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Yield and nitrogen leaching in rapeseed field under different nitrogen rates and water saving irrigation

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ABSTRACT

Irrigation water is limiting for crop production in arid and semi-arid areas and excess nitrogen (N) application is a source of groundwater contamination. Therefore, alternate furrow irrigation can be used as water saving irrigation (WSI) and a controlling measure of groundwater N contamination. The objectives of this investigation were to evaluate the effect of ordinary furrow irrigation (OFI), variable alternate furrow irrigation (VAFI) and fixed alternate furrow irrigation (FAFI) and different N application rates (0, 100, 200, and 300 kg ha^{-1}) on rapeseed yield and yield quality, drainage water, N leaching, uptake and N use efficiency. Results indicated that in terms of seed yield the VAFI is superior to FAFI and it is equivalent to the full irrigation (OFI). Therefore, VAFI is a water saving irrigation in the study region (25% reduction in water use) even under drought conditions with 175 mm of rainfall occurred mostly in winter. Furthermore, based on the seed yield, nitrogen use efficiency (NUE) and water use efficiency (WUE), it was concluded that VAFI with 200 kg N ha^{-1} is appropriate irrigation and N fertilizer management for rapeseed in the study region. However, based on the seed oil, protein yields, oil yield based WUE and apparent N recovery, VAFI with 300 kg N ha^{-1} is best treatment. Leaching during the growing season could be reduced by using VAFI especially under conditions with low rainfall in winter. Only in FAFI, N uptake decreased and soil residual N was increased as compared with OFI and VAFI. Thus, in order to avoid N losses, the amount of N fertilizer should be reduced in proportion to the amount of soil water available for plant water uptake under water saving irrigation (VAFI).

1. Introduction

Irrigation water is limiting for rapeseed production in arid and semi-arid regions in Iran. Therefore, water saving irrigation or partial root drying (PRD) irrigation is used in these areas (Samadi and Sepaskhah, 1984; Sepaskhah and Kamgar-Haghighi, 1997; Sepaskhah and Khajehabdollahi, 2005; Sepaskhah and Parand, 2006; Sepaskhah and Hosseini, 2008; Sepaskhah and Ahmadi, 2010). Furthermore, it has been reported that water productivity (WP) in water saving and PRD irrigation is higher for maize (Mintesinot et al., 2004; Sepaskhah and Khajehabdollahi, 2005; Sepaskhah and Parand, 2006) and wheat (Sepaskhah and Hosseini, 2008).

Nitrogen (N) is one of the main plant nutrients affecting plant growth (Weinhold et al., 1995). It has been reported that grain yield of maize (Uhart and Andrade, 1995) and wheat (Sepaskhah and Hosseini, 2008) was increased by application of N. Optimum amount of water and N should be used for a better management of crop production. Excess application of water and N resulted in N leaching in a semi-arid area (Gheysari et al., 2009).

On the other hand, N leaching contaminates the surface and subsurface water (Barton and Colmer, 2006). Subsurface water contamination by nitrate (NO_3) is usually occurred by excess use of N fertilizer (Asadi et al., 2002; Jalali, 2005). In semi-arid area over-irrigation is the cause of N leaching (Jalali, 2005). Therefore, application of N at a rate less than optimal and/or using water saving irrigation can reduce NO_3 leaching (Sexton et al., 1996).

Nitrate leaching was investigated under different irrigation and fertilizer management in semi-arid and arid conditions (Tamini and Mermoud, 2002; Darwish et al., 2003; Rajput and Patel, 2006). Results of N leaching indicated that it is affected by different methods of irrigation. Ahmadi et al. (2011) reported that under limited water conditions and applying water-saving irrigation strategies or PRD, sandy loam and coarse sand are better growth media such that N is more available for the potatoes.

In semi-arid and arid climates, water saving irrigation is used due to the shortage of irrigation water that does not meet the evaporation (ET) requirement of a crop, therefore, an application of N fertilizer based on full irrigation conditions could result an over N use and increase the potential for N losses to the groundwater (Tarkalson et al., 2006). Therefore, it is needed to determine the

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