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Improving Water Productivity in Semi-arid Environments through Regulated Deficit Irrigation

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Abstract: A twelve-year experiment (1998-2009) was conducted at Tal Amara Research Station in Lebanon to determine the effects of deficit irrigation on yield and water productivity in six annual crops; maize (1998-1999), soybean (2000-2001), cotton (2001-2002), sunflower (2002-2003), bell pepper (2005) and eggplants (2008-2009). Deficit irrigation was applied by exposing the crop to a certain level of water stress either during a particular growth period or throughout the whole growing season. At harvest, 1 m^2 quadrates were sampled randomly from the different irrigation treatments to determine yield (Y) and water productivity (WP) as the ratio of yield to evapotranspiration (ET). Results showed that deficit irrigation caused in all crops less yield but resulted in higher WP compared to the well-irrigated control. For soybean, deficit irrigation at mature seeds was more profitable compared to full bloom and seed enlargement. Moreover, flowering was sunflower most critical growth stage and therefore deficit irrigation should be avoided at this stage, while it can be acceptable at seed formation. For cotton, timing deficit irrigation at first open boll has been found to provide the highest lint yield with maximum WP, in comparison to deficit irrigation at early boll loading and mid boll loading. For maize, deficit irrigated-treatments at 80% and 60% of crop evapotranspiration produced less seed yield but resulted in higher WP than the well-irrigated control. In bell pepper and eggplants, deficit irrigation at 80% of ETc was recommended to obtain higher yield and optimized WP. We concluded that deficit irrigation resulted in water saving with the least yield reduction, and thereby considered optimal strategy for irrigation under semi-arid conditions.

Key words: Deficit irrigation, crop evapotranspiration, water productivity, lysimeter, yields.

The relative amount of water available to agriculture is declining worldwide due to the rapid population growth and the greater incidence of drought in recent years caused by climate change and different human activities. Competing agricultural, municipal and industrial water usage will eventually threaten food security (UNWWAP, 2003; World Bank, 2006). Continued successful management of the limited amount of water available for agricultural uses depends upon better agronomic practices and enhanced understandings of water productivity, defined as the crop productivity output per unit of water consumed (Howell *et al.*, 1998; Jones, 2004).

Optimal scheduling of water application is critical to make the most efficient use of water for crop production. This requires that water application is kept at the optimum level to achieve maximized returns. Deficit irrigation - the deliberate and systematic under-irrigation of crops (English *et al.*, 1990; Jurriens and Wester, 1994) is one way of optimizing water use efficiency (WUE) to achieve higher crop yields per unit of irrigation water (Saeed *et al.*, 2008; Domínguez *et al.*, 2012a). It is applied by eliminating irrigation that has the lower impact on yield (English, 1990; English *et al.*, 1990; English and Raja, 1996; DaCosta and Huang, 2006; Geerts and Raes, 2009). Using the deficit irrigation approach, the crop is exposed to a certain level of water stress either during a particular growth period or throughout the whole growing season (English, 1990; Pereira *et al.*, 2002; Karam *et al.*, 2003, 2005, 2006, 2007, 2009, 2011; Fereres and Soriano, 2007).

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