Response of Contrasting Cocksfoot Varieties to Summer Moisture Availability in a Mediterranean Environment

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RESPONSE OF CONTRASTING COCKSFOOT VARIETIES TO SUMMER MOISTURE AVAILABILITY IN A MEDITERRANEAN ENVIRONMENT

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Abstract

The responsiveness to water availability in summer and the effect of summer drought were assessed in a Mediterranean environment on both temperate and Mediterranean cocksfoot (*Dactylis glomerata* L.) materials. Three consecutive evaluation phases were contemplated: i) under rainfed conditions from autumn to spring; ii) under contrasting moisture conditions in the following summer; and iii) under rainfed conditions in the subsequent autumn-spring season to assess the effect of the previous summer treatments. The ability to become summer dormant under conducive conditions, such as in Mediterranean germplasm, proved a plant pre-requisite for survival under drought. All the "summer-active", temperate varieties did not survive drought stress. Mediterranean materials showed a facultative dormancy behaviour in that they responded to moisture availability in summer. There was evidence that selection for such responsiveness was effective, as shown by a variety selected from Mediterranean germplasm also considering this criterion. Forcing summer growth by preventing dormancy had little detrimental effect on subsequent autumn recovery of Mediterranean improved varieties but more evidence is required on this aspect.

Keywords: cocksfoot, *Dactylis glomerata* L., drought stress, Mediterranean environment, plant survival, selection, summer dormancy

Introduction

In the harsh Mediterranean environements of Italy the persistence of perennial grasses, such as cocksfoot (*Dactylis glomerata* L.), is heavily limited by long periods of drought in summer. In such conditions the most effective plant strategy of survival is stress avoidance through summer dormancy (Laude, 1953), which also represents a main selection criterion for varieties to be grown in rainfed conditions. Nonetheless, it could be appropriate to develop varieties able to combine effective summer dormancy under stressful conditions with a certain responsiveness to moisture availability in case of prolonged rainfall seasons or when supplementary irrigation in summer is provided. This objective requires the assessment of: i) responsiveness to water availability in summer of "summer-dormant", Mediterranean populations in comparison with "summer-active", temperate varieties; and ii) lack of negative effects of such responsiveness on subsequent autumn recovery and plant survival.

This study aimed at originating information on both these aspects.

Material and Methods

The experimental materials included: one wild population (Bonorva) from a harsh Mediterranean environment (Sardinia island, Italy); two varieties (Currie and K2M) selected from Mediterranean populations and known as "summer-dormant"; three varieties (Cambria, Dora, and Porto) adapted to temperate conditions; and one variety (Jana) originating from Bonorva and Currie after a selection process based on two consecutive phases, both contemplating summer irrigation: i) a preliminary phenotypic selection; and ii) a subsequent selection based on a half-sib progeny test which narrowed the previously selected plants.

In the present study, carried out in south Sardinia, these materials, established in a randomized complete block design with six replications, underwent a three-phase evaluation.

Phase 1: from autumn 1996 to spring 1997 all replications were grown under rainfed conditions (475 mm) and mowed 8 times between October 22 and June 5.

Phase 2: afterwards the experiment was split into two treatments, each including 3 replications, the first being irrigated to provide optimum moisture availability throughout summer 1997 and the second kept under rainfed conditions (60 mm of total rainfall from June to September). Dry-matter yield (DMY) was recorded five times between June 30 and October 10 in the irrigated treatment while no regrowth was harvestable in the rainfed treatment. Plant mortality was assessed in both treatments at time of autumn regrowth in the rainfed treatment.

Phase 3: the two treatments were then evaluated in the subsequent season under rainfed conditions (388 mm in the season) with 8 cuts from October 23, 1997 to May 13, 1998.

This procedure allowed the assessment of: i) the general performance of the two types of materials in rainfed conditions of a Mediterranean environment (phase 1); ii) the responsiveness of the same materials to the summer irrigation (phase 2); and iii) the effect of the two contrasting treatments in summer on plant survival and DMY performance in the following season (phase 3).

Results and Discussion

Under rainfed conditions (1996-97 season) the Mediterranean varieties Jana and K2M tended to yield most, although not significantly different from the best performing temperate varieties Cambria and Dora (Table 1). They were, however, significantly superior to these varieties for autumn and winter yield (data not shown). Jana proved much more yielding than the variety Currie and the wild population Bonorva from which it originated, providing evidence on the effectiveness of the selection carried out.

The responsiveness to moisture availability in summer, assessed in the irrigated treatment during summer 1997, showed that improved varieties originating from Mediterranean materials such as Jana and K2M can yield as much as “summer-active”, temperate varieties (Table 1). The outstanding superiority of Jana relative to the base materials from which it derived suggested that selection response for yield measured under summer irrigation was apparently even higher than that measured under rainfed conditions. The wild population showed in particular a very low responsiveness.

