Programs for Improvement of Medicago spp. at ENMP-Portugal. I. Distribution of annual medics as related to soil properties and climatic conditions

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PROGRAMS FOR IMPROVEMENT OF *MEDICAGO SP.* AT ENMP-PORTUGAL

I. DISTRIBUTION OF ANNUAL MEDICS AS RELATED TO SOIL PROPERTIES AND CLIMATIC CONDITIONS

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ABSTRACT

More than 100 entries of Medics were collected during three seed collection tours undertaken in the Centre and South regions of Portugal. Some soil properties and climatic conditions at collection sites were studied, and the species identification was done. The results of identification and environmental characterization showed the relevance of *Medicago polymorpha* as the most frequent and cosmopolitan species. Some species more adapted to low soil pH and reduced availability of some major elements were identified.

Key words: *Medicago*, annual medics, distribution, collection, Portugal.

INTRODUCTION

In 1991, 1992 and 1993 three general seed collection tours for forage and pulses were done in Portugal. These missions covered the Centre and South regions of the country. Overall 57 sites were visited, to cover a wide range of soil, altitude and rainfall features and hundreds of entries were collected. In this work, the results obtained with 111 genotypes of annual medics collected during these missions are presented in an attempt to relate the relative frequency of the species to some relevant physico-chemical soil properties and climatic data of the collection sites.

1. MATERIALS AND METHODS

11. Plant collection

The medics were collected in native pasture paddocks as pods. The collection sites were usually in paddocks adjacent to the road or along the road sides, when there was no pods of medics at the paddocks. For each collection site, a form from IBPGR (International Board for Plant Genetic Resources) recording geographic, environmental and human action details was filled. Species identification was carried out using morphological characteristics of the pods. Pods from each site were threshed and scarified seed was sown in rows in the middle of October. The plants were reclassified and the variation between plants in some morphological characters was examined.

12. Soils and climatic conditions

Topsoil samples (0-20 cm) from the prospected 57 sites were collected. The samples were air-dried and passed through a 2 mm sieve. Some physical and chemical properties were determined as follows: particle-size distribution by the pipette method with a solution of 3.6% Na hexametaphosphate and 0.8% Na carbonate as a dispersant; textural classes by the triangular diagram of Gomes and Silva (1962) in which silt is the 0.02-0.002 mm fraction; pH measured in a 1:2.5 soil: water suspension; organic matter by the Walkley (1947) chromic acid digestion procedure; total nitrogen by a modified Kjeldahl method (Bremner, 1965) adaptable to the digestion and distillation system "Tecator"; exchangeable basic cations by extraction with 1M NH_4Ac at pH 7.0 (Schollenberger and Dreibelbis, 1930; Gama, 1969) and measurement by atomic absorption

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spectrophotometry; exchangeable acidity by extraction with a 1M KCl solution (Barnhisel and Bertsch, 1982) and subsequent titration (McLean, 1965); "effective" cation exchange capacity ("effective" CEC) by the sum of exchangeable basic cations plus exchangeable acidity (Espiau and Pedro, 1980); available P and K by the AL-method (Egnér, Riehm and Domingo, 1960; Balbino, 1968); P and K concentrations in the extracts by the method of Murphy and Riley (1962), and by atomic absorption spectrophotometry, respectively. Exchangeable acidity was only determined in the samples with pH in water $\leq$ 5.4 (6 samples).

For the "effective" cation exchange capacity three classes were considered: < 10.0; 10.0 - 20.0; > 20.0 cmol(c) kg^{-1} (Alves and Cardoso, 1967; Cottenie, 1978). For total N content three classes were considered: < 0.5; 0.5 - 1.0; >1.0 g kg^{-1} (Alves and Cardoso, 1967). The classes of available P and K were established from the calibration of the AL-method for winter cereals (Almeida and Balbino, 1960; Balbino, 1968) respectively < 22; 22 - 44; > 44 mg P kg^{-1} and < 42.3; 42.3 - 83.0; > 83.0 mg K kg^{-1}. For the exchangeable Mg content three classes were considered: < 0.25; 0.25 - 0.50; > 0.50 cmol(c) kg^{-1} (Bolton, 1972).

