THE UTILIZATION OF SUBTERRANEAN CLOVER (TRIFOLIUM SUBTERRANEUM L.) IN SPAIN FOR PASTURE IMPROVEMENT

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1. THE ENVIRONMENT OF THE SOUTH WESTERN PASTORAL AREA

The area in which subterranean clover is used lies between 36° and 41° latitud with elevations varying from sea level in the south to 1000 m in the north, extending along the border of Portugal.

1. 1. The climate

Most part of the area is on Extremadura region and West Andalusia with altitudes generally below 500 m, mean annual rainfall ranging from 450 to 650 mm in the plateau and from 650 to 1000 mm in higher elevations. No effective rains for pasture growth are received most years from June to October, while precipitation in winter and spring is often characterised by extended spells without effective rainfall. The growing season extends from five to seven months as evapotranspiration potentiel suffers a rapid raising by middle of spring with more than 80 mm in May which cannot be compensated by rain (Llano-Ponte et al, 1975).

Temperatures in winter are fairly cool with mean minimum temperature in January ranging from 2° to 4° C. Snow is infrequent for the main part of the area except to the north with elevations over 800 m. Frosts, however, are common in winter and sometimes in early spring. Nevertheless winter temperatures are not low enough to completely

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stop pasture growth and some production is obtained. Summers, by contrast, are quite hot, day temperatures exceeding **40°C** are common throughout the region.

1. 2. The soils

The soils derived from Paleozoic shales and granites which contains most pastures resources are classified as " Southern Brown Earths ". Their pH is acid ranging from 4 to 6 with the soils derived from granites reaching the more acidic values in some places (Jiménez et al, 1974).

These soils are highly deficient in phosphorus and phosphorus fertilizer applications are necessary for the establishment and persistence of subterranean clover bassed pastures. Molibdenum shows a quite wide spread picture of clear responses to its application while calcium application is only of practical interest in the more acid soils, i. e. pH less than 5. As subterranean clover is present in spontaneous forms in natural pastures, suitable Rhizobium colonies are living in old pasture lands. Despite of this there are many situations in which inoculation is needed or recommended at the time of seeding.

1. 3. Agricultural systems in pasture lands

Most pasture lands are in private hands, being farms - " dehesas " - devoted to mainly animal productions with some agricultural activity in long leys phases. Not always the owner of the land and the owner of the stock are the same person and in this case a contract is made for partionning benefits.

Part of the pastoral resources surrounding villages are communal pastures which use to be intensively stocked and, at times, cropped.

Some transhumant practices still persist from north to south, i.e. from highland snow covered pastures to temperate pastures in the plains.

Another significant portion of the regional stock is moved every summer from pastures to cereal stubbles in the wheat areas. These are purely agricultural entreprises with no stock that use to sell the bycrop residues to the owners of stock of the neighbouring pasture lands. As the costs of moving the animal are increasing and mechanisation and intensification of cropping is progressing transhumant practices within and between regions are decreasing.

The trend at present in the pastoral farms is to set stock by fencing and intensification of pasture production and cropping for forages wherever possible.

2. SUBTERRANEAN CLOVER SCENE

2. 1. Early commercial sowings

While attempts were made earlier it was not until the 60's when subclover started to be sown commercially in a wider scale in private farms. By that time, Australian cultivars and technology, chiefly those existing in South Australia, were used. Thus cultivars Mount Barker, widely used at the beginning, and Clare there after gaining in popularity were extensively used in univarietal sowings. Other cultivars were introduced in much less extent Tallarook, Geraldton and Yarloop (Muslera, 1978, 1984).

Soon the occurrence of dry years revealed an imbalance with the environment and those cultivars coming from milder areas in Australia. However new sources of cultivars were available in Australia and new fashion cultivars were imported. Woogenellup, Seaton Park, Daliak and Howard were tested with Clare, the number one in popularity as its adaptability was much greater than Mount Barker. It was varied the degree of success of those cultivars with Daliak well adapted but not well accepted by farmers because its unimpressive looking. Woogenellup, more impressive looking, was better accepted but not very well adapted.

Seaton Park was a real success as did Clare.

