Response of woad (*Isatis tinctoria* L.) to different irrigation levels to optimise leaf and indigo production

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*Isatis tinctoria* L. is a potential new crop for southern European countries as source of natural indigo. It was cultivated extensively up to XVIII and then abandoned due to the discovery of indigo by synthetic way. Recently, there is an increasing demand for renewable materials for industrial uses, included natural dyes. To make possible the re-introduction of this crop into the agricultural systems it is necessary to provide new scientific information regarding the agronomic aspects of its cultivation in order to develop efficient and sustainable cultivation methods. Water represents an important factor for leaf production and indigo yield, nevertheless few data are available in this respect. For an efficient use of water resource the knowledge of crop coefficient (Kc) in the different plant growth stages, is of vital importance in order to estimate the crop water requirements (CWR). Therefore, the aim of the present work is to assess the Kc values for this specific crop and location and the effects of irrigation on both production quantities and quality.

Trials were conducted during the two growing seasons 2002 and 2003 at the Experimental Centre of DAGA-University of Pisa on silt-loam soil, comparing six irrigation levels (T₁₀₀, T₈₀, T₆₀, T₄₀, T₂₀, that received a seasonal water amount equivalent to 100, 80, 60, 40, 20 % of ETE and a rain-fed control T₀) in a randomised block design experiment with four replications. Two microlysimeters were employed to estimate ETE during the growing season while monitoring the climatic parameters and the phenological crop development. An automatized drip irrigation system was properly fit up. Daily meteorological data and CWR were automatically collected and recorded. The seasonal water consumptive use (m³ ha⁻¹), ETE and Kc (Kc=ETE/ET₀) were evaluated. A relationship between yield and seasonal volume has been also determined to maximise crop yield and indigo production.

The two growing seasons were characterised by contrasting rainfall distributions during spring and summer in comparison with long-term trend. The seasonal CWR from April/May to October/November differed significantly between the two years being significant higher (+37%) in 2003 wetter season (3327 vs 2080 m³ ha⁻¹). Kc maximum values ranged between 0.45 and 0.47 depending on the vegetative developmental stage (plant rosette at 20 and 30 cm diameter) and year (0.45-0.47 in September 2002; 0.46-0.47 in August 2003).

As overall mean among treatments in 2003 the seasonal leaf dry production was 9.5 % lower than 2002 (8.5 and 9.4 t ha⁻¹ as sum of 4 multiple harvests). A decrement of ~39% leaf fresh yield and – 54% indigo production was recorded from 2002 to 2003.

In 2002 the irrigation levels did not affect seasonal fresh and dry leaf production and indigo yield due to the exceptional rainy summer season. In the driest 2003 season the irrigation influenced significantly leaf fresh yield and indigo production. The results showed that 40%ETE supply it is enough to obtain a leaf yield (t ha⁻¹) higher than T₀ and T₂₀. On the other hand, water restitution higher than 40%ETE (T₆₀, T₈₀ and T₁₀₀) did not give further yield increment. Regarding indigo, water restitution over 60%ETE gave production significantly higher than T₀, T₂₀ and T₄₀.