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A comparison of the agronomic performance of grasspea and faba bean in a semiarid Mediterranean environment

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SUMMARY – Because of its reputed capacity of adaptation to drought, *Lathyrus sativus* L. is a grain legume of potential interest for southern Italy, and for this reason it was compared with a traditional grain legume, *Vicia faba* L., in two consecutive growing seasons. Species were field grown both under water stress, rainfed and irrigated conditions and assessed in terms of phenology, growth, yield, water use and water use efficiency. In general, the agronomic behaviour of both crops closely reflected water availability during the growing season and although an advantage of the faba bean was observed, the response of *Lathyrus* was also satisfactory.

Key words: *Vicia faba* L., *Lathyrus sativus* L., growth, grain yield, water use, water use efficiency.

***RÉSUMÉ –** "Comparaison des performances agronomiques du pois fourrager et de la féverole dans un environnement semi-aride méditerranéen". Les prestations agronomiques des cultures dans les milieux semi-arides méditerranéens sont étroitement dépendantes de leur capacité de valoriser les ressources hydriques disponibles limitées. Par rapport à sa capacité d'adaptation reconnue à la sécheresse,* Lathyrus sativus *L. est une légumineuse à grain d'intérêt potentiel pour le sud de l'Italie. Pour cette raison, pendant deux années consécutives, elle a été mise en comparaison avec une légumineuse à grain traditionnelle,* Vicia faba *L. Les espèces ont été cultivées en plein air en conditions de stress hydrique, de sécheresse et d'irrigation, et ont été évaluées pour ce qui concerne la phénologie, la croissance, la production, l'eau utilisée et l'efficacité d'utilisation de l'eau. En général, le comportement agronomique des deux cultures a été affecté par le niveau d'eau disponible pendant le cycle cultural ; la réponse productive de* Lathyrus *a été satisfaisante, quoiqu'il eût été remarqué un avantage productif de la féverole.*

Mots-clés : Vicia faba *L.,* Lathyrus sativus *L., croissance, production, eau utilisée, efficacité d'utilisation de l'eau.*

Introduction

Cool-season grain legumes are traditional components of rainfed agricultural systems in southern Italy where they are generally grown in rotation with cereals contributing positively to agro ecosystem sustainability. Because of its greater adaptability and yield potential together with the lower cultural input required, faba bean is prevalent compared to other usual winter legume crops such as lentil and grasspea, particularly in marginal cropping areas (Foti, 1979). A number of studies in different semiarid Mediterranean-type environments have demonstrated that the agronomic advantage of the faba bean can be attributed to a combination of different plant traits such as earliness, rapid leaf expansion, adequate biomass accumulation and its balanced partitioning among sources and sinks, with appropriate management (Santonoceto and Anastasi, 1995; Loss and Siddique, 1997; Loss *et al.*, 1997a,b; Sau and Mínguez, 2000; Santonoceto *et al.*, 2001). However, the extremely aleatory weather, which characterizes Mediterranean dryland environments often markedly limits the level of available water in the soil during the spring when the reproductive development of the crop occurs, with negative consequences on its performance in the absence of water supplies.

Grasspea, despite its often-unsatisfactory grain yield, could represent an alternative option thanks to its reputed capacity to tolerate and/or avoid drought (Abd El Moneim and Cocks, 1993; Siddique *et al.*, 1996; Thomson *et al.*, 1997). Nevertheless, because of the limited published information concerning the agronomic behaviour of grasspea in southern Italian environments it was considered useful to acquire experimental information by comparing this minor grain legume with a traditional crop such as faba bean under different levels of soil water availability.

