Relationship between seed yield and edaphic environment in subterranean clover

Carroni A.M., Piano E., Pecetti L.

in

Sulas L. (ed.).
Legumes for Mediterranean forage crops, pastures and alternative uses

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 45

2000
pages 349-353

Relationship between seed yield and edaphic environment in subterranean clover

A.M. Carroni, E. Piano, L. Pecetti
Istituto Sperimentale per le Colture Foraggere, viale Piacenza 29, 26900 Lodi, Italy

Summary - Seed yield is a must for annual self-reseeding legumes to ensure reliable pasture regeneration from year to year. In subterranean clover, production of seed is expected to be influenced by the edaphic conditions, also in consideration of the particular morphophysiology of seed set. In this study, the effect of the edaphic environment on seed yield and the possible interaction between soil and genotype were assessed by growing a range of genotypes in two soil environments of distinct physical features, i.e., a clay loam and a coarse sandy loam soil. Genotype × soil environment interaction proved significant. Genotype response included either situations of contrasting behaviour in the two soil conditions or situations of stable performance, the latter suggesting a possible selection for wide adaptation. No relationhip was found between genotype response and soil type at sites of origin.

Key-words: annual legume, seed yield, soil texture, *Trifolium subterraneum* L.

Résumé - *Pour les légumineuses annuelles auto-réensemençantes produire beaucoup de semence est une obligation pour assurer d'une année à l'autre une régénération certaine des pâturages. Dans le trèfle souterrain l'on s'attend que la production de semence soit influencée par les conditions édaphiques, en considérant aussi la particulière morpho-physiologie de la reproduction. Dans cette étude on a testé l'effet du milieu édaphique sur la production de semence, et l'interaction éventuelle entre le sol et le génotype, en cultivant de nombreux génotypes sur deux sols à caractéristiques physiques distinctes, c'est-à-dire un limon argileux et un limon sableux grossier. L'interaction génotype × milieu de cultivation a été significative. La réponse des genotypes a compris soit des situations de performance contrastante dans les deux conditions de sol, soit des situations de performance stable. Ces dernières suggèrent la possible sélection pour una adaptation ample. L'on a pas trouvé de relations entre la réponse des génotypes et le type de sol chez leurs endroits d'origine.*

Mots-clés: *légumineuse annuelle, production de semence, texture du sol,* Trifolium subterraneum *L.*

Introduction

The success of subterranean clover (*Trifolium subterraneum* L.) varieties depends primarily on their ability to produce seed, which is a driving factor to ensure reliability of pasture regeneration from year to year (Rossiter, 1966). Within a given area of climatic adaptation, subterranean clover might be grown under different edaphic situations. In Sardinia, which is a region of great interest for the species cultivation, the potential area of utilization encompasses soils of granitic, basaltic, schistose, trachitic or alluvial origin (Piano *et al.*, 1982) which are characterised by different chemical and physical properties. Among them, soil texture for instance is expected to affect burr burial efficiency of subterranean clover (Taylor and Rossiter, 1969) which, in turn, is related to seed set (Quinlivan and Francis, 1971). It is therefore important to examine the possible influence of the edaphic environment on seed yield and the occurrence of genotype × environment interactions. An assessment of such interaction effects might be useful to the breeders by enabling selection of genotypes with wide adaptation, which is a main breeding goal in many instances, or, alternatively, for selecting varieties targeted to extensive areas with distinct and uniform soil types. Knowledge on preferential adaptation of any variety to a given soil type may also provide guidelines for the choice of environments where commercial seed multiplication is optimised.

This study aimed at assessing: i) the influence of two different soil types on seed yield of subterranean clover strains; ii) the occurrence of genotype × environment (soil treatment) interactions; and iii) the relationship between the soil conditions of the environments of origin and the seed yield performance of the genotypes under the two experimental conditions.