More recently by the 80's, cultivars of recent release in Western Australia have been brought into the Spanish scene, Trikkala, Larissa, Nungarin and Esperance. These were released in Australia since 1975 to cover three main objectives (Stern et al, 1981):

Replace the highly oestrogenic Yarloop in wetter areas : Trikkala and Larissa.

Replace Seaton Park and Woogenellup in "scorched" (Kabatiella caulivora) areas : Esperance and Trikkala.

To spread further the subclover pastures into drier areas of the wheat belt under less than 400 mm rain : Nungarin.

Although none of these three objectives have been identified in Spain, the dynamic of searching for newer varieties in a need for improved adaptation, made possible this apparently contradiction.

At the same time an effort was made to produce local seed, first towards with Mount Baker and later with the easier harvesting Clare.

TABLE 1 :

Behaviour of cultivars brought in Spain

Decades		
60's	Mount Barker	Failure. Partially adapted to higher rainfall.
	Clare	Success
	Tallarook	Failure
	Yarloop	Partially adapted. Highly oestrogenic
	Geraldton	Success in lower rainfall. Oestrogenic
70's	Woogenellup	Partially adapted. Soft seeded

	Daliak	Well adapted. Small leafed. Relatively small commercial success
	Seaton Park	Success
	Howard	Unsuccess
80's	Trikkala	Soft seeded. No well fitted
	Larissa	Soft seeded. No well fitted
	Esperance	Fitted. Small growth
	Nungarin	Adapted to low rainfall and shallow soils

3. TECHNOLOGICAL PROBLEMS

3. 1. The technology of establishment

Many of the early sowings never reached a real establishment as subterranean clover pasture. Efficiencies of less than 20 % were the rule rather than exception. Whereas a variety of reasons are responsible ; we may identify the most common cause for the initial failure of establishment in the wrong method and time of sowing. Seed broadcast without covering in early autumn well behind the start of the season was a common practice in many cases. Thus seeds lying on top of the rough soils

gave an uneven germination due to washing down by rain water and dragging by ants, etc. ;

seedlings died due to radicles failed to penetrate crusted soils ;

were more susceptible to pathogenic attacks after several cycles of wetting and drying conditions when isolated rains came (Hagon, 1974).

Therefore plant densities as low as 5 – 10 plants per m^2 often resulted, and such low densities rendered subterranean clover plants very susceptible to the aggressive competence of other plants (Rossiter, 1966).

Later when specific machinary and techniques for covering the broadcasted seeds were used, efficiencies were greatly enabled, particularly when sown in more appropriate time, close to the start of the season or immediately after that.

For those stands properly established another problem raised right from the beginning. An unsuited level of regeneration caused a rapid drop of plant densities to below 5 – 10 % for the introduced subterranean clover.

Again various causes may be identified, some of them being related to incorrect utilization :

Failure to topdress with phosphate. A number of pastures, although receiving phosphate in the first year, have not received subsequent application in soils highly deficient in P. This may contribute by no means to clover deterioration.

Grazing mismanagement. Although subterranean clover is a very versatile specie adapted to a wide range of grazing systems, it is in fact very susceptible to the aggressive competition of plants which develop in zero grazing situations.

Incorrect varieties. The utilization of varieties which are not fit to the environment is, in general opinion, the most common cause of failure in persistence.

3. 2. Differential behaviour of cultivars

In the early times cultivars from the wetter areas in Australia entered into Spain. Thus cvs. Mount Barker, Tallarook, Yarloop and Clare were used. While being of use in Australia in areas of 500 – 800 mm of rain with 7 – 9 months growing season as in the South-West of Spain, the environment here was not withstanding harsher due to

hot summers

colder winters.