Altitude and average rainfall at the collection site were estimated using adequate maps and collected data (Mendes and Coelho, 1993).

2. RESULTS AND DISCUSSION

From a universe of 111 entries, the most representative species was *M. polymorpha* with 52 entries, followed by *Medicago orbicularis* with 11 entries. *M. arabica* and *M. doliata* have both 10 entries (Figure 1).

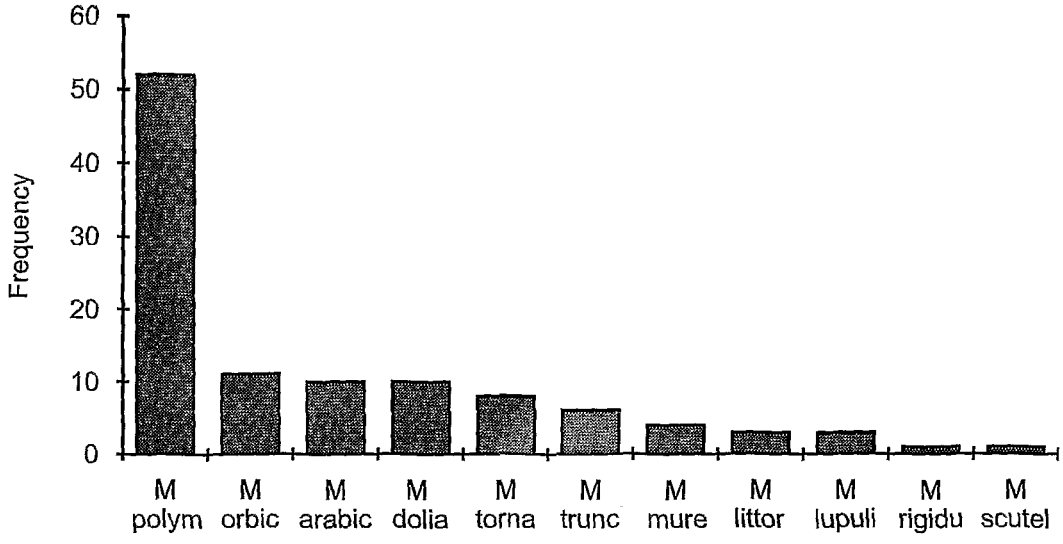

Figure 1. Number of entries of the different species of annual medics in the total collection.

These values are similar to some obtained by Prosperi *et al.* (1991) who found *Medicago polymorpha* the most frequent species in Spain and Portugal with 24.9% of the collection sites. These authors also found *M. truncatula, M. minima, M. orbicularis* and *M. aculeata* (*M. doliata*) to have good representativity.

Following *M. polymorpha*, *M. orbicularis*, *M.doliata*, *M. arabica*, *M. truncatula* and *M. tornata* were the species with higher representativity in the collection under study. In a group of 75 entries of *Medicago sp.* collected in Portugal and South West of Spain, Francis (1979), reported 48 genotypes of *M. polymorpha*, 9 *M. orbicularis*, 7 *M. murex* and 6 *M. arabica*. In Sardinia, Piano *et al.* (1982),

found *M. polymorpha* more ubiquitous and they considered *M. intertexa*, *M. tuberculata*, *M. orbicularis* and *M. truncatula* to be in close connection with calcareous and alluvial soils.

Due to their very low frequency (< 1%), *M. minima*, *M. rigidula* and *M. scutellata* were eliminated for the subsequent treatment of data.

21. Species distribution regarding to altitude and average rainfall

The altitude of the collection sites varied from 5 m to 550 m. Four ranges of altitude ($a \leq 100$; $101 < a \leq 300$ m; $301 < a \leq 500$ m; $a > 500$) were adopted. Five average annual rainfall ($r < 500$ mm; $500 \leq r < 700$ mm; $700 \leq r < 900$ mm; $900 \leq r < 1100$ mm; $r \geq 1100$ mm) were also considered.