Materials and methods

A set of 54 genotypes of subterranean clover, including 44 strains singled out from Sardinian native populations and 10 commercial varieties, were grown for two consecutive seasons (1995-96 and 1996-97) in concrete troughs, 1.15 m wide, 34.00 m long and 0.80 m deep, filled with two different soil types. These soils were particularly distinct for their physical characteristics and were examples of widespread soil types in Sardinia. One was a coarse sandy loam of granitic origin (78% sand, 12% silt, and 10% clay); the other was a clay loam of alluvial origin (38% sand, 28% silt, and 34% clay). Both soils had low organic matter and total nitrogen, high values of assimilable phosphorous, medium-high levels of exchangeable potassium, and low $CaCO_3$ content. All values of these chemical characteristics were lower in the sandy loam than in the clay loam soil. The pH was 7.8 for the former and 8.0 for the latter (1 : 2.5 in water).

The trial was conducted at Sanluri, south Sardinia (39°30' N, 8°50' E, 68 m asl) with a factorial experimental design with two replicates for each soil environment, in which the individual genotypes were allocated to plots 0.60 m wide and 1.15 m long containing two rows, 0.20 m apart, of 10 plants each sown in peat pots at the beginning of each season and transplanted after one month. The commercial varieties and the Sardinian strains, the latter being part of a set of elite lines under advanced selection, represented a wide range of flowering time. For this reason, supplementary irrigation was provided when necessary to ensure adequate moisture conditions for seed setting also for the latest genotypes. At the end of each season seed yield per plot was recorded. The data were subjected to a partially hierarchical analysis of variance (ANOVA) holding the main factors 'soil environments', 'seasons', 'genotypes' 'replicates within environments and seasons' and the relevant interactions between these factors.

On the basis of the available collection data, a subset of genotypes was identified originating from two contrasting soil types, broadly categorised as 'heavy' or 'light' according to their texture. The former class included the soils from clay to silty clay loam, and the latter the soils from sandy to sandy loam. For this subset of genotypes, which excluded the commercial varieties and native strains originating from sites with intermediate soil types, a second ANOVA was performed on seed yield data holding also the factor 'soils at sites of origin' to assess the occurrence of interaction between this factor and the genotype performance in the experimental soil environments.

Results and discussion

The main results of the two ANOVAs performed on seed yield data are summarised in Table 1. Soil treatments did not differ significantly, but a significant ($P \leq 0.001$) 'soil environment × season' interaction occurred, seed yield on the sandy loam being higher than on the clay loam in the first season.

As expected, wide variation occurred among genotypes for seed yield ($P \leq 0.001$) across soil treatments and seasons, the mean values ranging from 29.6 g/plot to 128.2 g/plot. No significant correlation was evidenced between mean seed yield across years and flowering time ($r = 0.15$, $P = 0.26$) indicating that these differences were not related to differences in maturity grading.

The variance attributed to the 'genotype × season of evaluation' interaction did not reach the significance threshold level of $P \leq 0.05$ but was close to it ($P = 0.06$), suggesting that some seasonal effects tended to occur in the genotype rankings.

Table 1. Summary results for the main sources of variation in the two ANOVAs performed on seed yield data.

Source of variation	Probability level of F test
Soil environments (E)	ns
Genotypes (G)	***
Seasons (S)	***
E × G	*
E × S	***
G × S	ns
Soils of origin (O)	ns
E × O	ns

ns, *, *** : F test not significant and significant at $P \leq 0.05$ and $P \leq 0.001$, respectively.

From a breeding point of view the most valuable result was the occurrence of a significant interaction between genotype seed yield and soil environment ($P = 0.04$). Genotype rankings in Figure 1 show that this interaction resulted in strong cross-over effects, in such a way that some top-yielding genotypes in one soil environment were among the bottom-yielding ones in the other environment. This finding suggests the occurrence of a kind of edaphic preference of these genotypes to either soil type. Interestingly, genotypes collected at the same site of origin (i.e., 56H, 56E, and 56C) had contrasting response in terms of interaction effects with the soil environment.

From Figure 1 it also appears that some genotypes were characterised by a remarkable stability of seed yield ranking across soil environments, both in the case of top-yielding and bottom-yielding strains. The top-ranking and stable genotypes are worth of consideration in the selection for wide adaptation, at least for the soil environments here examined.

