Growth and yield, water status and use of spring and winter rapeseed in relation to time of sowing

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ABSTRACT
An annual and a biennial rapeseed cultivar were sown on three different dates ranging between November and December in a semiarid environment of southern Italy to evaluate their behaviour in terms of growth and yield, water status and use. The results evidenced that both cultivars gave the greatest leaf area development, aboveground dry biomass and seed yield from the earliest sowing date. However, the spring cultivar took complete advantage of early sowing by producing a higher grain yield with less water consumption because it flowered earlier and had a longer seed filling period, which also occurred when the soil water reserve was still sufficient. Moreover, there was an indication that the annual cultivar presumably has a greater osmoregulation ability than the biennial one. This evidence could contribute in increasing the effectiveness for selection of cultivars suitable to drought environments.

Key words: growth and yield - sowing time – rapeseed - water potential - water use

INTRODUCTION
Rapeseed is considered to be a crop of potential interest in cereal based farming systems in southern Italy where it is grown between autumn and the onset of summer under rainfed conditions. However, the variability of climatic conditions which characterise these semiarid cropping areas can negatively affect the agronomic performance of the crop, particularly if there is low soil moisture and high temperatures between the end of spring and start of summer when the grain filling occur (Santonoceto, 1997). In this framework agreed with Turner (1977), various drought escape and tolerance strategies can be utilised by crops. In rapeseed grown in the south of Italy, a positive role in this sense has been attributed to the *habitus* and earliness of cultivars as well as to early autumn sowing time (Santonoceto and Anastasi, 1999), whereas there is limited knowledge regarding crop water requirements. On the other hand, studies in Australia have suggested that some *brassica* species have an integrated system of physiological traits involved in drought tolerance that includes the ability to maintain higher cell turgor at lower osmotic potentials, although less experimental evidence is available for *B. napus* species (Rao and Mendham, 1991; Lewis and Thurling, 1994; Wright et al., 1997). Our field study was performed in order to verify if and how all the above-cited bioagronomic and physiological factors could contribute in ensuring an optimal agronomic response of rapeseed in southern Italy environmental conditions.

MATERIALS AND METHODS
In the 1993-94 growing season, an annual (Activ) and a biennial (Ceres) rapeseed cultivar were sown on three dates (18 November, 6 and 21 December) at Gallina, Reggio Calabria (38°10'N, 15°45'E, 232 m a.s.l.) in southern Italy, on a sandy clay loam soil, with water content at field capacity and wilting point of 38.3 and 21.7% of volume, respectively. Sowing dates and cultivars were assigned as 1st and 2nd treatments, respectively, in a split plot design with three replicates. The size of sub plot was 17.5 m^2 (3.5 x 5 m). The field was managed using appropriate cropping practices.
Seasonal air temperatures and rainfall were recorded using an automatic weather station. During the crop cycle, 6 plants of each plot were periodically collected and their leaf area, using a Li-Cor LI 3100 area meter, aboveground dry biomass, and seed weight during filling period were determined. Water status of the plants was estimated by measuring the variations in midday total (ψ_t) and osmotic (ψ_π) water potential of three leaf subsamples per plot, using the psychrometric method, and leaf turgor potential was then derived. Evapotranspiration was

estimated as indicated by Rao and Mendham (1991), but considering the moisture gravimetrically measured in the 0-1 m soil profile. However, in order to make better comparisons, cumulative ETe was calculated from 110 days after the 1st sowing date onwards, when the soil moisture level was slightly below field capacity and attained similar values in all treatments. At harvest, plant population and yield were determined.

Polynomial exponential and gaussian functions, chosen in agreement with Hunt (1982) were fitted to dry matter and LAI data plotted against days after the 1st sowing date (DA1stSd). The r^2 values for fitted curves ranged between 0.97 and 0.99 ($p \leq 0.01$). According to Ackerson et al. (1980) the regression coefficients of the relationship between total and turgor leaf water potential were used to evaluate the differences in osmotic adjustment among treatments.

RESULTS AND DISCUSSION

During the season, mean temperature decreased from 15.9 to 11.4 °C between November and

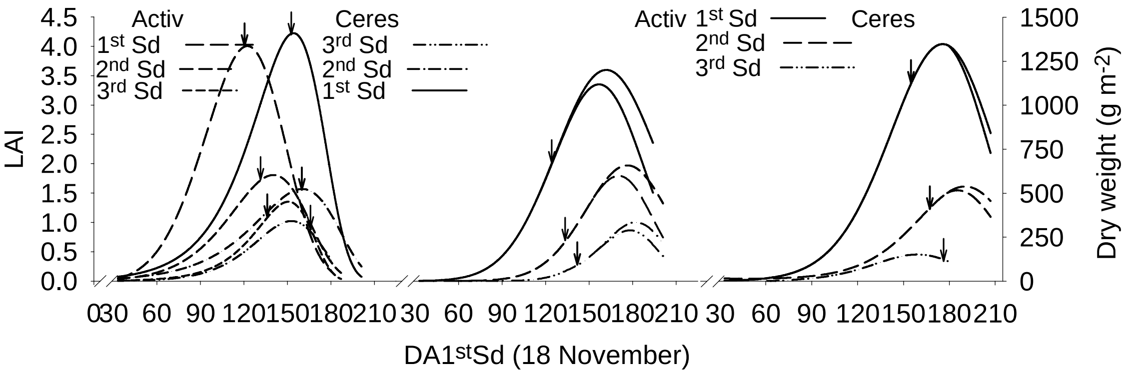

Fig. 1. Changes in LAI (left) and aboveground dry biomass (middle and right) of rapeseed with time (the arrows show the onset of flowering stage; the subdivision within each growth curve represents the seed weight).

