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in

Porqueddu C. (ed.), Tavares de Sousa M.M. (ed.).
Sustainable Mediterranean grasslands and their multi-functions

Zaragoza : CIHEAM / FAO / ENMP / SPPF
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 79

2008
pages 423-426

Article available on line / Article disponible en ligne à l'adresse :

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To cite this article / Pour citer cet article

Corleto A., Cazzato E. **Dry matter yield, earliness and plant regeneration of different subclover cultivars in southern Italy.** In : Porqueddu C. (ed.), Tavares de Sousa M.M. (ed.). *Sustainable Mediterranean grasslands and their multi-functions* . Zaragoza : CIHEAM / FAO / ENMP / SPPF, 2008. p. 423-426 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 79)

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Dry matter yield, earliness and plant regeneration of different subclover cultivars in southern Italy

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SUMMARY – Research was conducted over a 4-year period (1994-1997) on the Gaudiano di Lavello field (Basilicata region), 180 m a.s.l., 41° 3' N, 15° 48' E, on a sandy-loam soil. Twelve cultivars of *Trifolium brachycalycinum* (3), *Trifolium subterraneum* (7) and *Trifolium yanninicum* (2) were compared using a randomized block design with 3 reps and a plot area of 1 m^2. The following parameters were analysed for the 4-year period: (i) dry matter yield (DMY); (ii) biomass distribution during the year (BD); (iii) plant height (PH); (iv) flowering earliness (FE); and (v) plant regeneration (PR). DMY as a mean of a 4-year period ranged from 6.8 (*T. brachycalycinum* cv. Nuba) to 4.1 t/ha (*T. subterraneum* cv. Junee). BD calculated in fall, winter and spring period reached the highest values in spring (56%) while it was lower in winter (28%) and fall (16%). pH shows a wide range of variability between cultivars. As to FE it ranged from April 3 (*T. subterraneum* cv. Woogenellup) to April 23 (*T. yanninicum* cv. Larisa). PR, expressed as number of seedlings/m^2, varied from 2808 (*T. subterraneum* cv. Enfield) to 1555 (*T. brachycalycinum* cv. Nuba).

Key words: *Trifolium brachycalycinum*, *Trifolium subterraneum*, *Trifolium yanninicum*, biomass distribution, plant height, pasture improvement, cover crops.

RESUME – *"Rendement en matière sèche, précocité et régénération des plantes chez différents cultivars de trèfle dans le sud de l'Italie". Des recherches ont été effectuées pendant 4 ans (1994-1997) dans un champ expérimental du territoire de Gaudiano di Lavello (région de la Basilicata), situé a 180 m d'altitude, 41° 3' N, 15° 48' E, sur un terrain sableux-limoneux. Douze cultivars appartenant à* Trifolium brachycalycinum *(3),* Trifolium subterraneum *(7) et* Trifolium yanninicum *(2) ont été comparés en utilisant un exemplaire répliqué 3 fois sur une parcelle d'un m^2. Les paramètres suivants ont été analysés pendant 4 ans : (i) production de matière sèche (PMS) ; (ii) distribution de la biomasse au cours de l'année (DB) ; (iii) taille de la plante (TP) ; (iv) précocité de la floraison (PF) ; et (v) régénération de la plante (RP). La PMS, comme moyenne sur 4 ans, variait de 6,8 (*T. brachycalycinum *cv. Nuba) à 4,1 t ha^{-1} (*Trifolium subterraneum *cv. Junee). La DB calculée en automne, en hiver et au printemps, a atteint les valeurs les plus élevées au printemps (56%), par rapport à l'hiver (28%) et l'automne (16%). La TP montre une large gamme de variabilité pour les cultivars. Quant à la PF, elle oscillait entre le 3 avril (*T. subterraneum *cv. Woogenellup) et le 23 avril (*T. yanninicum *cv. Larisa). La RP, exprimée comme le nombre de plantules/m^2, variait de 2808 (*T. subterraneum *cv. Enfield) à 1555 (*T. brachycalycinum *cv. Nuba).*

