Agricultural Water Management 177 (2016) 215–220

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Effect of different furrow and plant spacing on yield and water use efficiency of maize

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ARTICLE INFO

Article history:
Received 28 April 2016
Received in revised form 27 July 2016
Accepted 27 July 2016

Keywords:
IWUE
Small-scale irrigation
Agronomic practice
Maize
Yield

ABSTRACT

In southern zone of Tigray, Ethiopia, there is a large competition between maize production and other horticultural crops for the limited irrigation water. Hence, there is an imminent need to improve the water use efficiency or more importantly the water productivity of the area. The objective of the study was to evaluate the effect of furrow and plant spacing and their interaction on yield and water use efficiency of maize. Experimental treatments include three levels furrow spacing (50, 70 and 90 cm) and three levels of plant spacing (20, 25 and 30 cm) were arranged in factorial RCBD design under three replications. Maize (BH543 variety) was used in this study in which all agronomic practices were treated equally including the amount of water applied. Maize water requirement was estimated using CROPWAT 8 software. The result revealed that there was significant difference among the treatments ($p < 0.05$) for grain yield, biomass yield and irrigation water use efficiency (IWUE). But it was not significantly different for the yield components (plant height and number of cobs per plant). Maximum grain yield (56.26 qt/ha) and IWUE (0.876 kg/m^3) were obtained from 50 cm furrow and 30 cm plant spacing interaction. But maximum biomass yield (250.6 qt/ha) was obtained from 50 cm furrow and 20 cm plant spacing interaction. The IWUE ranges from 0.357 kg/m^3 to 0.876 kg/m^3 for the equal amount of irrigation water applied (642 mm) for each treatment. This shows how much IWUE of small scale farmers can vary as their agronomic practice (plant and furrow spacing) is different from one another. Hence, it can be concluded that irrigation agronomist experts and development agents of the study area must create awareness to the small scale farmers to exercise 50 cm furrow spacing with 30 cm plant spacing to improve and increase the water productivity of maize.

1. Introduction

Soil, water, air and sunlight are the four key essential determinants for plant to grow. Therefore, water and its control mechanisms, are important to plant-growth and crop-production (Widtose, 2001). The sources of water for crop production are rainfall and irrigation water. The two types of agriculture seen from the perspective of water management, are rain fed and irrigation agriculture which both helps to present sufficient water in the root zone for germination, evapotranspiration and nutrient observation (Dupriez and De Leener, 2002)

Currently the Ethiopian government considers water as an essential policy instrument for development especially in ensuring food security of the rural population (Fitsum et al., 2009). As strategic intervention of addressing food security in Ethiopia the government and the cooperating sponsors has been chosen intensification small scale irrigation due to a number of reasons. The principal factors led to this choice is, irrigation increases the potential for producing more food consistently in the drought-prone and food-insecure areas (Catterson et al., 1999). But a number of problems and constrains are faced with small scale irrigation system of the country. Limited knowledge in modern irrigation management (irrigation scheduling techniques, water saving irrigation technologies, water measurement techniques and operation and maintenance of irrigation facilities); inadequate knowledge on improved and diversified irrigation agronomic practices and low level of awareness of users about irrigated agriculture are the dominant ones (Yalew et al., 2011).

Improving small scale farmers need to have efficient utilization of irrigation water (Shuhuai et al., 2012). Agronomic practices have a profound effect on farm water management practices. A number of factors such as nature of cultivar, plant density, sowing time, and nutrient and water management are involved in affecting profitable

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http://dx.doi.org/10.1016/j.agwat.2016.07.026
0378-3774/

yield (Masoud and Ghodratolah, 2010). Plant needs specific spacing to gain the limited irrigation water. Hence, varying plant spacing has different productivity and water use efficiency. Therefore, it is very important that those who work in irrigation agriculture understand clearly not only the benefits and consequence of irrigation but also what it takes to maximize or optimize the benefits and in how to contribute significantly in agricultural production growth.

Recently elsewhere, interest has arisen in the effects of row spacing on maize grain yield and yield components. Decreasing the spacing row to less than 1 m have increased grain yields (Karlen and Camp, 1985; Cardwell, 1982). However, others studies also shows similar grain yield for row spacing of 38 and 76 cm (Westgate et al., 1997). Sowing maize at row spacing that are less than 0.76 m may increase the maize's water use efficiency under limited water resource and better in controlling weeds as well (Forcella et al., 1992). However, the yield responses to the possible interacting effects of furrow spacing and plant density (spacing between plants) is not known especially in the study area.

