plant height (cm)
Atriplex halimus L.	689 A	1875 A	37.6 AD	1.15 C	86 CF
Ulmus pumila L.	218 B	496 BD	43.6 AD	0.58 GI	152 A
Robinia pseudoacacia L.	161 BC	516 B	31.1 D	0.21 K	160 A
Coronilla emerus L.	134 BD	285 BD	42.1 AD	1.53 B	70 DH
Prunus mahaleb L.	132 BD	350 BD	37.9 AD	0.51 HI	122 B
Ailanthus glandulosa Desf.	116 BD	344 BD	33.3 CD	0.94 DE	98 BC
Ulmus campestris L.	90 BD	166 BD	52.1 AC	0.71 FG	100 BC
Elaeagnus multiflora L.	86 BD	196 BD	48.8 AD	0.44 IJ	78 CG
Prunus tomentosa L.	60 CD	125 BD	48.2 AD	0.67 GH	87 CF
Prunus cerasifera Ehrh.	56 CD	133 BD	41.5 AD	1.38 B	88 CE
Amòrpha fruticosa L.	53 CD	160 BD	33.7 CD	0.26 JK	93 CD
Cercis siliquastrum L.	49 CD	127 BD	41.5 AD	0.20 KL	100 BC
Celtis occidentalis L.	42 CD	174 BD	37.4 BD	0.30 JK	73 CG
Kohlreuteria paniculata Laxm.	36 CD	87 BD	42.7 AD	0.23 K	61 FI
Elaeagnus umb. Thumb *aut.* Glory	30 CD	75 BD	42.3 AD	0.75 FG	88 CG
Prunus avium L.	28 CD	71 BD	40.7 AD	0.19 KL	90 CE
Juglans nigra L.	25 CD	58 BD	42.6 AD	0.01 L	59 GI
Juglans regia L.	22 CD	68 BD	32.9 D	0.01 L	66 EI
Amelancher canadensis (L.)	19 CD	35 CD	55.6 AB	0.33 JK	61 FI
Acer pseudoplatanus L.	19 CD	44 CD	43.9 AD	0.15 KL	80 CG
Prunus spinosa L.	19 CD	33 CD	56.6 A	2.33 A	42 I
Elaeagnus sp.	17 D	40 CD	40.6 AD	0.87 EF	70 DH
Gleditsia triacanthos L.	17 D	44 CD	38.9 AD	1.05 CD	43 I
Fraxinus excelsior L.	15 D	32 CD	47.9 AD	0.30 JK	46HI
Gleditsia triacanthos var. *inermis* L.	14 D	28 D	49.3 AD	0.30 JK	58 GI
Mean	86	223	42.5	0.62	82.8

(1) Values not having letters in common differ significantly at 1% level, according to Duncan's Multiple Range Test.

As to the dry matter content, which is the most important character, a great variability was observed between 689 g/p of d.m. produced by *Atriplex halimus* and 14 g/p of d.m. produced by *Gleditsia triacanthos* var. *inermis* with a mean value of 86 g/p.

Besides *A. halimus,* other species show a high d.m. yield per plant, such as *Ulmus pumila* (218 g/p), *Robinia pseudoacacia,* (161 g/p), *Coronilla emerus* (134 g/p), *Ulmus campestris* (90 g/p) and *Elaeagnus multiflora* (86 g/p), of good forage value, whereas the good yield response of *Prunus mahaleb* (132 g/p) and *Ailanthus glandulosa* (116 g/p) could suggest their use as non forage species.

A wide variability was also observed in terms of dry matter percentage from 31.1% in *R. pseudoacacia* to 55.6% in *Prunus spinosa*, with a mean value around 42.5%.

Most of the species tested showed a good stem/leaf ratio which provides reliable indications about forage digestibility with values below 1, except *P. spinosa* (2.33), *C. emerus* (1.53), *Prunus cerasifera* (1.38), *A. halimus* (1.15) and *G. triacanthos* (1.05).

The mean plant height was also greatly variable from 160 cm in *R. pseudoacacia* to 42 cm in *P. spinosa*, with a mean value of 82.8 cm.

Tall species usually showed a greater biomass; for some of them such as *A. halimus*, *C. emerus* and *E. multiflora* the high biomass production might be explained by the massive presence of branches starting from the base of the plant.

Qualitative characters

The qualitative characters tested, C.P., N.D.F. and Ash. (table 3), are the most relevant for a preliminary assessment of the nutritional value and of the digestibility of the biomass produced.

Table 3 - Crude protein content (C.P.), Neutral detergent fiber (N.D.F.) and Ash. content of different trees and shrubs (Altamura field, August 20, 1992) (1).