Mots-clés : Trifolium brachycalycinum*,* Trifolium subterraneum*,* Trifolium yanninicum*, distribution de la biomasse, taille de la plante, amélioration des pâturages, cultures de couverture.*

Introduction

Legumes are a fundamental resource for agro-ecosystem sustainability and because of their N-fixation capability they play an important biological role in the crop rotation and intercropping systems (Cazzato *et al.,* 2003). As for annual legumes, clovers and medics are the species most utilized for Mediterranean pasture improvement (subclover in particular) while medics are best adapted to alkaline soil. Recently clovers and medics are gaining importance as cover crops in the orchards of the Mediterranean environment, reducing the use of N fertilization and herbicides while, in the sloping ground, they mitigate the water erosion. A recent research conducted for a 5-year period by the Dipartimento di Scienze delle Produzioni Vegetali (Bari University), on the effect of different soil management practices in an olive grove, Basilicata region, showed that the soil cover with *T. brachycalycinum* cv. Clare or soil tillage management (with 3 hoeing per year), gave the best results in terms of olive production and quality (Corleto and Cazzato, 2008). In this paper are reported the results obtained in a 4-year period on the comparison of different cultivars of subclover belonging to 3 different species: *T. brachycalicinum* Katznelson and Morley, *T. subterraneum* L., *T. yanninicum* Katznelson and Morley (Smith and Roquette, 1988).

Materials and methods

The research has been performed for a 4-year period (from 1993-94 to 1996-97) at the Gaudiano di Lavello field, Basilicata Region. The experimental site (41° 3' N, 15° 48' E) had a sandy-clay textured soil, characterized as sub-alkaline, low in total nitrogen (1.10‰; Kjeldhal method) and high available phosphorus (127ppm, Olsen method) and exchangeable potassium (662 ppm, $BaCl_2$ + TEA method). The climate is dry in the summer and has a typical Mediterranean distribution of precipitation from autumn to spring. The long term average (1980-1995) total rainfall is 450 mm. Temperature did not shows significant variation from the long term average either as the average of minimum annual temperature (11.3℃) or as the average of maximum annual temperature (20.1℃). A randomized complete block design with 3 replications and plot size of 1 m^2 was used comparing 12 cultivars of subclover 3 of which (Clare, Nuba and Rosedale) belonging to *T. brachycalycinum*, 7 (Denmark, Enfield, Goulburn, Junee, Karridale, Leura and Woogenellup) to *T. subterraneum* and 2 (Gosse and Larissa) to *T. yanninicum*. Soil preparation was performed September 29, 1993, ploughing the soil to a depth of 30 cm and fertilizing with 100 kg ha^{-1} of P_2O_5 as superphosphate. Sowing in row 20 cm apart, using a seed rate of 40 kg ha^{-1}, was effectuated October 1st 1993. Emergence occurred October 8, 1993, October 24, 1994, August 30, 1995 and September 15, 1996. Every year at the end of emergence all the subclover cultivars covered uniformly the plot and weed contribution was not appreciable. The following indices were studied: dry matter yield (DMY), plant height (PH), reseeding potential (RP). DMY was estimated on the entire plot area. PH was determined with a stick meter on 3 different point of the plot taken at random just before the cutting. RP, expressed as seedling numbers m^{-2}, was determined counting, at the end of emergence, the seedling comprised in a square frame (cm 20x20) replicated 3 times in each plot. Date of flowering was taken at the appearance of the first flower. Herbage was cut by hand with a sickle leaving uncut 1 cm of vegetation. The cuttings were performed twice in the establishing year (1994); in the following years, 4 (1995), 5 (1996) and 4 (1997) cuts, were performed. Analysis of variance was applied using M-STATC statistical package for all the cultivars including the years. Significance of differences between treatment means was estimated by use of Student Newman Keuls (SNK) test.