Somewhat unexpectedly, there was no significant difference in seed yield between genotype groups originating from contrasting soil types (soils of origin), nor these groups differed for their interaction effect with the experiment soil environments (Table 1). Therefore, the observed significant interaction between genotypes and soil environments cannot be attributed, in this experiment, to a differential response of the same genotypes related to the physical features of the soil at sites of origin.

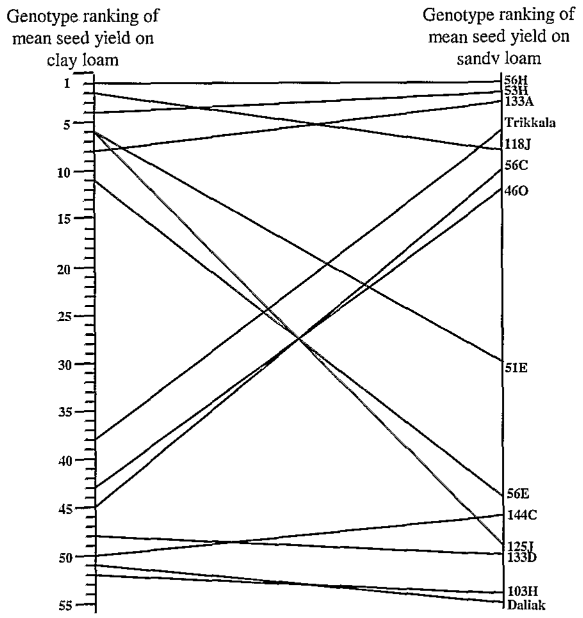

Figure 1. Seed yield ranking in the two soil environments of a subset of genotypes showing either cross-over effects or stability of response.

Conclusions

The occurrence of both situations of high stability of genotype performance across environments, although inferred from only two soil types, and situations of marked interaction between seed yield performance of genotypes and soil environments, suggests the possibility in subterranean clover to select either for wide or specific adaptation to edaphic conditions. It is however noticeable that in this experiment none of the genotypes showing marked effects of specific adapatation to a particular soil type outyielded in that soil the top-ranking, widely adapted genotypes (Fig. 1), so that selection for wide adaptation appears to be the most profitable option. In this respect, the promising indications from this study require further confirmation from investigations including a larger set of soil environments.

With regard to breeding implications, it would be worthwhile to assess whether some morpho-physiological characters, particularly those involved in the reproduction process, are related to the adaptive response of the genotypes. Candidate traits may certainly include burr burial capacity and its morphological components, but also ability to set seed when burial is prevented, and yield components such as number of burrs, number of seeds per burr and seed size.

The lack of influence of soil physical features at the collection sites on genotype response in the experimental conditions, i.e., 'genotype × soil environment' interaction effects, should be taken with some caution as the two soil environments could not necessarily be fully representative of the actual, diversified soil conditions at the sites of origin. Nonetheless, this result may also suggest that great variation occurs among genotypes for seed yield and related traits under similar edaphic conditions, as exemplified by the different response of strains from the same collection site. In this experiment, the performance of genotypes in terms of wide or specific adaptation appears to be a peculiarity of the individual genotypes *per se*, probably as a result of particular combinations of characters.

References

Piano, E., Sardara, M., Pusceddu, S. (1982). Observations on the distribution and ecology of subterranean clover and other annual legumes in Sardinia. *Riv. di Agron.*, 16, 273-283.

Quinlivan, B.J., Francis, C.M. (1971). The effect of burr burial on the seed of some early maturing subterranean clover cultivars. *Aust. J. Exp. Agric. Anim. Husb.*, 11, 35-38.

Rossiter, R.C. (1966). The success or failure of strains of *Trifolium subterraneum* L. in a Mediterranean environment. *Aust. J. Agric. Res.*, 17, 425-446.

Taylor, G.B., Rossiter, R.C. (1969). Seed production from three species of *Trifolium* on sandy soils in the wheat belt in Western Australia. *Aust. J. Exp. Agric. Anim. Husb.*, 9, 92-98.