Irrigation strategies to optimise water use efficiency and production in Polygonum tinctorium Ait., a new indigo delivering crop

Marcello Bertolacci\textsuperscript{1} and Luciana G. Angelini\textsuperscript{2}

\textsuperscript{1}Laboratorio Nazionale dell’Irrigazione, Dipartimento di Agronomia e Gestione dell’Agroecosistema;
\textsuperscript{2} Dipartimento di Agronomia e Gestione dell’Agroecosistema, University of Pisa S. Michele degli Scalzi 2, 56100 Pisa, Italy, fax 050 540633;angelini@agr.unipi.it

Indigo used in the dyeing industry mainly for denim, is currently synthesized from by-products of fossil fuels. However, several plants are able to synthesize indigo precursors such as Polygonum tinctorium Ait. (dyer’s knotweed) an annual plant of the Family Polygonaceae, very popular in Japan, China and Russia, where it has been employed for large-scale indigo production until 19\textsuperscript{th} century. Today there is increasing interest toward this species as new crop for indigo production but until now, no research has been carried out on its irrigation requirements.

The present study was to analyze the crop water requirement (CWR) and the irrigation response of this new crop under field conditions.

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 (T\textsubscript{100}, T\textsubscript{80}, T\textsubscript{60}, T\textsubscript{40}, T\textsubscript{20} that received a seasonal water amount equivalent to 100, 80, 60, 40, 20 \% of ETE and a rain-fed control T\textsubscript{0}) 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 (m\textsuperscript{3} ha\textsuperscript{-1}), ETE and K\textsubscript{c} (Kc=ETE/ET\textsubscript{0}) 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 set of data: 2002 can be considered an exceptionally wet growing season and 2003 a very dry one. Irrigation significantly influenced seasonal plant dry and fresh yield as well as indigo production in both years. A significant decrement of yield was observed with T\textsubscript{0} and T\textsubscript{20} treatments in comparison with T\textsubscript{40}, T\textsubscript{60}, T\textsubscript{80} and T\textsubscript{100}. Irrigation rates higher than 40\%ETE did not affect significantly plant and indigo production.

Seasonal CWR recorded from April/May to October were 2413 and 4767 m\textsuperscript{3} ha\textsuperscript{-1} for 2002 and 2003 respectively. To optimise plant production and water use efficiency (WUE= kg dry crop yield/m\textsuperscript{3} water) it is enough to supply 40\%ETE i.e 1907 m\textsuperscript{3} ha\textsuperscript{-1} in the driest season and 965 m\textsuperscript{3} ha\textsuperscript{-1} in the wet one. In fact going from T\textsubscript{100} to T\textsubscript{40} the WUE increased about 2 and 3 times in 2002 and 2003 respectively. Kc values differed significantly with the crop growth stage reaching the maximum value of 0.7/0.8 at full vegetative development when the plants were ready to be harvested for the first time at the beginning of July. Therefore the maximum Kc values of 0.5/0.6 were regained at beginning of September before the crop second harvest.