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A note on safflower plant ideotype suitable for Mediterranean environments.

A. Corleto
Crop Science Department, Bari University, via Amendola, 165/A 70126 Bari, ITALY, corletoa@agr.uniba.it

Abstract
This paper discusses the appropriate plant ideotype required for the Mediterranean environment of southern Italy where there is a need for crop diversification.

Key words: *Carthamus tinctorius* L - varieties - hybrids – day-length neutral - vegetative and reproductive stages – growing degree days.

Why Grow Safflower in Mediterranean environments?
For Southern Italy, characterized by a typically Mediterranean climate, it is important to introduce in the wheat monocropping system under rain-fed condition a winter oil crop that will increase crop biodiversity. This species could be Safflower a multipurpose species with unexploited potential and world adaptability. Indeed using special technical precautions and by a more appropriate knowledge of the organoleptic properties of oil and other by-products to use for animal feeding safflower could be ,in the near future, an effective alternative to the prevailing durum wheat monocropping for many Southern Italy areas. A proposed rotation of safflower –durum wheat seems desirable. The lack of safflower crop adoption as an oil crop in the Mediterranean environments is mainly due to the length of cropping cycle, about 240 days as a winter crop from November to July or 145 days as a spring crop from February to July, along with a low seed yield potential, around 0.8 t/ha obtained with safflower cropped at large extension in different farms of Southern Italy (Corleto et al, 1997). Safflower may be considered as a crop with good ability to improve some physical soil properties (porosity) due to its strong taproot system. These properties, added to the lower nitrogen fertiliser requirement than durum wheat, play a major role in favour of a good habitability of the soil as a consequence of a higher soil permeability, with a subsequent reduction of erosion in hilly areas and a lower nitrate concentration in groundwater (A.Corleto, 2001). For human nutrition, safflower oil has a nutritional value that is similar to that of olive oil; moreover, the high oleic type is very suitable for hypo-cholesterol diets, for frying and in the preparation of frozen food; it is very stable at high temperatures and does not produce any smoke or bad smell during frying (Dajue and Muendel,1996).The high linoleic type may also be used for industrial purposes such as the preparation of varnishes, the production of biodiesel and alcohols to use in producing surfactants (Dajue and Mundel,1996;Bergman and Flynn,2001).

Criteria for assessing field yield results
The benefit/cost analysis is the most reliable way to judge the cost effectiveness to grow the crop (A.Corleto, 2001; 2005). For safflower, cropping costs are similar to those of durum wheat except for the seed that should be sharply lower for safflower due to the low amount of seed/hectare that is used (25-30 kg/ha for varieties and 10-15 kg/ha for hybrids)). The market price of durum wheat in the 2006 cropping year was 17.5 euros per 100 kg of seed; safflower is supposed to have the same price as sunflower, namely 19.5 euros per 100kg of seed (Commodities exchange of Bologna, Italy,2006). The suggested criterion for an overall assessment is the ratio of safflower grain yield to durum wheat grain yield (R s/w), both expressed as farm average. In southern Italy durum wheat yields between 1.o and 4.0 t/ha. The crop cost expressed as grain value, at the current grain market price and E.U. subsidize, is roughly equivalent to 2.0 t/ha while for safflower, which cropping cost is a little lower than that of durum wheat, a grain production of 1.5 t/ha should refund the cropping expenses. If R s/w is $\leq$0.5 the safflower crop should not be recommended for that environment. If R s/w ranges between 0.6 and 1 safflower could be recommended and with R s/w > 1 it will be highly

recommended. Another good criterion could consist in comparing safflower grain yields with those of sunflower and rape both grown in Southern Italy. For sunflower, usually grown under irrigated conditions, the farm yield (average of the 95-97 three-year period) is around 1.8 t/ha whereas for rape, sown in autumn and rain-fed conditions(average of 95-99 five-year period) is 0.9 t/ha (Sources AISO). At the present rape cultivation almost disappeared and sunflower production has been strongly reduced. In my opinion safflower oil crop could gain growers confidence if the seed yield per hectare will steadily reach 2.0 t/ha.