M. polymorpha was present in all ranges of altitude and rainfall, although its frequency was higher in altitudes between 101-300 m and between 500 and 900 mm of rainfall (Table 1a.). *M. tornata* was present in the four ranges of altitude and in four ranges of rainfall. *M. arabica* was found in sites with altitudes higher than 100 m, but it was present in four of the five classes for rainfall even when $r \leq 500$ mm.

In opposition to *M. arabica* behaviour, *M. littoralis* was not found in sites with altitude higher than 300 m of and it had small representativity in the class of altitude 101-300m. *M. truncatula*, *M. littoralis* and *M. lupulina* were found only at altitudes less than 300m.

22. Influence of soil properties on the species distribution

When determining soil texture, nine classes were found in the group of soil samples correspondent to the germoplasm collection. The most abundant classes were the loam, sandy-loam and silt-loam with nearly 24.1% of the entries each one. Other classes with less importance were clay-loam (7.4%), sand and silty-clay-loam (with 5.5% each one). The classes loamy-sand, clay and sandy-clay-loam were meaningful.

The first chemical factor used to make the screening of the medic species was organic matter content (O.M.). Three levels were adopted (Costa, 1973):

a) O.M. ≤ 16 g kg^{-1};

b) O.M. between 16 g kg^{-1} and 50 g kg^{-1};

c) O.M. > 50 g kg^{-1}.

M. polymorpha, *M. arabica*, *M. tornata* and *M. littoralis* were present in all ranges. Although *M. arabica* appeared in conditions of low content of O.M. (1 entry), it seems that this species prefers medium or high level of O.M. conditions. *M. murex* and *M. lupulina* only appeared in the range of low and medium organic matter contents (O.M. less than 50 g kg^{-1}).

As regards to pH in water, the range with more collection sites was between 7.6-8.5 followed by the range 5.6-6.5.

M. polymorpha, *M. orbicularis* and *M. truncatula* were present in all ranges of pH while *M. murex* and *M. arabica* species were present at low and medium pH values. Piano *et al.* (1982) referred the ability of *M. polymorpha* and *M. arabica* to colonize acid soils, although they stated that these species have a wide adaptation to all soil types. *M. lupulina*, *M. doliata* and *M. tornata* appeared in the three ranges of soils with higher pH values.

Only the soil with the lowest pH (5.0) had an exchangeable acidity higher than 1 $cmol_{(c)}$ kg^{-1}. This value was much higher than the upper limit (0.2 cmol(c) kg^{-1}) indicating risk of Al toxicity for *M. sativa* (Moschler, Jones and Thomas, 1960). *M. polymorpha* was the species collected in this soil.

Table 1a. Distribution of the species in at the diverse edaphoclimate conditions

		M. polymorpha	*M. doliata*	*M. orbicularis*	*M. arabica*	*M. truncatula*	*M. tornata*	*M. littoralis*	*M. lupulina*	*M. murex*
Frequency		52	10	11	10	6	8	3	3	4
Altitude (m)										
	0 - 100	13	1	3	-	1	2	2	1	2
	101 - 300	28	8	6	6	5	4	1	2	2
	301 - 500	8	1	2	3	-	1	-	-	-
	> 500	3	-	-	1	-	1	-	-	-
Rainfall (mm)										
	< 500	2	-	-	3	-	-	-	-	-
	500 - 699	25	4	2	1	2	2	1	-	4
	700 - 899	17	5	4	4	4	3	-	-	-
	900 - 1099	6	1	4	-	-	1	1	2	-
	>1100	2	-	1	2	-	2	1	1	-
Soil Organic matter ($g.kg^{-1}$)	< 16	13	2	1	1	1	1	1	-	1
	16 - 50	38	8	10	8	5	6	1	3	3
	> 50	1	-	-	1	-	1	1	-	-
Soil pH										
	4,6 - 5,5	5	-	1	1	1	-	-	-	1
	5,6 - 6,5	16	-	1	6	1	6	2	1	2
	6,6 - 7,5	9	1	2	3	-	1	1	1	1
	7,6 - 8,5	22	9	7	-	4	1	-	1	-

Concerning the effective cation exchange capacity (CEC), the larger proportion of soils had high CEC (> 20 $cmol_{(c)}$ kg^{-1}) as there were 42 entries against 39 entries in soils with low CEC and 27 entries in soils with medium CEC (Table 1b.). This fact is probably related to the higher number of soils with pH > 7.5. The distribution of the species according the different ranges had not a clear pattern.

