THE STICS MODEL AS A TOOL FOR EXPLORING THE WATER USE EFFICIENCY IN THE SEMI-ARID ENVIRONMENTS.

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Introduction

Reviews dealing with water use efficiency analysis in literature aimed at highlighting different possible strategies for a more efficient use of water, particularly in areas where water resources are limited. One of these strategies consists in exploring the potential to improve water use efficiency via deficit irrigation (Mastrorilli et al., 1995; Oweis, 1997; Iniesta et al., 2008; Hu et al., 2009).
This study analyses the role of variability induced by climate and soil properties (texture and total available soil water in the root zone, TAW) on the "corn deficit irrigation – water use efficiency" relation. The analysis of water use efficiency was carried out by means of three indexes: crops water use efficiency (WUE_{ET} and WUE_T) and irrigation water use efficiency (IWUE). These indexes can be obtained by calculating the ratio between the yield (Y) and the seasonal values of evapotranspiration (ET), transpiration (T) and irrigation volume (I). The STICS model was retained for simulating the variables (Y, ET, T and I) required to determine these indexes. Preliminary verifications (Katerji et al., 2010) demonstrated that STICS simulate the four variables with an adequate precision under the different soil water conditions which can be observed in Southern Italy.

Material and methods

The three index (WUE_{ET} and WUE_T and IWUE) were simulated in three sites of Southern Italy showing contrasting water availability in the root zone (TAW was 208 mm in Foggia, 187 in Metaponto and 108 in Rutigliano) and soil texture (loam-clay in Foggia and clay in the other two sites), for 25-year periods (1981-2005 characterised by a particularly high level of rain variability), under three scenarios of irrigation scheduling (I - irrigation was scheduled when 25% of the TAW was depleted; II - 50% of the TAW depleted; III - 75% of the TAW depleted).

Results

Figure 1 shows, for the three irrigation scenarios, the average values of the three index (WUE_{ET} and WU_{ET} and IWUE), simulated by the STICS model, during the 1981-2005 period for the three sites.

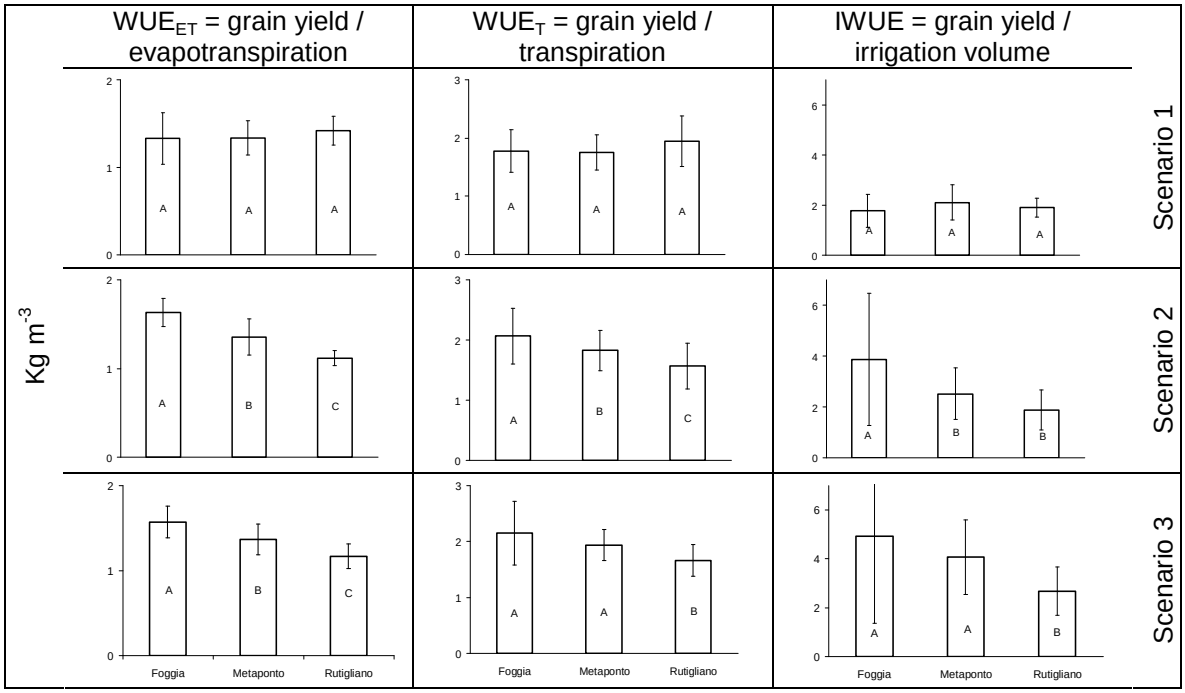

Figure 1. *Average (1981-2005 period) and standard deviations values of WUE_{ET}, WUE_T, and IWUE, simulated in Foggia, Metaponto and Rutigliano for three irrigation scenarios. Histograms having the same letters are not significantly different at P < 0.05 according the L.S.D. test.*

Climatic variability affected the three indexes in different ways during the 25-year period studied. The dispersion around the mean values of the water use efficiency is 17 % on average for the WUE (ET or T) indexes, whereas it could reach 54% for the IWUE index. This last index is only poorly reliable due to the high variability of rainfall during the corn growing season in the Mediterranean region.

For the same level of soil water deficit, TAW led to an improvement (the case of the site with a high TAW and loam-clay soil texture), a stabilisation (the case of the site with a high TAW and clay soil texture) or a decrease (the case of the site with a poor TAW and clay soil texture) in WUE_{ET} and WUE_{T} values. For the same conditions of soil water deficit and TAW, crops water use efficiency was higher in loam textured soil than in clay soil.

The results derived by analyzing three indexes (WUE_{ET}, WUE_{T} and IWUE) converge to the same conclusions on the "corn deficit irrigation –water use efficiency" relation observed at the three different sites.

Conclusion

Such approach based on STICS simulations can be applied for defining the more appropriate irrigation strategy. From a practical point of view, it becomes possible with this model to provide a flexible irrigation strategy which may be adapted to soil conditions (site specific). In a period of water crisis caused by drought, such a strategy also provides some tactical options to remedy such emergency. For instance, the deficit-irrigation practice in poor TAW soils should be avoided, while available water resources should be preferred for irrigating soils with a higher TAW value, which may optimize the utilization of limited water supply.

References

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