Performances of subsurface drip irrigation for maize under Mediterranean and temperate Oceanic climate conditions

R. Albasha[1 4], C. Dejean[1], J.-C. Mailhol[1], J.-J. Weber[2], C. Bollègue[2], J.-M. Lopez[3]

[1] *Institut national de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture (Irstea), UMR G-eau, 361 Jean-François Breton street, 34136 Montpellier, France.*
[2] *Campagnie d'Aménagement des Côteaux de Gascogne (CACG), Direction Exploitation – Service Irrigation, chemin de l'Alette, 65004, Tarbes, France.*
[3] *Centre de coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), UMR G-eau, 361 Jean-François Breton street, 34136 Montpellier, France.*
[4] *Department of Water Sciences, faculty of Civil Engineeing, University of Aleppo, Ibn-Albitar street, Aleppo, Syria.*

Objectives

Subsurface drip irrigation (SDI) performances were evaluated for maize under a semi-arid Mediterranean and temperate Oceanic climatic conditions during the 2012 and 2013 growing seasons. Performance measures were grain yield (GY), water productivity (WP) and irrigation water productivity (IWP).

Materials and methods

The experiments were performed at Lavalette station, near Montpellier, South-Eastern France (Mediterranean climate) and at La Mirandette station, near Auch, South-West France (temperate Oceanic climate). The soil was deep loam at Lavalette and loam sandy clay at La Mirandette. The soil at both stations presents high holding capacities within the range 130-180 mm m^{-1}.

The examined factor for growth was solely water availability under SDI. Irrigations were conducted to fulfil 80-85% of the maximum crop requirements (ETM) using SDI compared to fully-irrigated sprinkler treatments (SI). Deficit irrigation with SDI aimed to assess the potential of water saving using this technique. Rainfed treatments (RF) were conducted at each site to assess irrigation productivity using SDI and SI irrigation techniques.

Two ranges of dripline spacing were used for SDI in each site: "narrow" spacing of 100 cm (SDI-100) and 120 cm (SDi-120) and "large" spacing of 150 cm (SDI-150) and 160 cm (SDI-160) at La Mirandette and Lavalette stations, respectively.

Nitrogen availability was not a limiting factor for crop growth. Application methods of N-fertilizer varied among sites and years. N-fertilizer was applied for SDI exclusively by fertigation at Lavalette while at La Mirandette it was applied once by side dressing application in May 2012 and in 2013 by side dressing in early June then by fertigation throughout July. For sprinkler irrigation treatments, N application took place by surface application at Lavalette or by side dressing at La Mirandette.

Experimental measurements mainly included soil water content, leaf area index, grain yield and nitrogen content in plant and soil. Crop total water use was estimated using the PILOTE crop model [Mailhol, J.-C., Ruelle, P.,Walser, S., Schütze, N., Dejean, C., 2011. Analysis of AET and yield predictions under surface and buried drip irrigation systems using the Crop Model PILOTE and Hydrus-2D. Agricultural Water Management, 98, 1033-1044].

Results

The growing seasons were characterised by low and erratic rainfall at Lavalette and higher and more regular rainfall events at La Mirandette station. Total in-season rainfall was 236 and 137 mm at Lavalette and 217 and 341 mm at Mirandette, respectively in 2012 and 2013. The reference evapotranspiration in 2012 and 2013 totalled respectively 670 and 655 mm at Lavalette and 630 and 575 mm at La Mirandette.

Reducing irrigation quantities by 15-20% with SDI significantly affected GY at Lavalette station but had less effect at that of La Mirandette. GY at Lavalette ranged 13.7-15.9 ton ha^{-1} for SDI compared to 17.6-18.8 ton ha^{-1} for SI. At La Mirandette, GY ranged 13.0-16.5 ton ha^{-1} for all irrigated treatments.

Irrigation techniques did not systematically affect WP. At Lavalette, WP ranged 2.59-3.10 kg m^{-3} for SDI compared to 2.75-3.23 kg m^{-3} for SI. Similarly, at La Mirandette WP ranged 2.27-3.05 kg m^{-3} for SDI compared to 2.79-2.87 kg m^{-3} for SI.

IWP did not vary with the irrigation techniques. IWP ranged from 3.88 to 4.86 kg m^{-3} for SDI and from 3.75 to 5.18 kg m^{-3} for SI at Lavalette; while it ranged from 2.79 to 3.87 kg m^{-3} and from 2.50 to 4.01 kg m^{-3} for SI at La Mirandette.

The larger dripline spacing systematically affected GY at Lavalette. For SDI-160, GY was reduced by 10% compared that obtained under SI in 2012 and 2013. In contrast, at La Mirandette, dripline spacing had less pronounced effect on GY and fertilization method seemed to have played a significant role on determining GY in 2013.

Conclusions and perspectives

Under both Mediterranean and temperate Oceanic climatic conditions, deficit irrigation with SDI did not allow to increase water productivity for maize compared to the more conventional technique of sprinkler.

However, “narrow” spacing of 100-120 cm resulted in comparable grain yield and water productivity indicators to those of SI. “Narrow” dripline spacing is therefore preferred over “large” spacing of 150-160 cm under both climatic regions.

Under the temperate Oceanic climate with rainy conditions and for loam sandy clay soils, fertigation may not be a suitable method when large SDI spacing is adopted. Under these conditions, N availability is reduced at mid-distance between two driplines.

Further research is needed to identify the trade-off between surface and subsurface application of N-fertilizer.

Theme: Drip irrigation for water saving: the winning formula?

Keywords: Subsurface Drip Irrigation, Sprinkler Irrigation, Comparative analysis, Water Productivity.