Materials and methods

In the 2000-01 and 2001-02 growing seasons, a Sicilian landrace of *Lathyrus sativus* L. was compared with 'Sikelia', a cultivar of *Vicia faba* L. subsp. *equina*, under water stress, rainfed and irrigated conditions, in a hilly site of southern Italy, Gallina, Reggio Calabria (38°10'N, 15°45'E, 232 m a.s.l.). The soil of the experimental area was sandy clay loam, with water content at field capacity and wilting point of 38.3 and 21.7% of volume, respectively. The sowing "S" of the fields was done on 27 December in the 1st year and 29 January in the 2nd, adopting a randomized-block layout with three replicates. In the plots corresponding to the water stressed treatment, a plate canal system which covered about 50% of inter row spaces were placed on 9 and 5 March [72 and 45 days after sowing (DAS)] in the 1st and 2nd year, respectively, and intercepted rainfall was channelled into a ditch with an appropriate slope to guarantee rapid removal. Conversely, the plots of the irrigated treatment, received a complete replacement of ETm by means of a flood irrigation performed on 23 March and 17 April (86 and 78 DAS) supplying 125 mm of water (*I*), in both years. The plant population was established for both species at 35 plants/m^2.

The main phenological stages (emergence "E", onset of flowering "F", first pod visible "PV" and physiological maturity "M") were measured and leaf area, using a Li-Cor LI 3100 area meter, aboveground dry biomass and seed weight, during filling period, were performed on a sample of 5 plants periodically collected for growth analysis.

Total rainfall over the crop cycle (*R*) was 344 and 170 mm, respectively in the 1st and 2nd year, corresponding to the amount of water received by the rainfed treatment (control). The stressed treatments received 264 and 106 mm of rainfall, respectively in the 1st and 2nd year, because following the placement of the plate canal system 80 and 64 mm of rainfall were removed in the two years, respectively. Instead, the irrigated treatments received a total of 469 and 295 mm of water (*R*+*I*), respectively in the two years. Water use in each interval was estimated by summing rainfall, irrigation, and change in soil moisture content (ΔM) from the 0-100 cm soil profile. Productive water use efficiency (WUE) was calculated as the ratio of the final grain yield to the total water use throughout the crop cycle (Loss *et al.*, 1997b).

Results and discussion

Biological cycle

The duration of the biological cycle and a number of its phases differed mainly in response to the species. After emergence, occurring 23 DAS for all treatments in both years, the flowering as well as the appearance of the first pods in faba bean began 25 d earlier compared with grasspea, in the first year and approximately 15 d earlier, in the second. The difference at the end of the cycle between the two species, reduced to 5 and 9 d in the two seasons, respectively, enabled faba bean to have a longer grain filling period than grasspea, on average, 21 and 7 d for each year, respectively (Fig. 1).

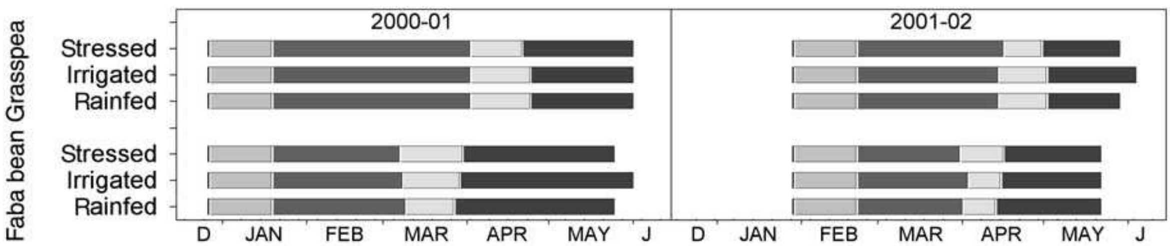

Fig. 1. Changes in crop cycle ("S-M") duration and its phases ("S-E", "E-F", "F-PV" and "PV-M") as a function of the experimental treatments.

