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Nitrogen dynamics in the soil-plant system under deficit and partial root-zone drying irrigation strategies in potatoes

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Abstract

Experiments were conducted in lysimeters with sandy soil under an automatic rain-out shelter to study the effects of subsurface drip irrigation treatments, full irrigation (FI), deficit irrigation (DI) and partial root-zone drying (PRD), on nitrogen (N) dynamics in the soil-plant system of potatoes. In 2005, FI and PRD_2 were investigated, where FI plants received 100% of evaporative demands, while PRD_2 plants received 70% water of FI at each irrigation event after tuber initiation. In 2006, besides FI and PRD_2 treatments, DI and PRD_1 receiving 70% water of FI during the whole season were also studied. Crop N uptake and residual NH_4-N and NO_3-N to a depth of 0–50 cm, at 10 cm intervals were analyzed.

For both years, the PRD_2 treatment resulted in 30% water saving and maintained yield as compared with the FI treatment, while when investigated in 2006 only, DI and PRD_1 treatments resulted in significant ($P < 0.05$) yield reductions. In 2005, the soil residual N content at harvest was significantly 29% lower with PRD_2 than for FI in the whole root zone; and leaf N concentration for PRD_2 was significantly higher than for FI. In 2006, soil residual N content at harvest was 33% lower with PRD_2 than for FI, which was not significant however. In the late season, reflectance vegetation index and leaf area index for the water saving treatments were higher than for the FI treatment. For both years the PRD_2 treatment had the lowest residual N content in the root zone.

We conclude that: (1) of the investigated water saving irrigation strategies (PRD_1 PRD_2, DI) PRD imposed just after tuber initiation until maturity (PRD_2) was the only strategy able to maintain yield; thus, soil drying induced by PRD or DI treatments should be avoided during early growth stages; (2) the PRD and DI treatments improved soil nitrogen availability late in the growing season maintaining top 'greenness' to a greater extent, as compared with FI.

Keywords: Nitrogen uptake; Potato (*Solanum tuberosum* L.); Residual nitrogen; Leaching; Water-saving irrigation strategy

1. Introduction

Potatoes (*Solanum tuberosum* L.) rate fourth in production volume among the world's various agricultural products after wheat, rice and corn (FAO, 1995). As a shallow-rooted crop, irrigation is crucial for growing potato plants even in humid areas. A high level of nitrogen (N) is recommended for potato cropping (Darwish et al., 2003) to ensure acceptable yield. Potatoes are grown on light texture soils with a low water holding capacity and thus with a high risk of leaching of nitrogen under excess irrigation or precipitation events. Introduction of efficient irrigation practices may reduce these potential losses and hence an important step may be taken toward compliance with legislation in European Union tying emissions to maximum or specified standards for environmental quality, e.g. nitrate concentration in the upper groundwater beneath agriculture lands (Vos and Van Der Putten, 1997).

As fresh water resources become scarce, it is difficult to irrigate crops to meet their full demand. To reduce the irrigation volume, irrigation techniques such as deficit irrigation (DI) have been developed meeting the minimum crop water requirement without any significant reduction in crop yield and quality (Davies et al., 2002). During the last decade a novel deficit irrigation strategy named partial root-zone drying (PRD) has been

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