Results

Dry matter yield

As average of a 4-year period (Table 1) DMY ranged from 6.8 t ha^{-1}, cv Nuba (b) to 4.1 t ha^{-1} cv. Junee (s). Beside Nuba, other 2 cultivars b type (Clare and Rosedale) gave high DMY (6.5 and 6.2 t ha^{-1}, respectively) followed by Woogenellup (s), with 5.9 t ha^{-1}. On the average the b type subclover produced 6.5 t ha^{-1} DMY, s type 4.8 t ha^{-1}, y type 4.5 t ha^{-1}. As mean of each year (Table 1) *T. brachycalycinum* compared with the other 2 species shown, even in the establishing year a higher DMY (4.7 t ha^{-1}) than *T. subterraneum* (2.2 t ha^{-1}) and *T. yanninicum* (2.4 t ha^{-1}). Besides *T. brachycalycinum* exhibited a better DMY stability from second to fourth year (6.6, 7.2, 7.4 t ha^{-1}) than *T. subterraneum (*4,9, 6.3, 5,6 t ha^{-1}) and *T. yanninicum* (4.0, 6.1, 5.4 t ha^{-1}). Among the cultivars, Rosedale (b) and Woogenellup (s), excluding the first year when only 2 cuttings were performed, show during the years a good DMY stability. (8.0, 7.0, 6.9 t ha^{-1} and 7.0,7.4, 6.5 t ha^{-1} for Rosedale and Woogenellup respectively). The seasonal biomass distribution, here reported as mean of a 4-year period, indicates that during fall all the 3 species shown similar DMY (between 0.7 and 1.0 t ha^{-1}) while in winter and spring *T. brachycalycinum* overcame the other species furnishing a higher DMY (2.1 *vs* 1.2 t ha^{-1} in winter and 3.3 *vs* 2.7 t ha^{-1} in spring).

Plant height

A wide range on plant height values, expressed as mean of a 4-year period, was observed among cultivars. Clare and Nuba (b types) show the highest values (15.2 and 14.6 cm, respectively) while the lowest values, comprised between 9.0 and 7.6 cm, were exhibited by the following cultivars: Leura, Enfield, Denmark, Junee, Goulburg, belonging to s type and Larissa (y). In the first year only 2 cuttings were performed (March and May) with the scope to permit a good plant establishment and development; b type cultivars (Clare, Nuba and Rosedale) along with Woogenellup (s), Gosse (y), and Karridale (b) show the highest pH comprised between 29.0 and 15.5 cm; this indicates their high

growing rate ability. All the cultivars tested show during the years a wide variability on PH, that appears to be highly dependent on environmental conditions, including crop management (cultivars x years interaction).

Table 1. Dry matter yield (t ha^{-1}) of different cultivars of subclover during a 4-year period

Cultivar	1993-94	1994-95	1995-96	1996-97	Mean
Nuba (b)	5.23 ej	6.03 bh	8.24 a	7.60 ad	6.77 a
Clare (b)	5.99 bh	5.83 bi	6.47 ag	7.76 ac	6.51 ab
Rosedale (b)	2.91 kn	7.99 ab	6.98 ae	6.89 ae	6.19 ab
Woogenellup (s)	2.81 kn	6.91 ae	7.44 ae	6.52 af	5.92 b
Karridale (s)	2.65 kn	5.58 cj	6.80 ae	5.59 cj	5.15 c
Leura (s)	2.63 kn	4.50 fk	6.72 af	5.55 cj	4.85 cd
Enfield (s)	2.83 kn	4.17 hk	6.01 bh	5.45 dj	4.62 cd
Denmark (s)	1.67 mn	5.44 dj	5.78 ci	5.56 cj	4.61 cd
Gosse (y)	3.41 jm	3.92 hk	5.47 dj	5.39 dj	4.55 cd
Larisa (y)	1.42 n	4.11 hk	6.77 ae	5.39 dj	4.42 cd
Goulburn (s)	1.20 n	4.26 gk	5.89 bi	5.36 dj	4.18 d
Junee (s)	1.86 ln	3.70 il	5.70 ci	5.31 dj	4.14 d
Mean *T. brachycalycinum*	4.71 ef	6.62 ac	7.23 ab	7.42 a	6.49 a
Mean *T. subterraneum*	2.23 g	4.94 ef	6.34 bd	5.62 ce	4.78 b
Mean *T. yanninicum*	2.42 g	4.02 f	6.12 cd	5.39 de	4.49 b
General mean	2.88 d	5.20 c	6.52 a	6.03 b	5.16

Values not having any letter in common are significantly different at P<0.01 level, according to SNK test.