Leaf area index and dry matter accumulation, grain yield and harvest index

Leaf area index (LAI) and dry matter values were lower for all treatments in the 2nd season than in the 1st owing to lower rainfall and delayed sowing. In each season, both LAI and dry matter accumulation in the plant and its organs evidenced clear changes in response to all experimental treatments (Figs 2 and 3). The greatest quantitative variations were observed among the three levels of available water: the differences compared to the rainfed treatment were, as was to be expected, from the subsequent sample to the placing of the canal system, for the stressed treatments, and from the one following the supply of water, in the irrigated ones. Following these samples, LAI and dry matter accumulation rate progressively increased more consistently from the stressed to the rainfed and from the rainfed to the irrigated treatment. In the same order of treatments, the peak values of dry matter were in grasspea: 325, 852 and 1190 g/m^2 in the 1st year and 208, 289 and 479 g/m^2 in the 2nd, whereas for faba bean the values were 389, 899, 1256 and 280, 320, 469 g/m^2, in the 1st and 2nd season, respectively. Following the subsequent samples, LAI values suddenly decreased almost to zero and total biomass declined compared to the above-mentioned peak values, mainly as a result of leaf loss. This decline, although appreciable in all treatments, was particularly marked in faba bean in the 1st year.

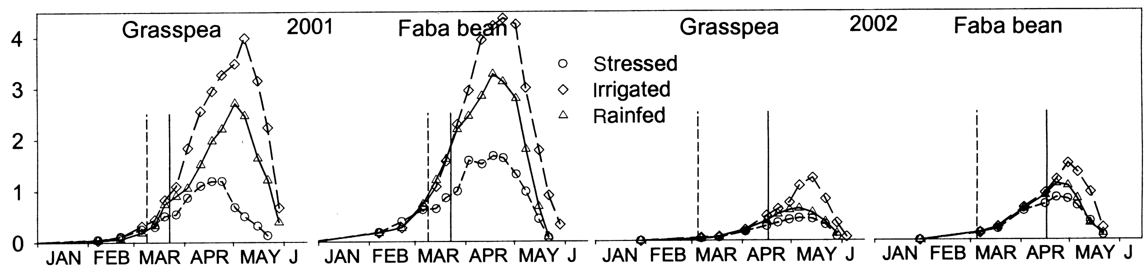

Fig. 2. Changes in leaf area index as a function of the experimental treatments. Vertical lines indicate the time of plate canal system placement (short dash) and the time of water supply (solid).