TABLE 2

Air mean maximum temperatures (°) in two experimental sites of Extremadura durant the dry period (May - September), versus two "typical" sites of Australia in the corresponding period (November - March)

	Extremadura			Australia	
	La Orden	El Gaitan		Merreding W.A.	Hamilton,Vic.
May	21	20	November	28	20
June	29	27	December	32	23
July	34	33	January	34	25
August	34	33	February	33	26
September	28	26	March	30	23

TABLE 3

Mean temperatures (° C) of the growing season in Spain and Australia

	Badajoz		Merredin,W.A.			Hamilton,Vic.	
Month	(1)	(2)	(1)	(2)	Month	(1)	(2)
October	24	13	24	12	April	20	8
November	17	8	20	9	May		6
December	13	5	17	7	June		4
January	13	4	16	6	July		4
February	15	5	16	5	August		4
March	18	8	20	6	September		5
April	21	10	25	10	October		6
May	25	12	28	13	November	19	7

(1) Maximum temperatures
(2) Minimum temperatures

Source : Llano-Ponte et al, 1975,
Climatic averages
Australia, 1975

Comparing (tables 2, 3) a " cool " place in Australia like Hamilton, Vic., versus Extremadura with similar winter temperatures, can be realized that summer temperatures are much higher in the later. On the other hand a temperate place like Merredin, W.A., with hot summers has a milder winter that the Spanish places.

Furthermore the erratic nature of the rain between and within seasons in Spain, soon revealed symptoms of responses "out of shape" in cultivars.

In 1975, Gomez, Ramos and Francis conducted a simultaneous study in Spain and Australia to assess differential behaviour in maturity grade. They found that the early group of cultivars delayed flowering for some 30 days in average in Spain. The dealy was considerably reduced in late group with some very late lines with high cold requirements flowering earlier in Spain.

TABLE 4

Maturity grade (1) of Trifolium subterraneum varietes cultivated at La Orden (Spain and Perth (W. Australia)

	La Orden	Perth	
Northam	119	83	Perth, W. Australia
Nungarin	121	79	Perth, W. Australia
Daliak	124	104	Northan, W. Australia
Geraldton	124	103	Geraldton, W.Australia
Yarloop	132	113	Waroona, W. Australia
Trikkala	133	115	Perth, W. Australia
Howard	137	127	Canberra, Australia ACT
Clare	144	133	Clare, S. Australia
Nangeela	147	151	Nangeela, Vic.
Larissa	151	146	Larissa, Greece
L.D. 1187	161	162	Avila, Spain
L.D. 1195	165	180	C. Rodrigo, Spain
L.D. 1190	174	187	C. Rodrigo, Spain
L.D. 1184	186	196	Avila, Spain

(1) expressed in days from germination to first flower
Source : Gómez et al, 1979.

Of special agronomic significance is the case of the early types as they shorten their range of maturities flowering closer to each other in Spain. This ease the choice of cultivars and it allows that earliest types which would have never been recommended can be tested.

For the late cultivar Mount Barker, although its delay in Spain isn't longer than one week, it needs around five months to flowering, i.e. early April. By that time season is about finishing and the risk for a premature final is high. Yet the soils are usually hardly crusted in late spring so preventing burrs to buried. Unburied burrs produce less seeds of smaller size and reduced viability (Collins et al, 1976).

Thus it is again realized that relative adaptability is inversely related to maturity grade (Rossiter, 1959, 1966).

3. 3. The seed phase

It is known that for correct regeneration enough number of seeds must be present in the field ready to germinate and produce plants at the right time in the beginning of the season (Hagon, 1974). For these two interacting principles must occur :

the plant must be able to produce enough quantity of seeds ;

enough quantity of seeds must arrive in good conditions to germinate at the real start of the season.

This late principle is strongly related to the adverse nature of the environment acting in the sense of eroding the seeds bank previously formed in the soil.

One of the environmental aggression comes from predators, one of them is the seed harvesting ant (Messor barbara) very active in Spain. This aggression was evaluated in an experiment carried out in

Extreamadura (Gomez et al, 1977). By the end of September more than half of the seed laying on top of the soils and covered with a layer of sand, have disappeared (Gómez et al, 1977). Although these results are restricted and figures for wide areas still remain unassessed, these predators, is clear, that are very active and can cause patches of bare ground in the stands.

The most important environmental aggression is by no means the wetting and drying cycles of the start stop nature of the season characteristic of this environment. Erratic rains occur during summer and very often in September before the season starts, promoting germination in those permeable seeds whose impermeability coat has been broken by temperature cycles. It is known that as greater the cycle and as higher the maximum temperatures as rapid the rate of "softening" (Quinlivan, 1961). It is also known that a genetic component is involved so that some varieties are more resistant to the temperature softening effect (Quinlivan, 1970).