Maize is among a high water demanding crop throughout its all growing stages of its physiological development. Maize is very sensitive to water stress but can attain its high yields when nutrients and water are in optimally available the ground (Traore et al., 2000). Under this condition, the effects of water stress on maize not only reduce the main grain yield but includes the reduction of plant height, diameter of shank, leaf area index and root growth (Wilson et al., 2006). Many ways of conserving agricultural irrigation water have been investigated for different climatic and agro ecologic areas. Stone and Nofziger (1993) have used wide-spaced furrow irrigation or skipped crop rows as a means to improve irrigation water use efficiency (IWUE). They used as fixing some furrows for irrigation, while keeping adjacent furrows without irrigating throughout the growing season. Surface irrigation has been and still continues to be the widely used method of water application to agricultural lands. Design, evaluation and management of furrow irrigation, as one of the surface irrigation methods, rely on infiltration characteristics (Nasseri et al., 2007).

In southern zone of Tigray Regional state, maize is often produced by furrow-irrigating under the limited water resource and maize crop is the most competent of irrigation water with horticultural crops in the district. Hence agronomic practice that can improve irrigation water productivity of small scale farmers is important for the area. This study investigated the effect of different furrow and plant spacing combinations on yield, yield components and irrigation water use efficiency of maize crop as well as the water saving efficiencies of the combinations in order to provide theoretical basis for drought resistant and water saving planting mechanism of Maize crop under the specific soil and environmental conditions of the study area.

2. Materials and methods

2.1. Study area

A field experiment was carried out in 2013, at Tumuga site which administratively located in Raya Alamata district of southern zone in the Tigray regional state (Fig. 1). This site is considered as a representative site for the lowland irrigation schemes of southern zone of Tigray regional state. It is located at 12°5′25.47″ to 12°20′7.06″N

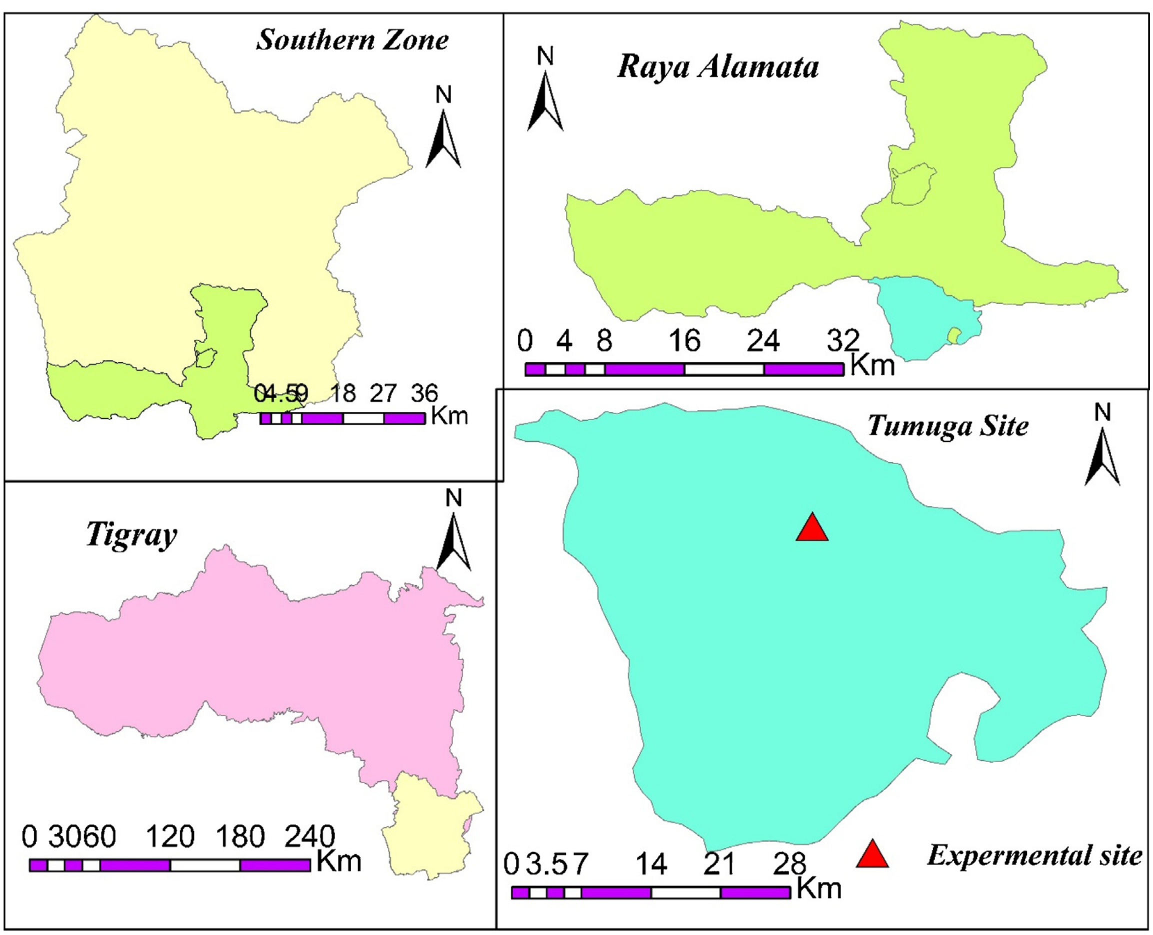

Fig. 1. Location map of the experimental site.