Review of 'plant available water' aspects of water use efficiency under irrigated and dryland conditions

M Hensley[1], ATP Bennie[1], LD van Rensburg[1]* and JJ Botha[2]

[1] Department of Soil, Crop and Climate Sciences, University of the Free State, PO Box 339, Bloemfontein 9300, South Africa

[2] ARC Institute for Soil, Climate and Water, PO Box 26448, Langenhoven Park, Bloemfontein, 9331, South Africa

Abstract

This review provides an overview of Water Research Commission (WRC)-funded research over the past 36 years. A total of 28 WRC reports have been consulted, 13 of these compiled by the University of the Free State, 4 by the University of Fort Hare, and the remainder mainly by the ARC-Institute for Soil Climate and Water. This work has resulted in extensive capacity building in this field – numerous technical assistants and 58 researchers have been involved, of which 23 are still active in research.

The focus on the water flow processes in the soil-plant-atmosphere continuum (SPAC), with particular emphasis on processes in the soil, has greatly enhanced understanding of the system, thereby enabling the formulation of a quantitative model relating the water supply from a layered soil profile to water demand; the formulation of logical quantitative definitions for crop-ecotope specific upper and lower limits of available water; the identification of the harmful rootzone development effects of compacted layers in fine sandy soils caused by cultivation, and amelioration procedures to prevent these effects; and management strategies to combat excessive water losses by deep drainage.

The explanation of the way in which SPAC is expressed in the landscape in the form of the ecotope has been beneficial with regard to the extrapolation of studies on particular SPACs to the large number of ecotopes where detailed studies have not been possible. Valuable results are reported regarding rainfall and runoff management strategies. Longer fallow periods and deficit irrigation on certain crop ecotopes improved rainfall use efficiency. On semi-arid ecotopes with high-drought-risk clay and duplex soils and high runoff losses, in-field rainwater harvesting (IRWH), designed specifically for subsistence farmers, resulted in maize and sunflower yield increases of between 30% and 50% compared to yields obtained with conventional tillage.

An indication of the level of understanding of the relevant processes that has been achieved is demonstrated by their quantitative description in mathematical and empirical models: BEWAB for irrigation, SWAMP mainly for dryland cropping, and CYP-SA for IRWH.

Five important related research and development needs are identified.

The WRC has played, and continues to play, an important role in commissioning and funding research on water utilisation in agriculture and has clearly made an excellent contribution to the progress made in addressing the needs and requirements of subsistence, emergent and dryland farmers in South Africa.

Keywords: BEWAB, SWAMP, CYP-SA, in-field rainwater harvesting, dryland ecotope, irrigation