Species	C.P. (%)	N.D.F. (%)	Ash. (%)
Elaeagnus multiflora L.	17.1 A	55.6 AB	5.4 F
Elaeagnus umbellata Thumb *autumn* Glory	16.5 AB	54.7 AC	5.2 F
Robinia pseudoacacia L.	15.8 AC	32.4 GK	10.1 BC
Elaeagnus sp.	15.7 AC	50.6 AD	6.0 DF
Amorpha fruticosa L.	14.3 AD	37.8 DJ	7.8 CF
Gleditsia triacanthos L. var. *inermis*	13.9 AD	42.5 CG	6.9 CF
Juglans regia L.	13.8 AD	28.9 HK	9.6 BE
Gleditsia triacanthos L.	13.5 AD	43.1 CG	6.9 CF
Juglans nigra L.	12.7 AD	23.3 K	10.7 BC
Coronilla emerus L.	12.5 AD	43.3 BG	9.7 BE
Acer pseudoplatanus L.	12.4 AD	24.9 JK	9.8 BD
Ulmus campestris L.	12.3 AD	37.4 EJ	12.8 B
Cercis siliquastrum L.	11.6 AD	31.3 GK	7.2 CF
Ailanthus glandulosa Desf.	11.6 AD	43.3 IK	10.3 BC
Prunus cerasifera Ehrh.	11.0 BD	45.8 AF	6.9 CF
Fraxinus excelsior L.	10.9 BD	29.0 HK	9.8 BD
Prunus tomentosa L.	10.8 BD	38.1 DI	9.1 BF
Kohlreuteria paniculata Laxm.	10.6 BD	30.5 GK	8.0 CF
Prunus avium L.	10.5 BD	26.7 IK	8.3 CF
Celtis occidentalis L.	10.2 CD	39.6 DI	12.9 B
Amelancher canadensis (L.)	9.9 CD	38.2 DI	8.4 CF
Ulmus pumila L.	9.8 CD	41.6 DH	8.7 CF
Atriplex halimus L.	9.3 D	49.5 AE	21.0 A
Prunus mahaleb L.	8.8 D	33.9 FK	9.4 BE
Prunus spinosa L.	8.6 D	56.3 A	5.8 EF
Mean	12.2	38.0	9.1

(1) Values not having letters in common differ significantly at 1% level, according to Duncan's Multiple Range Test.

These characters showed a great variability also between the species tested, as espected.

Crude protein was ranging between 17.1% (*E. multiflora*) and 8.6% (*P. spinosa*) with a mean value around 12.2%.

The values observed for *E. multiflora* are not significantly different from those of *A. glandulosa* (11.6%) and include many species as *R. pseudoacacia*, *A. fruticosa*, *C. emerus*, etc..

A. halimus showed a quite low crude protein content (9.3%) as a result of an unfavourable stem/leaf ratio.

The N.D.F. values (reflecting the total cell wall content) were around a mean value of 38% with extreme values of 56.3 *(P. spinosa)* and 23.3% *(Juglans nigra)*.

The ash content also showed considerable variations around the mean value of 9.1%. The highest value was expressed by *A. halimus* (21.0%) and can be explained by the high salt content in leaves; the lowest values was found in *Elaeagnus umbellata* (5.2%).

For some species (table 4) the three characters were analysed separately for stems and leaves.

As expected, leaves showed a higher crude protein content (13.9%) and ash content (16.1%) whereas stems were characterized by a higher N.D.F. content (67%).

Tab. 4 - Crude protein content (C.P.), Neutral detergent fiber (N.D.F.) and Ash.content of different trees and shrubs determined on leaves and stems separately (Altamura field (August 20, 1992).

Species	C.P. (%)		N.D.F. (%)		Ash (%)	
	stems	leaves	stems	leaves	stems	leaves
Robinia pseudoacacia L	7.1	15.8	65.6	24.7	8.3	11.1
Ulmus campestris L.	4.3	13.1	64.5	20.2	6.9	18.5
Atriplex halimus L.	4.2	13.1	77.8	30.0	6.9	30.8
Coronilla emerus L.	7.5	12.7	62.0	23.9	5.1	15.5
Prunus mahaleb L.	3.7	11.4	65.2	20.5	6.7	11.6
Amorpha fruticosa L.	7.0	17.6	66.8	28.4	7.0	9.0
Mean	5.6	13.9	67.0	24.6	6.8	16.1

Discussion and Conclusion

The wide variability observed in the characters studied is mostly related to the diversified genetic characteristics of the species tested and to the impact of unfavourable environmental conditions: shallow and rocky soil and low rainfall (which was around 430 mm in the three years of the research), mostly concentrated in autumn-winter.

Although with some cautiousness related to the specific conditions of the test, i.e., the low number of plants and replicates and the singleness of the yield determination performed in the hottest and driest period in the year, the results obtained provided helpful information. *A. halimus* was shown to be the most productive species although it showed low protein contents and high N.D.F. and ash content values. Such values greatly differ from those found by other Authors (Cook, 1972; Le Houérou, 1980; Bouzid, 1990). This is presumably related to the old age of the tissues forming leaves and stems of plants which had never been used before, as evidenced by other Authors on *A. halimus* (Cook, 1972; Bouzid, 1990) and other species (Tsiouvaras and Nastis, 1990).

Another species of good forage value and which provided good yield results, in the year of the determination, is *R. pseudoacacia* which showed a good qualitative level of the biomass produced.

For the purpose of the biomass increase in bare pasture areas in Southern Italy, the two species are the most performing since they produce green biomass for most of the year, when they are combined.

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