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Development of grazing-type lucerne: yield variation and relationship with plant morphology in the *Medicago sativa* complex

L. Pecetti, P. Valentini and E. Piano
Istituto Sperimentale per le Colture Foraggere, viale Piacenza 29, 20075 Lodi, Italy.

Summary: For agronomic, economic and environmental reasons the development of lucerne varieties adapted to grazing could meet the demand for a more extensive, sustainable agriculture. In this sense, a breeding programme activated atLodi has carried out the evaluation for plant morphology and dry matter yield of a large collection of accessions belonging to different taxa of the *Medicago sativa* complex. The "taxonomic" groups were rather differentiated both morphologically and productively. The subsp. X *varia* and the artificial crosses between different taxa combined an interesting morphology with good productivity. Deep-crowned, possibly grazing tolerant plants were frequent in these groups as well as in the subsp. *falcata* and in "mielga" wild populations of the subsp. *sativa.* Wide differences were also found among accessions within groups for herbage yield and frequency of different plant types. Plants could be categorised into models with distinct top-growth morphology and vigour. The different frequency, among and within groups, of such models was apparently related to the inter- and intra-taxa variation for yield. Implications of the results on selection of grazing lucerne are discussed.

Key-words: creeping root, lucerne, *Medicago sativa* complex, rhizomatous habit, top-growth morphology

INTRODUCTION

Agriculture extensification and sustainability are foreseeable in the future even in the so-called "developed" areas, where the reduction of inputs and the reclamation of marginal or abandoned lands could result in an agronomic, economic and environmental improvement. In this context, the development of lucerne (*Medicago sativa* complex) varieties tolerant to grazing can represent an important tool for newly framed livestock systems. This kind of lucerne ought to possess specific characteristics able to confer adaptiveness to this utilization, associated with good herbage yield. In particular, the presence of a large, deep-set crown and the ability to spread sideways are indicated as features conferring persistence under grazing (Heinrichs, 1963). The rhizomatous habit (horizontal, underground stems) and the creeping rootedness (development of new shoots from horizontal roots) are two mechanisms of spreading in lucerne. Plants with these characters are found to various extent in the different taxa of the M. sativa complex (Heinrichs, 1963), including wild populations of the subsp. sativa called "mielga" (Ben Chabaane, 1990).

The evaluation of a large collection of lucerne germplasm pertaining to the complex was carried out at Lodi within a breeding programme aimed at developing varieties tolerant to grazing. In a previous work (Piano *et al*, 1995) differences among "taxonomic" groups for some morpho-physiological traits were assessed. This paper further reports on the variation of herbage yield among and within groups as related to the occurrence of plants with characters possibly conferring adaptation to grazing.

MATERIALS AND METHODS

Ninety accessions were grown at Lodi for three years including the establishment year, in a randomised complete block design with two replications. Each plot contained 20 plants spaced 45 cm within and between rows. The accessions had various geographic origin and were classified as follows: 44 populations of *M. sativa* subsp. *sativa*, 17 of which were wild "mielga" populations from Spain; 9 of *M. sativa* subsp. *falcata*; 17 of *M. sativa* subsp. X *varia*; and 20 breeding populations or commercial varieties deriving from artificial crosses including two or three of the previous taxa. In the second year, the dry matter yield (DMY) of each plot was recorded on a plant basis over five cuts made between April 27 and October 20. In the spring of the third year the individual plants were visually examined for the presence of a shallow or deep-set crown and then categorised into distinct morphological models on the basis of their top-growth habit and vigour. The three shallow-crowned models (T) and the four deep-crowned models (CR) schematically reproduced in fig.1 and better described in Piano et al (1995) were individuated.

Variation of DMY among and within groups of accessions was assessed by analysis of variance and Duncan's multiple range test. Differences of DMY among morphological models were tested by the same statistics. Frequency distribution of the seven models were computed among and within "taxonomic" groups, and tested by Pearson's chi-square.

RESULTS AND DISCUSSION

The "taxonomic" groups of accessions were rather distinct for DMY (Table 1). The cultivated accessions of the subsp. *sativa* were the most productive. Among the groups considered to be most interesting for a possible selection of grazing types; the subsp. *falcata* and the "mielgas" had yield levels distinctly lower than the subsp. X *varia* and the artificial crosses. A great variation among accessions within each group was, however, present as indicated by the range values reported in Table 1.

Table 1. Mean values (g/plant) of dry matter yield cumulated over five cuts in five germplasm groups of lucerne, and range of values among accessions.

Germplasm group	N	Mean	min	max
M. sativa subsp. *falcata*	9	106.3c	15.2	151.5
Artificial crosses	20	207.2ab	105.6	458.6
« Mielga » populations	17	135.6c	82.3	180.3
M. sativa subsp. *sativa*	27	250.1a	87.1	412.5
M. sativa subsp. X *varia*	17	183.7b	108.9	296.3

Mean values followed by the same letter are not different at $P \leq 0.05$ (Duncan's test).