Causes which hinder achieving high productivity

Safflower yield potential is affected by the too long cropping cycle and by the occurrence of the part of the reproductive stages (from heads appearance to seed filling) in June when the evapotranspirative demand increases ,rainfall is sharply reduced, photosynthesis rate is strongly cut down by the increase of dead leaves.

Figure 1. Course of rainfall and potential evapotraspiration as a mean of 12 years registered in different low land locations of Southern Italy. Data are mean of 4 locations.

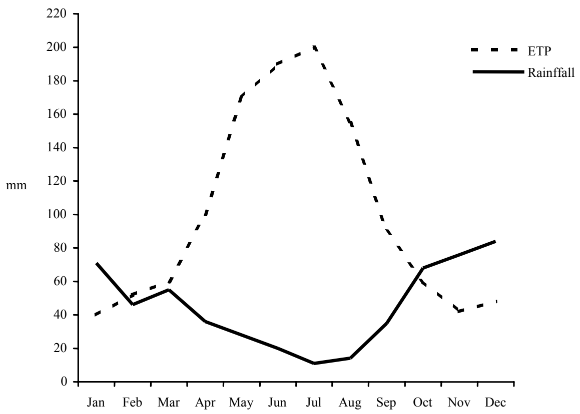


Fig 1 reports the course of rainfall and potential evapotranspiration as a mean of 12 years(1960-1971) registered in different low land locations of Southern Italy and calculated with the Blaney and Criddle formula (1950) which tends to overestimate the values. The water deficit starts in February and ends in November. Total water deficit is very high (827mm) and from middle of June to middle of August the daily evapotranspiration rate varies between 6 and 9 mm/day. Therefore the development of cultivars that mature 4-5 weeks earlier than those commercially available at the present on the world market probably would make possible in Southern Italy the cultivation of safflower in rotation with durum wheat.

The greatest drawback is that the flowering period falls in June when a long water stress period starts. We really need to obtain varieties and hybrids that bloom within mid-May as it is for wheat.

How to reach the goal

Commercial varieties grown in Mediterranean environments are generally characterized by a long rosette stage and flowering is stimulated by the increase in day length. D.D. Rubis (2001) produced safflower lines of reduced height that were flowering very early (selected within Gila dwarf type) and characterized by day-length neutral. Improvement in earliness associated with good productiveness was made as a result of crossing with very big stiff stem plants and with tall late plants, but not with commercial varieties. Therefore the first step is to produce a line characterized by short rosette stage, insensitive to day-length that will soon after start the stem elongation followed by bud initiation that represents the beginning of the reproductive plant development stage (Tanaka et al, 1997). Another source of improvement can be found in the use of new extra early dwarf safflower varieties that have been developed by AICRP, college of agriculture, Indore (M.P) centre in India which have numerous advantages as extra earliness, higher per day yield, bald grain, minimum disease and aphid problem, easy harvesting, as reported by S.L. Deshpande et al (2001).

Future safflower commercial cultivars will be, with no doubt, hybrids day-length neutral with seeds consisting of about 20% hull and 55% oil (Rubis, 2001). At the present the available hybrids have a higher yield potential both for seed and oil than open pollinated varieties. Research conducted in Southern Italy (Corleto et al, 1997) showed that hybrids exceeded the varieties both for seed yield (+ 53%) and oil yield(+60%). However among varieties, Bacum and Benno seemed able to compete, under good fertility conditions, with the hybrid genotypes. Other research (Singh et al,2001;Hill,2001) has found with the use of hybrids yield increases ranging from 10% to 223%:however ,it must be pointed out that in some case the seed yield of the varieties used as comparison was low(0.6 t/ha).