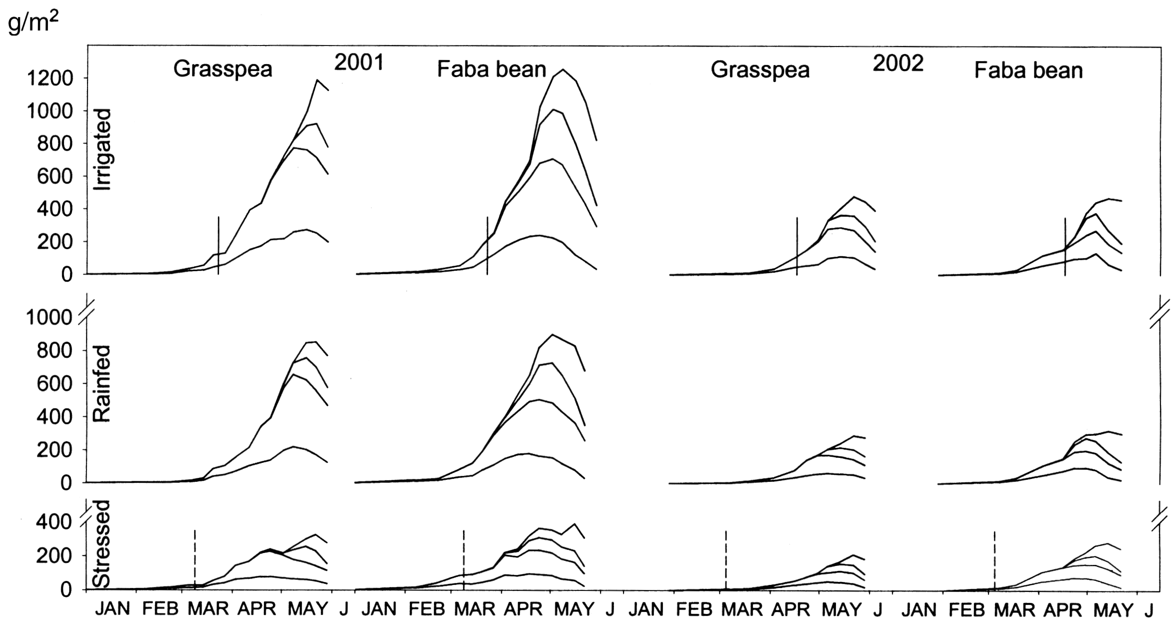

Fig. 3. Changes in aboveground biomass accumulation and its partitioning (from below to above: leaves, stems, pod walls and seeds) as a function of the experimental treatments. Vertical lines indicate the time of plate canal system placement (short dash) and the time of water supply (solid).

The most evident differences between the two species were in terms of timing. Indeed, LAI development and dry matter accumulation changes in grasspea revealed, with the same values, a delay from one to approximately three weeks compared with faba bean.

Despite the fact that the grain filling phase of faba bean began considerably earlier than grasspea, the leaf development of the former species was able to guarantee an adequate production of assimilates. In fact, leaf expansion of faba bean at the start of pod setting, attained the same level that grasspea reached some weeks later in correspondence with the same developmental phase.

The weight and timing differences regarding the dynamics of total biomass accumulation were also observed for each plant organ. The final drop in weight described earlier for the entire plant was also observed in leaves, stems and pod walls. It could be ascribed, in the former, to their loss and in the other two plant structures, to the translocation of assimilates towards the seeds (Loss *et al.*, 1997a). On the other hand, gradual increases were only observed in the seeds until the end of the life cycle when, among the levels of available water, in both years, significant increases in grain yield were evidenced from the stressed to the rainfed and from the rainfed to the irrigated treatments. In each of these, faba bean revealed a significant advantage with respect to grasspea (Fig. 4).

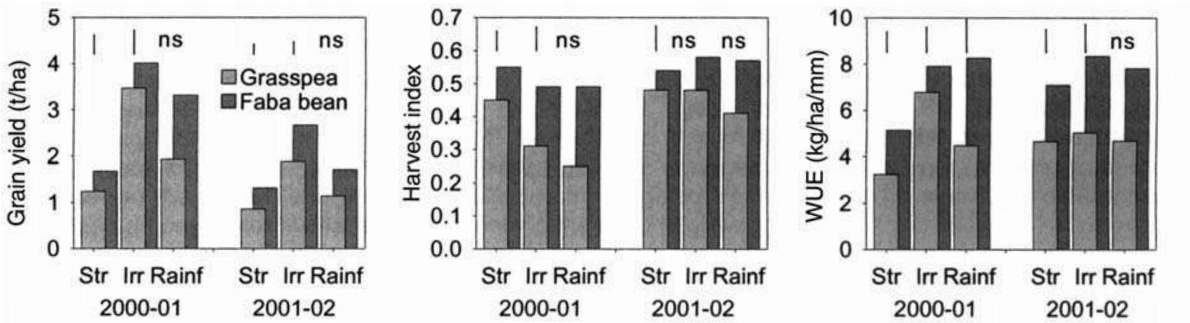

Fig. 4. Changes in grain yield, harvest index and water use efficiency as a function of the experimental treatments. In each season vertical segments from left to right indicate the lsd ($p \leq 0.05$) for species, water availability and their interaction (ns: not significant).

The percentage of grain weight on final aboveground biomass was more relevant compared to the other considered structures in all treatments with the exception of irrigated and rainfed grasspea in the first season, when it was lower than that of the stem. Faba bean evidenced the highest incidences ranging, during the two years and within the different level of available water, from 49 to 58%. In grasspea, instead, the highest values did not exceed the threshold of 48% (Fig. 4).

Soil water content, crop water use and productive water use efficiency

The variations in soil water content, which considerably differed between the two growing seasons, were, in each of the latter and within the same level of soil water availability, quite similar between the two species (Fig. 5).

