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Effects of irrigation strategies and soils on field grown potatoes: Root distribution

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ABSTRACT

Root distribution of field grown potatoes (cv. Folva) was studied in 4.32 m^2 lysimeters and subjected to full (FI), deficit (DI), and partial root-zone drying (PRD) irrigation strategies. Drip irrigation was applied for all irrigations. Irrigations were run in three different soils: coarse sand, loamy sand, and sandy loam. Irrigation treatments started after tuber bulking and lasted until final harvest with PRD and DI receiving 65% of FI. Potatoes irrigated with water-saving irrigation techniques (PRD and DI) did not show statistically different dry root mass and root length density (RLD, cm root per cm^3 soil) compared with root development in fully irrigated (FI) potatoes. Highest RLD existed in the top 30–40 cm of the ridge below which it decreased sharply. The RLD was distributed homogenously along the ridge and furrow but heterogeneously across the ridge and furrow with highest root density in the furrow. Most roots accumulated in the surface layers of coarse sand as compared to the other soil types. In the deep soil profile (30–70 cm) a higher root density was found in loamy sand compared with the sandy loam and coarse sand. Approximately twice the amounts of roots were found below the furrows compared with the corresponding layers below the ridges. The RLD values in the soil profile of the ridges and the furrows followed the Gerwitz and Page model: $RLD = \alpha \times \exp(-\beta \times z)$. The highest value of surface root density (α) and rate of change in density (β) was found in coarse sand while the lowest values of α and β were found in the sandy loam and loamy sand. The model estimated the effective rooting depth in coarse sand and sandy loam quite well but did slightly overestimate it in the loamy sand. Statistical analysis showed that one α and β value can be used for each soil irrespective of the irrigation treatment. Thus, the effective rooting depths corresponding to root length densities of 0.1 and 0.25 cm cm^{-3} for sandy loam, loamy sand, and coarse sand soils were 99, 141, and 94 cm, and 80, 115, and 78 cm, respectively, calculated from top of the ridge. The findings of this study can be used in practice for efficient use of water and nutrients in the field.

1. Introduction

Soil water uptake is a function of root distribution and root activity. A good knowledge of soil water uptake is essential for sustainable irrigation scheduling and development of an efficient agricultural water management (Coelho and Or, 1999; Lv et al., 2010). Soil water distribution, soil texture, and soil structure have the major effects on root growth and distribution (Jones, 1983; Coelho and Or, 1999; Dexter, 2004; Wang et al., 2006). Under unfavorable conditions of soil water content, plants enhance their ability for improved water uptake through extending the rooting system and increasing root length density (RLD, cm root per cm^3 soil) (Passioura, 1983; Turner, 1986; Benjamin and Nielsen, 2006; Songsri et al., 2008).

Global decline in fresh water resources did not only cause development of irrigation technologies, but also innovation of water saving irrigation strategies that save a substantial amount of water compared to full irrigation (FI) that is now believed as a luxury use of water (Kang and Zhang, 2004). Partial root-zone drying (PRD) irrigation is the newest strategy of deficit irrigation (DI) where half of the root zone receives, in shifts, the same amount of water as supplied to both sides in DI. PRD and DI have been extensively and successfully tested on many field and horticultural crops without significant loss of economic yield (Sepaskhah and Ahmadi, 2010).

Potatoes are among the four major crops in the world after wheat, rice and corn (Wright and Stark, 1990). Although potatoes are more drought sensitive than many other field crops due to

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