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Effect of surge flow and alternate irrigation on the irrigation efficiency and water productivity of onion in the semi-arid areas of North Ethiopia

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ABSTRACT

The study was conducted in the semi-arid areas of northern Ethiopia with the objective of evaluating the effect of surge flow and alternate irrigation on irrigation performance indicators, water use efficiency and crop yield. The experiment consists of two factors, irrigation systems (alternate furrow (Af) and conventional furrow (CF)) and irrigation flow methods (continuous (C), Surge 1 (S_1), Surge 2 (S_2), and Surge 3 (S_3)). Eight treatment combinations replicated three times were arranged in a factorial randomized complete block design. Onion crop was used as indicator crop for the experiment because of its dominant and cash crop in the region. The result of this experiment indicated that the interaction effect of the irrigation system and irrigation flow methods did not show statistically significant difference on the performance indicators, crop yield and water use efficiency. The irrigation system (Af and CF) as a factor has not significant effect on yield of onion. However, the irrigation flow methods (C, S_1, S_2 and S_3) were significantly affected the irrigation performance indicators (application efficiency, distribution uniformity, deep percolation and tail water runoff losses) and likewise, irrigation water use efficiency and yield of onion were significantly different. Higher crop yield (13208 kg/ha), water use efficiency (1.96–2.55 kg/m^3), application efficiency (52.9–58.7%) and distribution uniformity (81.4–86.2%) were obtained from both surge flow and alternate irrigation as compared to continuous flow and conventional furrow irrigation (every furrow water application) which was recorded less 10142 kg/ha, 1.36–1.65 kg/m^3, 44–54.7%, 67.1–79.6%, respectively. The result of this study explicitly showed that demonstration of these irrigation methods can enhance the poor water management practices in the semi-arid areas of Ethiopia and elsewhere in the world with limited water resources and similar soil characteristics. The authors of this paper recommend the farmers, irrigation experts, water resources managers and decision makers in the region to apply those techniques for improving water use efficiency.

1. Introduction

Agriculture in the semi-arid areas of the Northern Ethiopia is known for its subsistence and rain fed, which is characterized by low yield due to variation in the amount and distribution of rainfall. To tackle the problems of recurrent drought and food insecurity of the region, efforts have been made recently to harvest runoff and groundwater for agricultural development (Abdurahman, 2010; Abdi El-Rahman, 2009; Abraha, 2014; Haregeweyn et al., 2006; Yazew, 2005; Zenebe, 2009). The government has geared itself with an ambitious plan to eradicate food deficiency of the region by utilising the available water resources (Awulachew et al., 2007; Gebreyohannes et al., 2013). To this effect, small-scale irrigated agriculture has significantly increased in the past 10–15 years (Nyssen et al., 2010; Mekonen and Brhane, 2011). For example, irrigable land has increased from 15,000 ha before 2004 to more than 243,000 ha in 2015 (BoARD, 2015). Furthermore, the regional government has an ambitious plan to irrigate 50% of the total 1.5 million hectares of cultivated land of the region in the near future (Gebresilassie, 2014; Hagos et al., 2002).

However, despite the limited amount of water resources in the region, attention given to agricultural water management is very low and its sustainability is under pressure (Mintesinot, 2002; Kifle and Gebretsadkan, 2016). Poor on-farm irrigation water management practice is leading to erosion and sedimentation of reservoirs, poor water distribution and salinity development of irrigated lands

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(Ritzema et al., 1996; Strelkoff et al., 1999; Yazew, 2005; Umali, 1993). The conventional furrow irrigation methods practiced by most farmers in the country is known to be less efficient despite irrigation water in the region is scares (Kifle and Gebretsadkan, 2016; Yazew, 2005). In fact, field application efficiency of the traditional irrigation system in the region is very low which ranged from only 30% to 50% (FAO, 1995, 1997). However, well managed irrigation application systems have better water productivity compared to that of the already practiced traditional irrigation practices in the country (Kifle et al., 2008; Tsegay et al., 2015; Yihun et al., 2013; Mintesinot, 2002; Kifle and Gebretsadikan, 2016).