In the irrigated treatments there was a clear increase in soil moisture in the sampling following irrigation, whereas the differences between the stressed and rainfed treatments were less evident. This latter aspect highlights a lower water use by the stressed treatments as a consequence of the lower amount of rainfall received after the positioning of the canal system. Indeed, from the stressed treatment to the rainfed and from the rainfed to the irrigated treatment, water use increased, in the 1st and 2nd year respectively, from 381 to 432 to 511 mm and from 186, to 245 to 374 mm in grasspea, whereas in faba bean it increased from 328 to 401 to 506 mm and from 186 to 219 to 320 mm (Fig. 5). The difference in water consumption as well as the different productive response of the studied treatments caused significant variations in terms of WUE in response to the three levels of soil water availability and the two species (Fig. 4). Between the latter, WUE was always higher for faba bean. This species, in the 1st year, evidenced significantly greater values when grown in both rainfed and irrigated conditions but, in the 2nd year, the values of this agronomic index significantly increased from the stressed to the rainfed and from the rainfed to the irrigated treatment. With regard to grasspea, significant increases of WUE emerged, in the first year, passing from the stressed to the rainfed and from the rainfed to the irrigated treatment, but no significant differences emerged among water availability treatments in the second growing season.

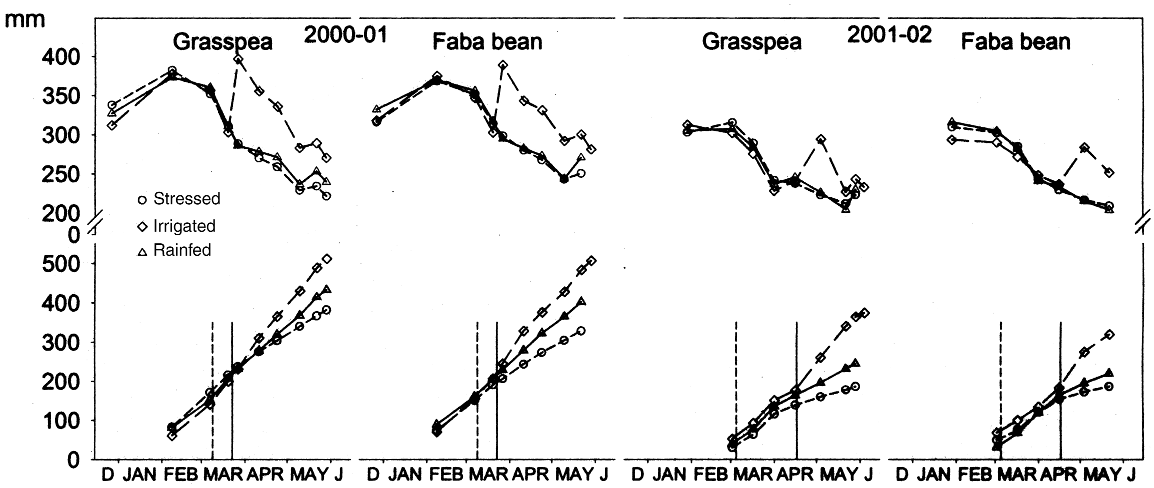

Fig. 5. Changes in soil water content (top) and cumulative water use (bottom) as a function of the experimental treatments. Vertical lines indicate the time of plate canal system placement (short dash) and the time of water supply (solid).

Conclusions

The results obtained confirm that under the environmental conditions of southern Italy, earliness plays a key role in many winter grain crops also when it is possible to supply them with irrigation water during the critical stages of their growth. However, it needs to be associated with other traits which, interacting with it, are able to support adequate productive levels. At the same level of soil available water, these traits can be the following: (i) optimum LAI and biomass accumulation, reached when sufficient soil moisture and not excessive temperatures can promote photosynthesis; (ii) adequate duration of grain filling period and a balanced partitioning of assimilates from the vegetative organs to reproductive sinks with a consequent increase of harvest index; and (iii) greater WUE.

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