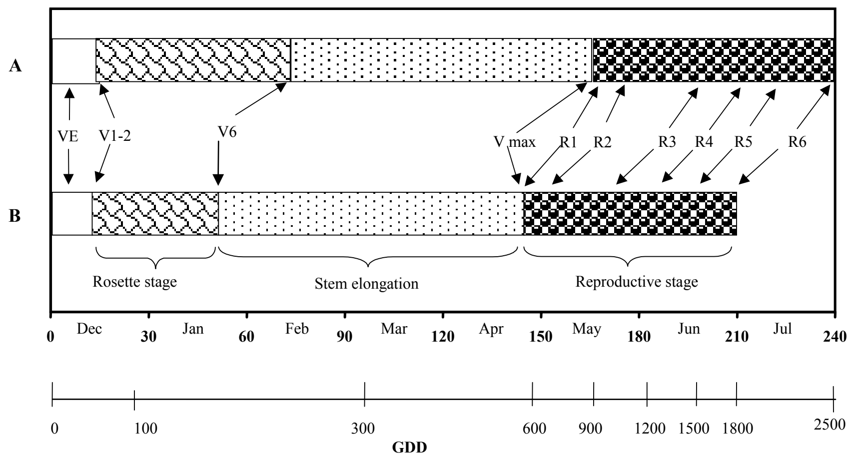
Safflower plant ideotype for Mediterranean environments

To develop a plant ideotype it is essential to know the vegetative and reproductive stages of the species under study.

In the case of safflower, plant development stages have been described by Tanaka *et al.,* (1997). The authors distinguish a vegetative stage (V) that starts with the cotyledons emergence (VE) and ends when steam elongation is completed (V max). Stage from V1 to V6 have been referred to as rosette stage. The reproductive plant development stage (R) begins with bud initiation ((R1) and goes through the appearance of secondary branches (R2), onset of anthesis (R3), complete flowering (R4) beginning of seed filling (R5) and seeds physiologically mature (R6). Each stage has been associated with the relative GDD (Growing Degree Days) calculated with the formula suggested by Bauer et al., (1984) (see note 1)[1]. In the figure 2 are reported the actual (A) and potential (B) length of safflower growth cycle determined in a flat area of Southern Italy.(A.Corleto,2008).

The mean length of vegetative and reproductive stages of safflower cultivars at the present available is as whole of about 240 days and 2500 GDD, with sowing in December and harvesting at the end of July. The safflower ideotype should complete the full growth cycle using 1800 GDD instead of 2500 GDD and complete the cycle at the end of June. To reach this objective a reduction of the length of rosette stage is essential. The ideotype plant should start the stem elongation stage within January 20 instead of February 15.

Figure 2. Actual (A) and potential (B) length of safflower growth cycle in a flat area of mediterranean environment.



A= Mean length of vegetative and reproductive stages (240 days, GDD 2500) of safflower cultivars available on the market, in a flat area of Mediterranean environment (Southern Italy).
B= Mean length of vegetative and reproductive stages (210 days, GDD 1800) of a safflower plant ideotype, for the same environment

Conclusion

Safflower oil crop has been extensively studied in southern Italy since 1970's. The lack of safflower crop adoption as an oil crop in the Mediterranean environments is mainly due to the length of cropping cycle, along with a low seed yield potential, around 0.8 t/ha. This paper underlines the necessity to create a plant ideotype, day-length neutral, characterized by a reduction of the length of rosette stage that should end in the middle of January, and be able to complete the full growth cycle at the end of June. Safflower oil crop could gain growers confidence if the seed yield will steadily reach 2.0 t/ha.

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[1] GDD were calculated by summation of degree days (Dn) accumulated over a 24-h interval (from midnight to midnight) starting from seedling emergence (January 10, 2003). The following formula suggested by Bauer et al.1984 was applied: Dn= $\sum[(Tmax+Tmin)/2 - t_b]$; where: daily maximum air temperature (T_{max}) and daily minimum air temperature (T_{min}) were provided by a computerized weather station present in the experimental field. The base temperature (t_b) was assumed to be 4° C since in previous researches in the same locality plant growth was active with temperature around 4°C. However no experimental results are available on this aspect in the literature and the t_b (10°C) reported by Tanaka seems to be too high.

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