Quality and maximum profit of industrial tomato as affected by distribution uniformity of drip irrigation system

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Accepted 2 December 1995

Abstract. The tomato industry reformed its system of payment by weight of tomato, introducing a corrective system based on percent level of fruit dry matter produced. Such a decision implies significant changes in the management of irrigation systems, with a need to emphasize the technological quality of the marketable product. Three levels of distribution uniformity of the irrigation system are analysed, and related production functions of crop yield and percent of dry matter are presented as well as their use on the optimisation of dry matter, expected revenues and seasonal applied water. Results are critically influenced by the distribution uniformity. They demonstrate the inter-relationship between crop production, percent fruit dry matter and irrigation management, and the importance of considering non-uniformity in the economic analysis of industrial tomato production. Decreases in uniformity lead to a reduction in dry matter production per unit land. Decreases in dry matter are also observed with increasing levels of seasonally applied water, with the optimal level always lower than the required for maximum yield. Such interaction suggests a continuous and inverse relationship between profit and water applied. However, due to the corrective system of payment, by levels of percent of dry matter produced, for some uniformity, the expected revenue follows the yield-water production function instead of the dry matter function. This fact introduces disturbances in the optimal water applied inducing higher than expected levels of water applied for profit maximisation. The simulated data also show that incentives to switch to new systems or management practices able to raise the distribution uniformity result more from profit losses than increases in water price.

Key words: tomato crop-water production function, distribution uniformity, quality of tomato, dry matter

Introduction

Efficient use of irrigation water, yield increases and potential for higher income are pushing farmers in Portugal to adopt high frequency irrigation systems for the production of tomatoes (Lycopersicon esculentum Mill) for industry (Calado 1991), despite the high initial costs of installation. The system is used daily or several times per week to satisfy the crop water needs and obtain the maximum possible yields.

Water application is a management decision which controls, subject to several alternatives, inflow rate, time of application, total water volume and,
indirectly, the crop growth. When the distribution of infiltrated water is uniform over the entire field there exists a potential to give the exact amount of water to satisfy the crop needs and obtain the maximum production possible. This method is adequate for most crops and for those whose commercial quality of the final product is not affected by high level of soil water. Drip irrigation field experiments with the industrial tomato (Calado 1991) showed that increasing levels of water application resulted in yield increments but decreased the marketable quality of the fruit with reductions in sugar content and in the percent of soluble dry matter of the harvested fruit (°Brix).

The industry has traditionally valued tomatoes by the kilo of produce and only recently, with a mandatory norm from the European Community (C.E.E. 1991), a corrective system has been introduced in Portugal for payments to be done according to the °Brix of the fruit. The norm set the payments by ranking class of produced °Brix. This shift toward the technological quality of the harvested product forces the farmer to a different management of his irrigation system. The interdependency between total yield and °Brix, and the decreasing quality of marketable fruits with high levels of applied water, will require the optimisation of tomato water application. Evaluations by Letey et al. (1984) and Sammis & Wu (1985) of crop water application and the effects of optimal levels of applied water on profitability of irrigation suggest taking into account the distribution uniformity of the irrigation system.

Non-uniform water distributions of high frequency irrigation systems are the result of different emitter flow rates, function of hydraulic design of the system and emitter manufacturing characteristics, clogging and temperature variations. The effect of non-uniformity is the same despite the cause, but it affects the optimal yield, and the seasonal amount of water applied (Seginer 1978; Santos 1990). Due to the flow rate variations some areas of the field are irrigated in excess and others in deficit. In the case of the industrial tomato, it is expected that in the areas of the field with excess water there is a total crop yield and fruit dry matter reduction and water percolation under the root zone, with additional costs in irrigation water. Meanwhile, in the deficit water areas, a reduction in the tomato crop yield production is expected, but with substantial increases in the technological quality of produced fruits and water savings.

Crop water production functions are usually derived from field plots and they imply uniform water application across the field. Situations are usually very different in farmers’ fields where the depth of applied water may vary considerably with location (Seginer 1978; Warrick & Yates 1987). Thus, field-level production functions may differ from those estimated assuming uniform irrigation. Letey et al. (1984) presented a very flexible method to integrate crop-water production functions with a spatial variability of applied