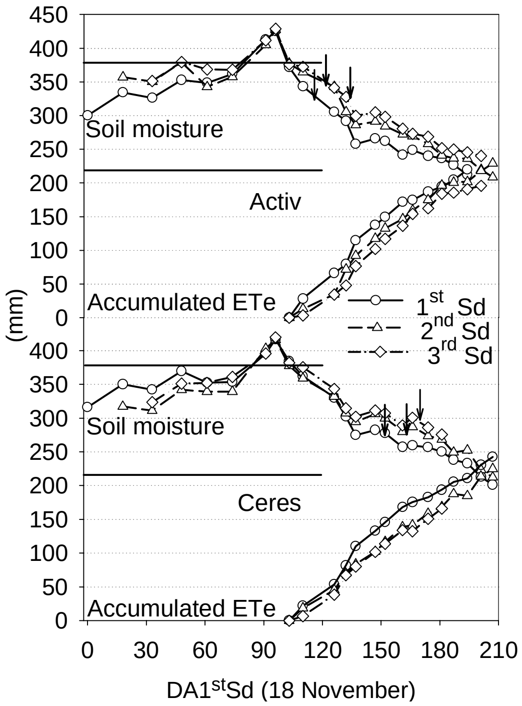

Fig. 2. Changes in soil moisture content (reference segments=field capacity and wilting point) and cumulative ETe of rapeseed (the arrows show the onset of flowering stage).

February, and then progressively increased reaching 21.9 °C in June, whereas total rainfall was 500 mm. The mean plant population was 45 (±4 s.e.) plant m^{-2}. Annual and biennial cultivars reached the onset of flowering stage, on average, at 115, 122, 130 DA1stSd and at 151, 166, 170 DA1stSd, between the 1st and last sowing time, respectively. In general, LAI and aboveground biomass typically evidenced a gaussian and a sigmoidal time course in all the studied treatments (fig. 1). The first trait, increased up to 4.0 and 4.2 at 124 and 154 DA1stSd, 1.8 and 1.6 at 140 and 160 DA1stSd, 1.3 and 1.0 at 151 and 153 DA1stSd, in Activ and Ceres, from the 1st to the 3rd sowing time, respectively, then decreased up to maturity, more slowly with the intermediate sowing, particularly for Ceres. Similarly, dry biomass increased with time reaching a maximum of 1199 and 1347 g m^{-2} at 162 and 176 DA1stSd, 657 and 538 g m^{-2} at 176 and 190 DA1stSd and 333 and 152 g m^{-2} at 182 and 159 DA1stSd, in Activ and Ceres, between the 1st and the last sowing time, respectively, and subsequently declined. Thus, as the sowing time advanced accumulated dry matter decreased consistently due to the reduced leaf area development, although differently for the two cultivars, in any case with clear consequences in productive terms. Activ always revealed a productive advantage compared to Ceres (3.1, 1.8 and 0.7 t ha^{-1} against 1.3, 0.9 and 0 t ha^{-1}, from the 1^{st} to the last sowing time, for the two cultivars, respectively), as a consequence of its earlier flowering and greater seed filling duration (37 against 13 d, on average), even though the biennial cultivar did not give any yielding at all with the 3^{rd} sowing time. A similar time course of soil water content was found for the two varieties within each sowing time (fig. 2). This variable initially increased, on average, from 308.0 to 422 mm, thus above field capacity, then progressively decreased reaching an average value of 207 mm near the wilting point threshold. Cumulative ETe after 110 $DA1^{st}Sd$ attained 220 and 243, 229 and 225, 196 and 166 mm, in Activ and Ceres, from the 1^{st} to the last sowing time, respectively. Therefore, with the earliest sowing time, soil moisture and evaporative demand did not limit growth and vegetative development of both cultivars during the winter and early spring period, so that because of its precocity annual cultivar used less water and its reproductive development occurred when soil water reserve was not exhausted with respect to biennial cultivar. This confirms the decisive role played by variety *habitus* in these environmental conditions where there is always an agronomic advantage using the spring cultivars. Moreover, irrespective of sowing time, the values of leaf ψ_t and ψ_π ranged from –0.6 to –1.6 MPa and from –1.2 to –2.0 MPa in Activ and from –0.5 to –1.9 MPa and from –1.2 to –2.1 MPa in Ceres between the 1^{st} and the last sampling (not presented). However, as shown in figure 3, the lower slope values of the regression lines of turgor potential on the total potential for the annual cultivar suggested that it presumably has a greater degree of osmoregulation than the biennial one. The study highlights, therefore, that in semiarid Mediterranean environments the earlier sowing time as well as the choice of spring rapeseed cultivars can be more effective options as a means of escaping terminal drought and improving agronomic performance, especially when they are associated to turgor maintenance ability of the plant. Nevertheless further research is needed using a range of varieties to assess the variability in the above-mentioned and other possible important physiological traits involved in the drought tolerance of the species.

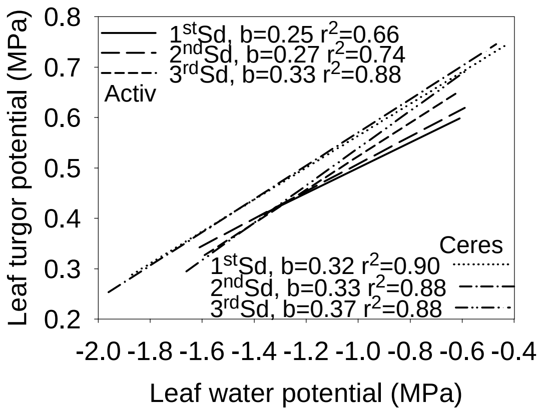

Fig. 3. Relationships between total and turgor leaf water potential of rapeseed.

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