Adjustment of radiation use efficiency of winter wheat by air temperature at different irrigation regimes and nitrogen rates

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In this research, radiation use efficiency (RUE) of winter wheat was determined under different irrigation regimes and nitrogen application rates in experimental field at southwest Iran (semi-arid region) in 2009–2010 and 2010–2011. The experiment was laid out as a split plot design, with irrigation treatments as main plots and N fertilization as sub-plots with three replications. Irrigation treatments were 1.2 (I4), 1.0 (I3), 0.8 (I2), and 0.5 (I1) times of the full irrigation requirements and N treatments were 0 (N1), 46 (N2), 92 (N3), and 136 (N4) kg ha\(^{-1}\). Air temperature had significant effects on RUE that was adjusted by multiplication of hourly temperature factor to the hourly values of solar radiation (RUE\(_a\)). The values of RUE\(_a\) were significantly different from the values of RUE in both growing seasons. The values of RUE\(_a\) ranged from 1.44 to 1.83 g MJ\(^{-1}\) and 1.45 to 1.81 g MJ\(^{-1}\) in 2009–2010 and 2010–2011, respectively. In both growing seasons, minimum and maximum values of RUE were at I1N1 and I4N4 treatments, respectively. The methods of daily maximum and minimum air temperature were modified for considering the effects of air temperature on RUE at locations where hourly air temperature and radiation were not available.

Keywords: air temperature; irrigation regimes; applied nitrogen; radiation use efficiency; winter wheat

Introduction

Radiation use efficiency (RUE) is a parameter that relates dry matter (DM) production to intercepted solar radiation (Monteith 1977). Several crop growth simulation models used RUE to forecast crop growth and yield (Ritchie and Otter 1985; Muchow et al. 1990; Sharpley & Williams 1990; Brisson et al. 2003; Hoogenboom et al. 2004; Zand-Parsa et al. 2006). In these models, DM production was calculated as the product of the amount of intercepted solar radiation and RUE.

Several factors can influence RUE (Sinclair & Muchow 1999). Estimates of RUE depend on whether radiation is measured as total solar radiation or as photosynthetically active radiation (PAR). Some authors suggested that the conversion of RUE based on intercepted PAR was achieved simply by multiplying total solar radiation by 0.5 (Sinclair & Muchow 1999). Bonhomme (2000) showed that the multiplication factor depended on canopy leaf area index (LAI). The values of RUE were known to be affected by abiotic factors such as air temperature (Ritchie & Otter 1985; Andrade et al. 1993), vapor pressure deficit (Kiniry et al. 1998; Kemanian et al. 2004), soil water content (Wajid et al. 2007), Al toxicity (Valle et al. 2009), and nutrient levels (Sinclair & Horie 1989; Muurinen & Peltonen-Sainio 2006). The drought stress reduced RUE progressively by