The seven top-growth models individuated in this evaluation were distributed in a quite different manner in the five groups (Fig. 2), the chi-square test being significant at $P \leq 0.001$. As expected, the accessions of the subsp. *sativa* were largely constituted by erect, shallow-crowned plants (60% of T3 and 25% of T2). Deep-crowned plants, all characterised by a branch-rooted system, were found in all groups, although the frequency of the different categories varied among them. These plants were rhizomatous in three categories (CR1, CR3 and CR4), with rhizomes of decreasing length from CR1 to CR4, while CR2 plants could be defined as true creepers. This category was the most rare among the CR ones in the collection, its frequency ranging from 0 to 2% in the groups (Fig. 2).

Top- and bottom-ranking accessions for DMY were separated in each "taxonomic" group, their mean yields (indicated in Fig. 2) being always different at $P \leq 0.05$ according to t-test. For each group, the frequency of the seven morphological models was computed within both top and bottom accessions (Fig. 2) and compared by chi-square. In all cases the test was highly significant ($P < 0.001$) indicating different distribution of the morphological categories between the best and worst yielding entries. In the subsp. *sativa* top-yielding accessions were substantially represented only in the shallow-crowned, erect T2 and T3 categories. In the subsp. *falcata* and in the "mielgas" the top accessions had higher frequency of CR3 and lower frequency of CR1 than the bottom accessions. In these groups, particularly in the subsp. falcata, selection for CR3 is expected to cull high yielding materials. The subsp. X *varia*, assumed to be a natural hybrid between the subsp. *sativa* and *falcata* (Small et Brookes, 1984), had higher frequency of T3 plants in the top entries, as the subsp. *sativa*, and higher frequency of CR1 plants in the bottom accessions, as the subsp. falcata (Fig. 2). In terms of model distribution top and bottom accessions of this group were therefore representative of the two genetic extremes from which the taxon derives. The accessions coded as "crosses", representing artificial hybrids between different taxa, had model frequencies distinct from that of the natural hybrids, probably as a consequence of deliberate selection, particularly against falcata-like, CR1 types. This group presented the largest yield variation within models, the most common categories T3 and CR3 showing a similar frequency in the top and bottom accessions (Fig. 2). The crosses were characterised by the highest frequency of CR4 plants (10%) which, in addition, were almost exclusively represented in top-yielding accessions. This latter trend was also evident in the subsp. X *varia* and in the "mielgas". Selection for the CR4 model is therefore likely to be associated to selection for high DMY. Similarly, where present, true creeping CR2 plants were always found only in top-yielding accessions.

The different distribution both among "taxonomic" groups and among accessions within groups of distinct top-growth models can account for the previously mentioned inter- and intra-taxa variation of herbage yield, as these models, both in shallow-crowned and deep-crowned categories, showed, on average, fairly distinct yield levels (Table 2). Nonetheless, appreciable variation occurs within models, related to both the accessions (as indicated in Fig. 2 by the occurrence of both top and bottom accessions in the same model) and the "taxonomic" groups, which are characterised by distinct productivity across models (Table 1 and Fig. 2). For instance, the best yielding category CR4 is expected to have a higher yield level in the crosses and in the subsp. X *varia* than in the "mielgas".

Table 2. Mean values (g/plant) of dry matter yield cumulated over five cuts in seven top-growth morphological categories (models) individuated in a lucerne germplasm collection.

T1	T2	T3	CR1	CR2	CR3	CR4
97.0c	192.3b	243.9b	121.8c	197.3b	202.0b	326.6a

Mean values followed by the same letter are not different at $P \leq 0.05$ (Duncan's test).

CONCLUSIONS

The results suggest that a breeding programme for grazing-type varieties could rely on different sources of variation which appear available for the selection to act. The first source is represented by the "taxonomic" groups which are differentiated for morphology and yield levels. With the possible exception of the cultivated subsp. *sativa*, all the groups pertaining to the complex contain to a varying extent materials potentially useful for the development of grazing-tolerant lucerne. The second source of variation is that of the morphological models, which have distinct top-growth morphology and vigour. Each model could indeed represent a possible ideotype for given environmental situations and/or management systems, as exemplified by more or less favourable growing conditions, more or less intense grazing pressures, different livestock species, special utilizations such as soil-protecting cover crops, etc. The third available source of variation is represented by the populations (accessions) within "taxonomic" groups. It appears sound to exploit for breeding purposes the wide differences found among these populations in terms of productivity and frequency of plants with characteristics possibly conferring tolerance to grazing. The on-going breeding programme at Lodi is engaged at all these three levels of the selection activity.

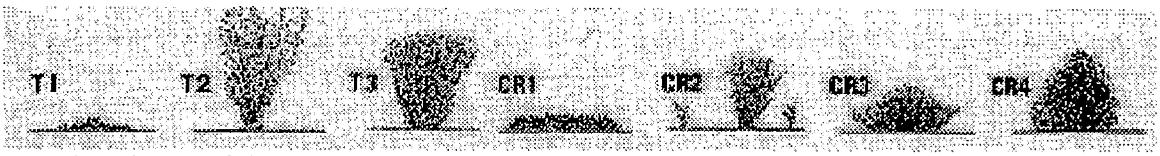

Fig. 1. Scheme of the seven top-growth models individuated in the present study.

