Adaptation of landrace and variety germplasm and selection strategies for lucerne in the Mediterranean basin

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Abstract

Lucerne (Medicago sativa L.) can enhance the economic and environmental sustainability of crop-livestock systems in the western Mediterranean basin, but requires improved adaptation to stressful environments because of a predicted shortage of irrigation water and climate change. This study reports on three-year dry matter yields of five landraces from Morocco, Italy and Tunisia and seven varieties from France, Italy, Australia and USA assessed across 10 agricultural environments of Algeria, Tunisia, Morocco and Italy of which four were rainfed, one was continuously irrigated (oasis management), and five were irrigated but adopted a nine-week suspension of irrigation during summer. Our objectives were targeting cultivars to specific environments, and assisting regional breeding programmes in defining adaptation strategies, genetic resources and opportunities for international co-operation.

The crop persisted well in all environments, but environment mean yield was strictly associated (P < 0.01) with annual and springsummer (April–September) water available. Rainfed cropping implied 42% lower yield with 61% less spring-summer water available relative to irrigation with withheld summer water across three sites hosting both managements. All of these sites showed genotypexmanagement interaction (at least P < 0.10). Cross-over genotypexenvironment (GE) interaction between top-yielding cultivars occurred across the
10 environments. Total number of harvests (range: 9–23), soil salinity as measured by electrical conductivity (range: 0.20–6.0 dSm⁻¹), and average spring-summer water available (range: 102–932mm) were selected as significant (P < 0.05) environmental covariates in a factorial regression model explaining 53% of GE interaction variation.

This model was exploited for targeting cultivars as a function of site-specific levels of these factors. Its indications agreed largely with those of an additive main effects and multiplicative interaction model with two GE interaction principal components. An Italian landrace exhibited specific adaptation to severely drought-prone environments, whereas landraces from north Africa were not adapted to such environments. One Moroccan landrace was specifically adapted to high number of harvests (partly reflecting frequent mowing). One variety selected for salt tolerance, and one Moroccan landrace, were specifically adapted to salt-stress environments. Environment classification as a function of GE interaction effects indicated three groups which may be object of specific breeding: (i) rainfed or irrigated environments featuring limited spring-summer water available (<350 mm), nil or low soil salinity, and moderate to low number of harvests; (ii) salt-stress environments; and (iii) environments characterized by high number of harvests.