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Summary: The growing ability of pasture species during the cool season is a key factor in the Mediterranean basin. This study assessed the variation of dry matter yield (DMY) during autumn and winter in subterranean clover strains from Sardinia. The results evidenced that wide variation exists among strains for DMY in the cool season. Earliness did not appear an essential factor to obtain high early production in absolute terms, although it influenced the yield distribution pattern. Seedling density at the break of the season mostly affected autumn yield but had minor influence on the subsequent cold-season yield.

Key-words: autumn-winter yield, Mediterranean environment, pasture, subterranean clover, *Trifolium subterraneum L.*

INTRODUCTION

In the Mediterranean region, the climate is characterised by the erratic occurrence of rainfall and by the alternance of a wet, relatively cold period with a generally long, hot and dry summer. Optimum temperature for growth corresponds, therefore, with optimum moisture only for short periods, resulting in high seasonality of herbage production. While late-spring and summer growth is restricted by heat and drought stress, autumn growth is unreliable depending on the break of the season, and winter production is often hampered by the low temperature. The occurrence of periods of shortage represents a well-known structural constraint for livestock systems and pasture management in the Mediterranean area.

These climatic conditions have favoured annual species, better adapted through a cool-season-growth-habit and seed-escape to summer drought (Buddenhagen, 1990). Therefore, in rainfed agriculture a particular interest has been raised by annual, self-regenerating forage legumes because of their growth cycle and their ability to repristinate pasture swards year after year (Cocks et al, 1980). In relation to seasonal production main selection objectives for these species are: i) the enhancement of growth during the cool season when the potential evapotranspiration is low and rainfall is probable; and ii) the ability to react promptly to the first autumn rains of agronomic efficacy, which in self-reseeding annuals depends largely on the available seed bank in the soil (Cocks, 1988).

The ability to grow during the cold autumn-winter season has been assumed as an important selection criterion in a breeding programme aimed at developing subterranean clover varieties for the Mediterranean zones of Italy (Piano, 1987). This note reports on the variation for autumn and winter yield observed in strains singled out from Sardinian native populations.

MATERIALS AND METHODS

The data examined in the present study refer to a two-year period and are part of the results issued by an experiment carried out for a longer span at Sanluri, south Sardinia. The evaluation involved 356 lines (genotypes) of Trifolium subterraneum L. originating from populations collected in a range of environmental conditions in Sardinia. In this paper, total dry matter yield (DMY) refers to the cumulated values recorded for each line over 14 cuts. The autumn-winter production was assessed by three cuts in each season, made between the end of November and the beginning of March in 1991-92, and between the beginning of November and mid-February in 1992-93. Autumn-winter yield (AW-DMY) is meant here as the cumulated value over these six cuts. The DMY obtained in the coldest periods of winter, i.e. the cumulated yield of the cuts made on January 30, 1992, March 4, 1992 and February 10, 1993, here expressed as winter yield (W-DMY), was assumed to be a parameter of growing ability under low temperature. The ratio of both the autumn-winter yield and the winter yield over the total yield recorded in the two seasons was also computed (AW/T and W/T, respectively). About three weeks after the beginning of the rainy season in autumn 1992, the sward regeneration was assessed as number of seedlings per plot (SEEDLINGS). The flowering time (FLOWER) of the lines, expressed as the number of days from sowing to the first flower appearance, was known from previous experiments and ranged between 90 and 156 days among lines when evaluated at Perth, Western Australia (Piano, 1984).

An analysis of variance (ANOVA) tested the variation among lines and among populations (mean of the lines from the same collection site) for the recorded traits. Correlation coefficients of the seasonal production (absolute values and ratios) with total production and flowering time were computed. Correlations between the regeneration parameter (SEEDLINGS) and yield of the three autumn-winter cuts were also assessed.

RESULTS AND DISCUSSION

Table 1 reports the summary statistics of line values for the traits regarding forage yield and sward regeneration. Highly significant variation among lines was found for all traits ($P<0.001$) except winter ratio. The level of diversity among populations (sites of collection) was similar to that among lines (data not shown), except that variation for winter yield was not significant, indicating that wide differences occurred for this trait among lines within populations. Overall variation among lines, as depicted by the CVs, tended to be higher for W-DMY and W/T than for AW-DMY and AW/T (Table 1).