In the Spanish environment temperatures of 60° C in the top of the bare soil are very common during the summer together with night temperatures of 25° C or less. The effect of these temperatures on the seeds bank of the soil was investigated in two places of Extremadura (Gomez et al, 1975 ; Ramos et al, 1979). A range of six varieties was used including local and commercial lines. Soon after seed set samples of each variety were collected and placed in two experimental sites with adequate replications. Along the three months time periodical analyses were made to determine the residual hard seeds. Results showed a dramatical effect of the temperatures on cv. Mount Barker : 92 % of its seeds being softened. For the cultivars Daliak and Geraldton the figures were 47 % hard seeds, showing a high genetic resistance as did the Spanish line 67 CAE with 45 % hard seeds (table 5)

Another annual legume investigated, all of them represented by local types, showed a picture of very sligh response to temperature treatment with Medicago polymorpha L. being more susceptible than others.

TABLE 5

Percent hard seeds that remain impermeable after 90 days during summer in the fiels in two localities of Extremadura

Variety	La Orden		El Gaitan		Transformed mean	Retransformed mean
	Rep 1	Rep 2	Rep 1	Rep 2		
Victor	5.0 (12.92)	10.0 (18.44)	27.4 (31,56)	25.0 (30.00)	(23.23)	– 15.6
67– CAE	43.5 (41.27)	42.3 (40.57)	51.3 (45.75)	44.9 (42.07)	(42.42)	45.5
Mt.Barker	30.9 (33.77)	16.9 (24.27)	0.9 (5.44)	0.0 (1.99)	(16.37)	7.9
Clare	43.0 (40.98)	34.7 (36.09)	38.4 (38.29)	29.3 (32.77)	(37.03)	36.3
Daliak	37.3 (37.64)	23.2 (28.79)	89.5 (71.09)	34.9 (36.21)	(43.43)	47.3
Geraldton	30.6 (33.58)	45.5 (42.42)	30.6 (33.58)	80.3 (63.65)	(43.31)	47.1

Variance due to	D. F.	M. S.	R. V.	
Repititions	3	36.70318	1	N.S.
Treatments	5	545.58145	3.21	*
Error	15	169.79070		

L.S.D. between treatment means P 0;05 = 19,63.

3. 4. Fitting the maturity of cultivars

As we said beforehand, there is a strong correlation between maturity or earliness of flowering and adaptability to succeed in a particular environment (Rossiter, 1966).

It was first stated (Gómez, 1975) after observations made on different collections and years that for local types the mean flowering time, while similar to that of Mount Barker and Clare, showed a range as wide as 60 days, for whole samples.

Francis et al (1976) established another approach for the subterraneum L. (S) types by making observations on a restricted collection from Iberian peninsula available in W. Australia. They established the correct maturity in that of the cultivar Daliak i.e. some three to four weeks earlier than Mount Barker.

Ecological evidences however indicated a greater complexity. Gomez and Ramos (1981) conducted a study looking through a sample of 739 lines collected from 1967 to 1969 in Extremadura. The sample contained 52 % of S types, 45 % of brachycalycinum Katz. et Morl. (B) types and the rest 3 % of yanninicum Katz. et Morl. (Y) types. The first look at the sample as a whole showed a confuse shape with flowering time ranging from 115 to 190 days (Table 4). When splitting the sample into subspecies, it was found the B types flowering at the 160 - 165 days range in great majority (71 % frequency), the rest of them ranging from 150 to 190 days. The S types on the other hand ranged their flowering time from 115 to 165 days with 86 % of them in a wide range of 125 to 155 days in which individual frequencies are lower than 20 %.

In this context cv. Clare, a B type, flowered at 147 days mark slighly behind the range of the local group and some two weeks earlier than the most common type. Within the S group cvs. Northan and Nungarin are earlier and Tallarook is later than the range encountered in local group, cv. Mount Barker was in the 7 % tail (Tables 3, 4).