Earliness

Date of appearance of the first flower was comprised from April 3 (Woogenellup, s) to April 23 (Larissa, y) showing a range of about 3 weeks. Within *T. brachycalycinum* Clare and Rosedale flowered within the 1st week of April while Nuba flowered 2 weeks later. Among s types cultivars Woogenellup was the earliest (April, 3) and Karridale the latest (April, 17); the 2 y types present in this trial, one (Gosse) was early (April, 10) and the other (Larissa) late (April, 23).

Plant regeneration

PR, expressed as number of seedlings m^{-2}, was determined at the end of emergence of each year. The mean values of a 4-year period ranged from 2808 seedlings m^{-2} produced by Enfield(s) to 1555 seedlings m^{-2} obtained with Nuba, (b).The cultivars belonging to *T.subterraneum* shown on the average a higher number of seedlings m^{-2} (2416) than *T. brachycalycinum* (1618) and *T. yanninicum* (1804). However this character seems to be highly influenced by the environmental conditions of each year (cultivars x years interaction).

Discussion and conclusion

The results obtained in this research have pointed out the high yield potential of Nuba, Clare , Rosedale (b types) and Woogenellup (s type). However environmental conditions can strongly influence DMY. A comparison among several cultivars grown in different Australian environments (Smith *et al*.,1987) shown a DMY potential comprised between 3.8 and 6.0 t ha^{-1}. In a replicated trial in an organic vineyard in Mendocino County, California, the cultivars tested gave the following results: Koala (9.7 t ha^{-1}) Trikkala (8.3), MT Barker (7.6), Seaton Park (6.8) (Bugg *et al.,* 1996). Subterranean clover when used for Mediterranean pasture improvement under rain fed conditions ensures higher DMY and better herbage quality than perennial grasses such as *Festuca arundinacea*, *Lolium*

perenne, *Lolium multiflorum* and *Dactylis glomerata* (Corleto *et al.*, 1984). In the establishing year Nuba and Clare yielded much more than Rosedale because the last one shown in the first cut a lover plant density probably due to a higher percentage of hard seed in the seed sample sown. Cultivars belonging to *T. brachycalycinum* have shown higher DMY either in winter or spring than *T. subterraneum* and *T. yanninicum*. This will permit a higher stocking rate during winter season. A high positive relation has been found between pH and DMY: taller cultivars produced higher DMY and these was the case of Clare, Nuba, Rosedale and Woogenellup. The variability observed on PR (between 2808 and 1555 n. of seedlings m^{-2}) appears to be related with seed production that is higher in s types cultivars (data not reported in this paper) but the values observed can be considered optimal to ensure a good soil cover. Earliness did not influence DMY. The earliest cultivars such as Woogenellup, Clare and Rosedale were the more productive along with Nuba (b type) that was the latest. A different behaviour was shown in other researches. A trial conducted in Portugal (Crespo and Romano, 1982) on 464 lines shown that early lines of *T.subterraneum* gave higher DMY than late ones while lines of *T. brachycalicinum* were less influenced by earliness. On the contrary a study conducted at Tamworth Agricultural Institute NSW, Australia (Lodge and Harden, 2007) shown that early maturing cultivars and lines of *T. brachycalycinum* and *T. subterraneum* tended in general to perform poorly. It has to be pointed out that subterranean clovers can play an important role also as cover crop in orchards. More recently winter self sown legume that complete their active growth by the end of May have gained strong recognition in this environments (Talamucci, 1997). Since water competition is the main issue when using cover cropping under dry farming conditions, the proper species and variety should be selected from cultivars displaying smaller size with a low yield potential and low regrowth after cutting, but characterised by a high persistence and high self-seeding ability (Porqueddu *et al.*, 2000). Several cultivars mainly belonging to *T. subterraneum* tested in this trial have the above mentioned characteristics and could be successfully used as covercrop.

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