Available online at www.sciencedirect.com
SCIENCE DIRECT®
Soil & Tillage Research 89 (2006) 35–44
Soil & Tillage Research
www.elsevier.com/locate/still

Impacts of a gravel–sand mulch and supplemental drip irrigation on watermelon (*Citrullus lanatus* [Thunb.] Mats. & Nakai) root distribution and yield

Zhong-kui Xie, Ya-jun Wang *, Xing-hu Wei, Zhi-shan Zhang

Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, No. 260 Gonggang West Road, 730000 Lanzhou, China

Received 2 February 2005; received in revised form 2 June 2005; accepted 20 June 2005

Abstract

We investigated the root distribution and yield of watermelon grown with a gravel–sand mulch, a plastic-film mulch, or a combination of the two mulches, and in a non-mulched control under natural precipitation and under three levels of drip irrigation (23, 45, and 68 mm). Roots reached depths of 1.5 m in mulched fields, but most roots (more than 85.3% in 2001 and 92.5% in 2002) in the non-irrigated control were found within the top 100 cm of soil. The gravel–sand mulch increased watermelon root length density (RLD) by 75% compared with the control. In the mulched field, RLD was higher in the top 30 cm of soil in the control (non-irrigated) treatment in 2002 than in 2001, a relatively dry year. Root growth was densest at 68 mm of irrigation in 2001 and without irrigation in 2002. RLD reached a maximum of 1.95 cm cm^{-3} when irrigation and rainfall totalled 194 mm, but decreased at higher levels. The relationship between RLD and total irrigation plus rainfall followed a quadratic curve. In fields mulched with the gravel–sand mixture, roots grew more in the absence of the plastic-film mulch, except in the 68-mm irrigation treatment in 2002, but there was little difference among treatments in 2001. In the mulched field, watermelon yields decreased significantly with decreasing irrigation in 2001, but the yields did not differ significantly from those in 2002. Watermelon extracted more water from soil in 2001 than in 2002. These results demonstrated that rainfall and irrigation affect both the horizontal and vertical distribution of roots and yield. Moderate water deficits increased root length.
© 2005 Elsevier B.V. All rights reserved.

Keywords: Gravel–sand mulch; Root length density; Crop productivity; Water extraction; China

1. Introduction

Precipitation is the major water source for agricultural production in the semiarid regions of northwestern China. However, precipitation in this area is relatively low, with annual means of between 250 and 350 mm. Water shortages are thus a major

* Corresponding author. Tel.: +86 931 4967198; fax: +86 931 8273894.
E-mail address: wxhcas@lzb.ac.cn (Y.-j. Wang).

0167-1987/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.still.2005.06.013

constraint on crop production. For successful agricultural production, farmers must maximize their utilization of rainwater. Efficient rainwater use can be achieved by means of various soil and water conservation practices. The use of a mulch consisting of a mixture of sand and gravel is one farming technique that conserves the region's sporadic and limited rainfall (Gale et al., 1993). The effects of gravel mulch in reducing evaporation and runoff, improving infiltration, increasing soil temperature, and maintaining soil fertility have been widely studied (Adams, 1966; Modaihsh et al., 1985; Van Wesemael et al., 1996; Nachtergaele et al., 1998; Wang et al., 2004). Although mulch created from a mixture of sand and gravel decreases evaporation and increases soil water content, water stress can still occur during seasons with very low rainfall (Wang et al., 2004). Therefore, only drought-tolerant crops can grow well in the mulched fields. Moreover, plastic-film mulch is usually used in fields mulched with a gravel–sand mixture to further decrease evaporation and to increase soil temperature.

The results of a study of common bean (*Phaseolus vulgaris* L.) by Sponchiado et al. (1989) indicated that drought tolerance was associated with depth of rooting. Husain et al. (1990) hypothesized that decreasing the rate of leaf area expansion and increasing root growth were potentially advantageous adaptations by faba bean (*Vicia faba* L.) to water deficits. However, the spatial configuration of a root system in the soil can vary between and within crops. Drought-tolerant crops typically have a plastic root system capable of modifying its structure in response to different environments and capable of increasing root growth in soil layers with the most favorable conditions so as to contribute to the maintenance of adequate water and nutritional status. Watermelon (*Citrullus lanatus* [Thunb.] Mats. & Nakai) root systems typically exhibit good development, and the species has low evapotranspiration (ET), high yield, and high water-use efficiency (WUE). Erdem and Yuksel Nedim (2003) showed that the maximum seasonal evapotranspiration for watermelon in Turkey ranged between 363 and 400 mm. In another study, watermelons used only 210–237 mm of water in 2001 and 293–317 mm of water in 2002 in fields with a gravel–sand mulch and different irrigation treatments in northwestern China (Wang et al., 2004), and both the mulch and slight water stress improved the soluble solid content of the fruit. Furthermore, watermelon grown in fields covered with a gravel–sand mulch can obtain a good price because the melons they ripen earlier than non-mulched melons as a result of higher soil temperatures in the mulched field. Therefore, watermelon is a suitable main crop in northwestern China when planted in mulched fields.

The root growth and root distribution of a crop are significantly affected by the shoot:root ratio (Kage et al., 2004; Wilson, 1988; Husain et al., 1990) and by several soil factors, including soil moisture (Aina and Fapohunda, 1986), soil compaction (Dexter, 2004), soil strength (Gerard et al., 1982), and soil temperature (Mcmichael et al., 1996). It is well known that rooting depth and root system development is closely related to soil moisture content. For example, Gerard et al. (1982) and Jones et al. (1991) reported that in a dry soil layer, root distribution and the downward penetration of the rooting front are restricted by the increased soil resistance to penetration. In field-grown rice (*Oryza sativa* L.), there is some evidence that drying soils can promote root growth as measured by the total root mass (Ingram et al., 1994) or rooting depth (Mambani and Lal, 1983). Nevertheless, Manschadi et al. (1998) showed that under semi-arid conditions, root growth of faba bean was significantly reduced compared with growth in well-watered fields. In addition, differences in the method and frequency of irrigation caused changes in the root characteristics of capsicum (*Capsicum annuum* L.); at lower levels of drip irrigation, plants produced longer roots with less mass, whereas length decreased and mass increased at higher levels of irrigation (Antony and Singandhupe, 2004). Logically, there is a complex relationship between soil structure, root distribution, and water uptake by crops. The spatial distribution of the root system affects the water uptake (Aina and Fapohunda, 1986) and WUE (Antony and Singandhupe, 2004) of crops. The temperature, moisture, and bulk density of a soil should change after mulching the soil with sand and gravel at the soil surface, and this should affect the root distribution of crops, including watermelon.

However, little information exists on the root characteristics of watermelon. Moreover, there is no published research that reports the impact of gravel–sand mulches and plastic-film mulches on watermelon root distribution as a function of irrigation plus precipitation. Therefore, the present study focused on

Download English Version:

https://daneshyari.com/en/article/306610

Download Persian Version:

https://daneshyari.com/article/306610

Daneshyari.com