Small scale farmers in Ethiopia, particularly in the Tigray regional state adopt a traditional way of surface irrigation application methods. Unfortunately these methods often have lower application efficiency and distribution uniformity. High runoff and deep percolation are considered as the main losses (Kifle et al., 2008, 2014; Horst et al., 2007). Minimizing deep percolation and runoff while meeting irrigation requirements of crops can increase irrigation performance in the semi-arid areas of the country. Elsewhere in the world, several management techniques have been developed to reduce water losses during application of irrigation water at field level. Some of these are the cutback stream method, the runoff recovery system, and the intermittent application of water (surge flow) and alternate irrigation. Several studies, conducted in Ethiopia, Egypt and Pakistan under cropped condition has indicated that surge flow irrigation methods improved over all irrigation performance and irrigation water use efficiency (Kifle et al., 2008; Ismail et al., 2004; Mahmood et al., 2003; Amer, 1998; Zaghloul, 1988). However, most of these investigations were carried out on surge flow irrigation where furrow lengths are greater or equal to 70 m and with every furrow irrigation application systems. Likewise, several types of research have also been conducted on alternate irrigation and water productivity. Alternate furrow irrigation uses less irrigation and maintains the same grain yield but it has better water use efficiency compared to conventional furrow (Graterol et al., 1993; Kang et al., 2000). In the semi-arid areas of northern Ethiopia with a limited amount of irrigation water the effects of surge flow and alternate irrigation under very short furrow length and different irrigation method of application has yet to be studied. Irrigated agriculture in the region is dominantly small scale and at plot levels which make be difficult to practice long furrow length.

The onion crop was used as an indicator crop in the experiment because of its integral part of Ethiopian dish and cash crop. This crop is commonly produced under furrow irrigation in arid and semiarid parts of the country. Hence, this study is aimed at improving the traditional irrigation system thereby to formulate irrigation improvement strategies that can enhance irrigation efficiency, water productivity and production. The specific objective of the study was evaluating the effect of surge flow and alternate irrigation systems on irrigation efficiency, water use efficiency and yields of onion in the semi-arid areas of Northern Ethiopia.

2. Materials and methods

2.1. Description of the study area

The experiment was conducted in Mainigus irrigation scheme found in the central zone of Tigray region, Laeelay maichew district near Axum town in the Northern Ethiopia (Fig. 1). Mainigus irrigation scheme is located at 38.4° E and 14.1° N with an altitude of 2080 m a.s.l. The soil type of the experimental site is clay textured. In the irrigation scheme, farmers produce different vegetable and cereal crops including, maize, onion, tomato, potato, pepper, and cabbage. The study area is characterized by semi-arid climate where more than 80% of the rainfall occurs during the rainy season from June to September.

The mean annual rainfall for the last consecutive twenty years (1990–2009) of the districts is 670 mm/year. A dry period over the study areas is extended up to ten months and the maximum effective rainy season extends from 50 to 60 days. Mainigus irrigation scheme which uses micro-dam as a sources of water has the capacity to irrigate 120 ha of land; however, at present it is irrigating only 30–40 ha of land on average. The reason behind for the observed

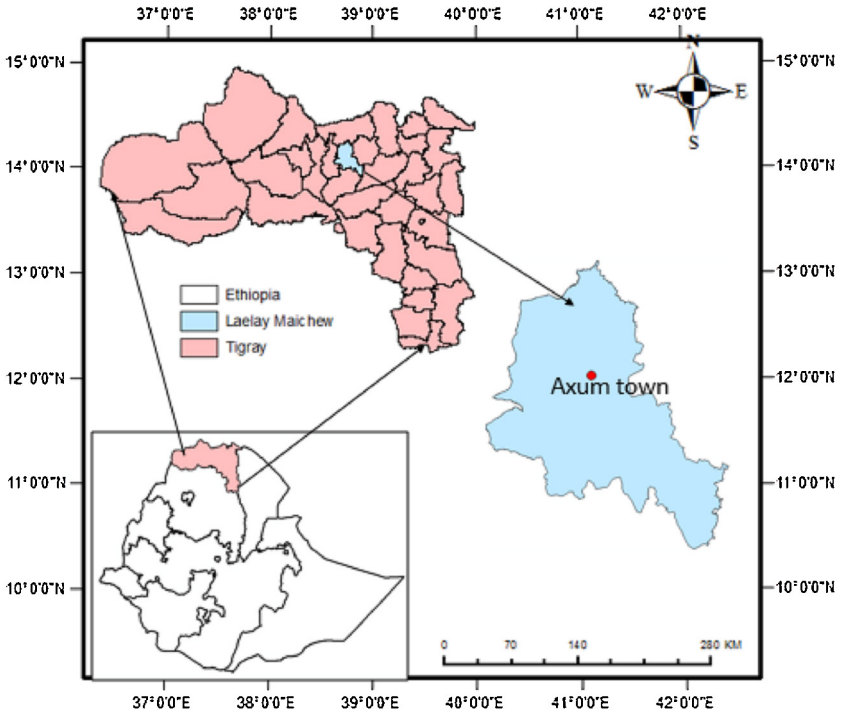

Fig. 1. Location map of experimental site.