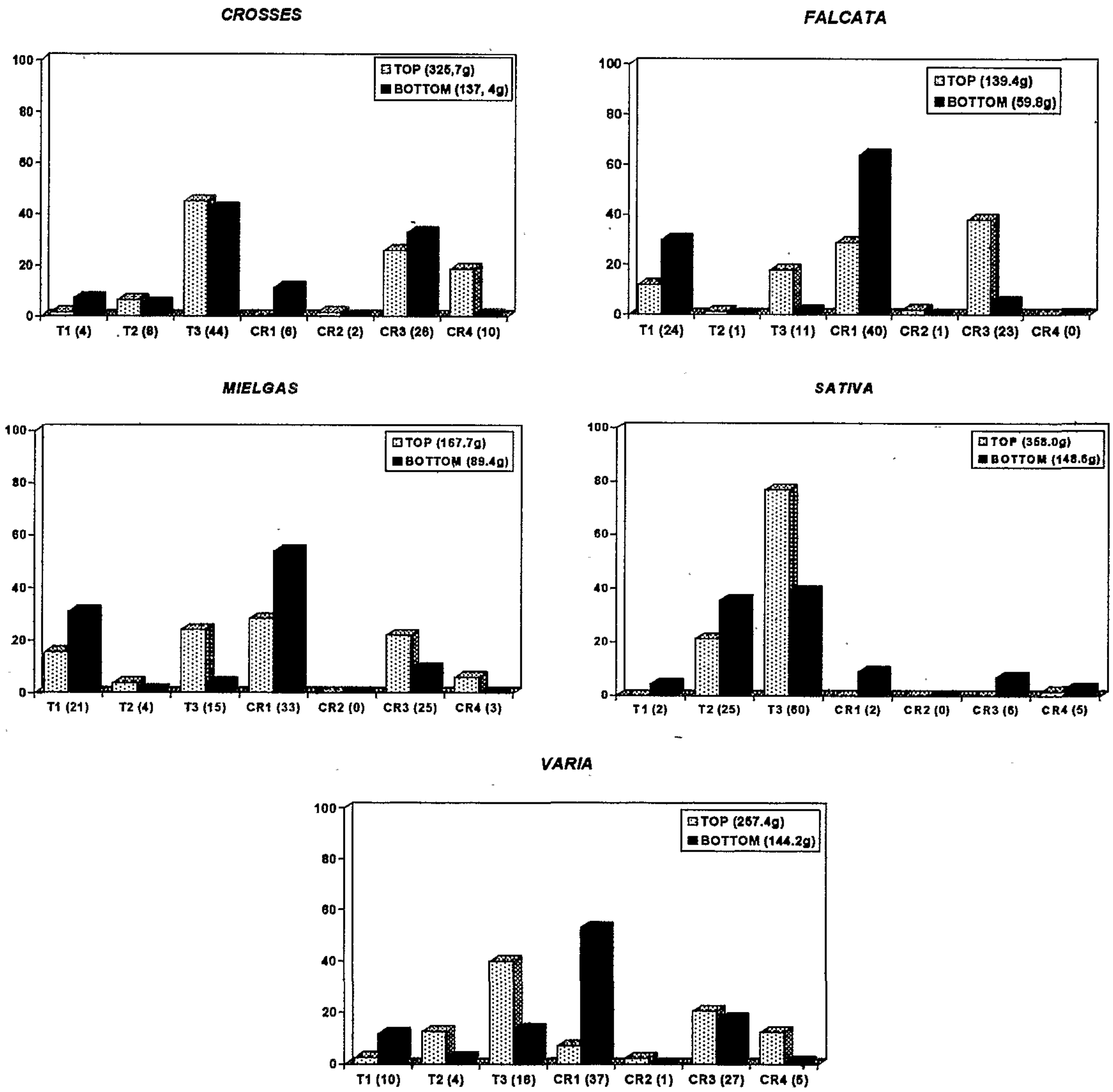

Fig. 2. Frequency distribution (% of plants) of seven morphological categories (models) in five germplasm groups of the Medicago sativa *complex (top row of values in each box) and in top- and bottom-yielding accessions of each group (bars). Dry-matter yield mean values (g/plant) of top- and bottom-yielding accessions are indicated on the X-axis.*

REFERENCES

Ben Chabaane A., 1990. Etude de la variabilité d'une collection de luzerne spontanée (Medicago sativa L.) dans le but de son amélioration génétique. M.Sc. Thesis. CIHEAM and IAM Zaragoza, 120 p.

Heinrichs D.H., 1963. Creeping alfalfas. Adv. Agron. 15 : 317-337.

Piano E., Valentini P., Pecetti L., Romani M., 1995. Morpho-physiological evaluation of lucerne germplasm in relation to the selection of grazing tolerant varieties. Submitted for publication.

Small E., Brookes B.S., 1984. Taxonomic circumscription and identification in Medicago sativa-falcata (alfalfa) continuum. Econ. Bot. 38 : 83-96.