Table 1. Summary statistics and probability level of the F-test in the analyisis of variance of total, autumn-winter and winter DMY, and regeneration parameter of subterranean clover lines.

Character	Mean	CV	Range	Prob.
Total DMY[a] (g/plot)	591	20	266-859	< 0.001
AW-DMY[b] (g/plot)	206	20	76-328	<0.001
W-DMY[c] (g/plot)	118	25	44-214	<0.001
AW/T[d] (%)	36	19	19-64	<0.001
W/T[d] (%)	20	24	10-37	0.21
DEEDLINGS 1992-93 (no./plot)	1739	49	300-3900	<0.001

a: cumulated over two seasons (14 cuts); b: cumulated over six cuts in two seasons; c: cumulated over three cuts in two seasons; d: AW-DMY and W-DMY as proportion of the total DMY.

As expected, total DMY and flowering time were positively correlated (Table 2), for lengthening of the growth cycle does certainly contribute to higher dry matter accumulation. Flowering time and both autumn-winter and winter yield were not correlated (Table 2) indicating that in absolute terms earliness per se does not imply greater yield ability in the cold season. On the contrary, earliness determined higher ratios AW/T and W/T, as indicated by the negative coefficients. This result could be simply related to the fact that the relative contribution of AW- and W-DMY to the total production is expected to be greater in genotypes with shorter cycle. This is made evident by the negative relationship of both AW/T and W/T with total DMY which, in turn, increases on increasing the cycle length, i.e. flowering time. That the absolute seasonal yields (AW and W) were positively correlated with the total DMY suggests that the yielding ability during the cold season is also function of the genotype vigour and, thereby, of its general yield potential. The values of the correlation coefficients computed for the population means were always larger than those computed for the individual line values, except for the correlation of both AW-DMY and W-DMY with total DMY (data not shown). The lack of significance for these correlations at the population level is related to the occurrence of an interestingly high variation among lines within populations for the yield parameters.

Table 2. Correlation coefficients between total dry matter yield, seasonal dry matter yield, and flowering time of subterranean clover lines.

	Total DMY	FLOWER
Total DMY	-	0.49**
AW-DMY	0.53**	-0.08ns
W-DMY	0.42**	0.01ns
AW/T	-0.54**	-0.51**
W/T	-0.41**	-0.27**

*: $P \leq 0.05$; **: $P \leq 0.01$; ns: $P > 0.05$

The correlation coefficients between the sward regeneration parameter and the yield in the three autumn-winter cuts (Table 3) indicate that the effect of seedling density after the break of the season has certainly an influence on the cold-season yield but this is substantially restricted to the first cut. The magnitude of the correlation indicate, however, that the seedling density alone accounts only for a limited part of the differences in dry matter recorded in the first cut, the variation among strains for growth rate and general plant vigour being certainly other important factors.

Table 3. Correlation coefficients between the sward regeneration parameter recorded in autumn 1992 and dry matter yield recorded in the three autumn-winter cuts (in parentheses the date of each cut).

	1st-cut DMY (09.11.1992)	2nd-cut DMY (15.12.1992)	3rd-cut DMY (10.02.1993)
No. of seedlings per plot	0.54***	-0.11ns	0.21**

**: $P \leq 0.01$; ***: $P \leq 0.001$; ns: $P > 0.05$

CONCLUSIONS

This study has evidenced that wide variation exists in subterranean clover strains for dry matter yield in the cool season. Such a variation is of great importance for breeding purposes, as it enables selection of lines with good yielding ability during autumn and winter. A previous study conducted on populations from Sicily indicated that variation for early dry matter production may be related to variation for climatic characteristics among the sites in which the populations originated, and suggested that breeding for cold-season yield could rely on materials from warmer rather than cooler sites of origin (Pecetti et Piano, 1993). Similar plant/environment relationships could probably occur also in the present materials. The results have highlighted that earliness is not necessarily associated to high early production in absolute terms, so that it is expected that varieties with this character can be selected from lines of different maturity requirements, suited to distinct target environments.

As also found by Cocks (1988) with annual medics, high herbage yield in the first autumn cut appears appreciably affected by the number of seeds readily germinating at the break of the season, thus emphasizing the role of seed banks in the soil. However, the yield obtained with further cuts in the cold season is likely more dependent on the intrinsic vigour of the strains provided that the level of regeneration is not a limiting factor.

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