4. SELECTING CULTIVARS. A NEWER APPROACH

Owing to the pressing search for new cultivars in the yet reduced Spanish market for subterranean clover an attempt was med to produce Cultivars specially tailored to fit the environment. The programme aimed at exploiting the genetic resource of a local germplasm bank of more than 2.000 introductions which contains in great majority locally collected lines.

It aimed from the beginning at producing cultivars for those situations uncovered by the existinq cultivars. In the low rainfall areas under 500 mm and in shallow soils cvs. Daliak and Geraldton were available with the former being not very much appreciated because of its short and poor winter growth and the latter being potentially oestrogenic. While new cultivars have appeared in Australia for low rainfall areas, Nungarin and Northam are some two weeks earlier than the model.

For the medium-early range cv. Seaton Park is available and is producing good results because of its good forage production, moderately high hardseededness and good burr burial and seed production.

On the contrary there is no suited cultivar for the medium-late range as Trikkala is soft seeded, Esperance has an inherently poor forage production, Dinninup is out of the market for its oestrogenicity and Woogenellup has low hardseededness. This model needs to combine some ability to produce good seed on top of the soil as it has to face situations of increasingly crusted soils in spring.

Finally the programme aims at producing a fitted B type for high forage production in the higher rainfall areas and / or clay deep soils. The situation require a late type able to set seed when soils are crusted and cannot be penetrated. This ability has been developped in the brachycalycinum group. Cultivar Clare is the only one adequated of the existing cultivars but its forage production can be improved.

TABLE 6

Advanced selection varieties of trifolium subterraneum with reference to existing cultivars

Variety	Maturity G.days	Hard seed	Growth vigor	Oestrogenici	Seed yield	Origin	ADAPTATION Rainfall Soil capac Low	HIGH	Clay deep Soils/PH / 7
Early									
704	118	+++	++	Free	++	La Serena,Spain	+		
1063 A	118	+++	++	Free	+++	Turkey	+		
1142	122	+++	+++	Free	++	La Serena,Spain	+		
Geraldton	123	++	+	High	++	Australia	+		
710 Serena	124	++	+++	Free	++	La Serena,Spain	+		
Medium-early									
Daliak	127	+	+	Free	++++	Australia	+		
1252 Cachorrilla	127	+	++	Free	+++	Coria,Spain	+	+	
92	129	+	++	Free	++	Olivenza,Spain	+	+	
102	130	+	++	Free	++	Alconchel,Spain	+	+	
1055	130	++	+++	Free	++	Portugal	+	+	
Seaton Park	131	+	++	Free	++	Australia	+	+	
Medium-late									
1322	136	+	++	Free	+++	Olivenza,Sapain		+	
274 Areces	138	++	+++	Free	+++	Don Benito,Spain		+	
Woogenellup	143	–	+++	Free	+++	Australia		+	
Late									
Clare	147	–	++++	Free	++++	Australia		+	+
1209	155	+	++++	Free	++++	V. de Alcudia,Spain		+	+
11	155	++	++++	Free	+++	Barcarrota,Spain		+	+
9	156	+	++++	Free	+++	Barcarrota,spain		+	+
708-Gaitan	158	+	++++	Free	++++	Badajoz		+	+

5. SUMMARY

In the Extremadura and West Andalusia site conditions are rather Variable. Altitude ranges from sea level to 1.000 m, rainfall varies between 450 and 1000 mm, mean minimum temperature in January from 2 to 4° C. Soil pH is low (4 to 6). There is a high phosphorus deficiency. Sometimes calcium application and inoculation for subclover is needed.

Formerly, frequent failures of subclover pastures were observed due to poor establishment techniques, grazing mis-management and choice of incorrect varieties. Among the reasons why Australian cultivars only fit into part of the target area are : 1) Their maturity range is much smaller in Spain than in Australia ; 2) Most of them fail to burry their burrs in usually hardly crusted soils (unburried burrs produce less seed) ; Seed impermeability is mostly low resulting in a lack of persistence. Therefore only Clare and Seaton Park are so far well accepted for commercial sowings. By an own selection program promising lines were identified with caracters that are not covered by Australian cultivars.

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