Analysing the distribution of the medics in function of the major nutrients content (N, P and K), we only found 4 species associated with soils of low N total (< 0.5 g N kg^{-1}). These species were *M. polymorpha* (4 entries), *M. arabica* (1 entry), *M. tornata* (1 entry) and *M. murex* (1 entry).

Regarding to available P, all the species were found at a low P content. Four species were associated to a medium content (P between 22 to 44 mg kg^{-1}) and six species to an high P content. The small number of species associated to medium P contents is due to the fact that only three soil samples or collection sites were assigned to this range.

As to available K, higher number of entries (72% of all genotypes) and species (all of them) were associated to an high K content (> 83 mg kg^{-1}). This is related to the predominance of soils with high and medium CEC (71 entries) and to the appreciable values of exchangeable K in the exchangeable complex in many soils (results not shown). It seems interesting that the same species which were found in soils of low K content (*M. polymorpha, M. tornata* and *M. murex*) were quite the same also related to low N levels.

Although three classes of exchangeable Mg were adopted, the collected soil samples had only medium and high Mg contents and these ones were dominant. Only *M. polymorpha, M. orbicularis, M. arabica* and *M. tornata* were found in soils with medium contents of the nutrient.

CONCLUSION

From the results one may suggest the following tendencies:

- *M. polymorpha* was the most frequent and more cosmopolitan species. It was found in the most diverse conditions of altitude, rainfall and soil properties;

- *M. polymorpha, M. arabica* and *M. murex* were present in conditions of low soil pH. *M. polymorpha, M. orbicularis* and *M. truncatula* were present in all ranges of pH. From the analysis done, *M. polymorpha* and *M. arabica* seemed to be tolerant to low pH and low N content. *M. polymorpha* was also present in soils with low K content;

- *M. tornata* and *M. murex* were present in soils of low N and K content.

These results show the diversity and richness of *Medicago* species in Portugal and the different adaptability of the species to the diverse environmental conditions of the country.

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Table 1b. Distribution of the species on the diverse edaphoclimate conditions

	M. polymorpha	*M. doliata*	*M. orbicularis*	*M. arabica*	*M. truncatula*	*M. tornata*	*M. littoralis*	*M. lupulina*	*M. murex*
Cation exchange capacity ($cmol.kg^{-1}$)									
< 10,0	19	-	2	7	2	5	1	1	2
10,0 - 20,0	13	5	1	2	3	1	2	-	-
> 20,0	20	5	8	1	1	2	-	2	2
Soil N content ($g.kg^{-1}$)									
< 0,5	4	-	-	1	-	1	-	-	1
0,5 - 1,0	15	3	1	1	2	-	2	1	1
> 1,0	33	7	10	8	4	7	1	2	2
Soil P content ($mg.kg^{-1}$)									
< 22	25	2	6	7	2	7	3	3	3
22 - 44	3	1	-	-	1	1	-	-	-
> 44	24	7	5	3	3	-	-	-	1
Soil K content ($mg.kg^{-1}$)									
< 42,3	4	-	-	-	-	1	-	-	1
42,3 - 83,0	15	1	2	4	-	2	2	1	2
> 83,0	33	9	9	6	6	5	1	2	1
Soil Mg exchangeable ($cmol.kg^{-1}$)									
< 0,25	-	-	-	-	-	-	-	-	-
0,25 - 0,50	2	-	1	1	-	2	-	-	-
> 0,50	50	10	10	9	6	6	3	3	4

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