From the yield results it can be argued that the yield potential of both Mediterranean and temperate varieties under irrigation in summer is rather low relative to that achieved under rainfed conditions from autumn to spring, probably due to a limiting effect of high temperatures on growth. This aspect may deserve further consideration in relation to cost-effectiveness of selection aimed at improving summer growth, especially when this limited responsiveness would be associated to detrimental effects on plant adaptation.

In the rainfed treatment during summer 1997 no yield was measurable either because the materials were dormant or because the moisture conditions were not conducive to growth for “summer-active”, temperate varieties.

The two contrasting moisture treatments imposed in summer affected differently plant mortality of Mediterranean and temperate varieties. No differences in plant survival, measured at the autumn recovery, were found among entries in the irrigated treatment whereas in the stressed treatment all the temperate varieties did not survive summer drought resulting in no yield in the subsequent rainfed season (Table 2). Plant survival of the Mediterranean varieties and population was about 90% in either treatment (data not shown). These results confirm previous evidence on the complete unsuitability of temperate-type varieties to rainfed Mediterranean environments (Volaire, 1995), for lack of summer

dormancy does not confer any productive advantage while determining great susceptibility to drought stress.

Forcing summer growth by irrigation, thus preventing dormancy in the Mediterranean materials, had not detrimental effects on total yield performance in the subsequent rainfed season (8 cuts) both in the high yielding (Jana and K2M) and in the less performing (Currie) Mediterranean varieties which did not yield significantly different in the two moisture treatments (Table 2). Actually, a significant detrimental effect of summer irrigation was evidenced in these varieties limited to the first harvest of the autumn regrowth; afterwards there was a prompt recovery of the gap (data not shown). A marked effect throughout the next season was instead present in the wild population Bonorva in which yield following summer irrigation was only 53% of that following the rainfed treatment (Table 2). This result indicates that in this population the forcing of vegetative activity in summer probably caused a marked depletion of soluble carbohydrate reserves on which autumn recovery mainly relies (Volaire, 1995).

In conclusion, the results of the present investigation indicate that: i) the ability to become “summer-dormant” is a plant pre-requisite for summer survival in Mediterranean environments; ii) Mediterranean population/varieties have however a “facultative dormancy” behaviour and show responsiveness to moisture availability in summer; iii) selection for responsiveness to summer moisture availability seems effective; and iv) preventing summer dormancy had little detrimental effect on subsequent autumn recovery of Mediterranean improved varieties but more evidence is required on this aspect.

References

Laude, H.M. (1953). The nature of summer dormancy in perennial grasses. Bot. Gazette **114:** 284-292.

Volaire, F. (1995). Growth, carbohydrate reserves and drought survival strategies of contrasting *Dactylis glomerata* populations in a Mediterranean environment. J. Appl. Ecol. **32:** 56-66.

Table 1 - Dry-matter yield (g plot $^{-1}$) in the 1996-97 rainfed season (8 cuts between October 22 and June 5) and in the irrigated treatment in summer 1997 (5 cuts between June 30 and October 10) of Mediterranean and temperate cooksfoot germplasm

Entry	1996-1997 rainfed season	Summer 1997 irrigated treatment
Jana	436.0 a	105.7 a
K2M	416.5 ab	99.0 ab
Cambria	392.5 abc	80.7 ab
Dora	381.3 abc	96.3 ab
Porto	346.0 bc	89.0 ab
Currie	320.7 c	69.7 b
Bonorva	201.6 d	24.4 c

Means in each column followed by the same letter are not different at $P \leq 0.05$, according to Duncan's multiple range test.

Table 2 - Effect of two moisture treatments during summer 1997 (stressed and irrigated) on dry-matter yield (g plot $^{-1}$) of the subsequent 1997-98 season under rainfed conditions (8 cuts between October 23 and May 13) of Mediterranean and temperate cooksfoot germplasm

Entry	After stressed treatment (S)	After irrigated treatment (I)	S vs I significance
Jana	326.8 a	307.4 ab	ns
K2M	246.2 b	304.9 ab	ns
Cambria	0.0 c	239.1 ab	**
Dora	0.0 c	248.8 ab	**
Porto	1.0 c	322.8 a	*
Currie	199.6 b	214.7 b	ns
Bonorva	225.8 b	119.4 c	*

ns, *, ** : not significant and significant at $P \leq 0.05$ and $P \leq 0.01$, respectively, according to ANOVA.

Means in each column followed by the same letter are not different at $P \leq 0.05$, according to Duncan's multiple range test.