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Yield and water use efficiency of furrow irrigated potato under regulated deficit irrigation, Atsibi-Wemberta, North Ethiopia

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ABSTRACT

The pressure on availability of water in Tigray regional state is likely to increase as the requirement for food production in couple with rapidly growing of the population is at increasing rate. Hence, improving water productivity using regulated deficit irrigation is important to reduce the water consumption while minimizing adverse effects on the crop yield. This study was conducted in the eastern zone of Tigray regional state, Atsibi Womberta district. The aim of this study was to determine the yield and water use efficiency of potato under deficit irrigation practice in the 2012 growing period. The effect of water deficit or water stress on crop yield and water use efficiencies were evaluated. Guasa variety potato was grown under eight (T_1–T_8) irrigation treatments. The treatments were replicated three times under completely randomized blocks experimental design. Water was applied to every furrow using watering can with fixed interval and variable depth irrigation scheduling technique was selected. Yield of potato was significantly ($p < 0.05$) affected by water stress (deficit irrigation). The highest yield was found in T1 (18770 kg/ha) which was not subjected to water stress (full water requirement) whereas minimum yield of potato was obtained under the fully stressed treatment T8 (7037 kg/ha). There was no significant different between the yield of T1 (18770 kg/ha) and T6 (14440 kg/ha) which was 25% deficit throughout the growing season. According to the result obtained, stressed at the middle stage was affected more the yield of potato as compared to other treatments. This showed that stressing the crop at flowering/middle stage is sensitive to deficit irrigation. Giving 65% of crop water requirement throughout the growing season is better than stressing the crop only at the middle stage. The second sensitive period for water stress is the late crop stage. Crop water use efficiency was not statistically significant. Though it was not significantly different, T6 (2.86 kg/m^3) and T4 (1.60 kg/m^3) had the highest and the lowest water use efficiency respectively. This elaborated that applying 75% of crop water requirement has better water use efficiency than optimal or "no stress" irrigation. It can be conclude that using deficit irrigation is a good water management technique to save irrigation water without reducing the yield of potato. For dry land areas like The Tigray regional state of Ethiopia and other similar agro-ecology elsewhere in the world with scarce water and agricultural water management is very poor. The authors of this study would like to recommend farmers, water managers, water use associations and decision makers to use water efficiently using deficit irrigation and increase their agricultural production by expanding irrigable land with the same amount of water in a given irrigation scheme

1. Introduction

The history of agriculture in Tigray, North Ethiopia is the history of subsistence. Agriculture in this region is dependent on unreliable rainfall. The pattern of rainfall had been low, torrential and erratic in distribution. Availability of water resources for economic development in the semi-arid areas of Ethiopia is also strongly influenced by various anthropogenic and natural factors (Ayenew, 2007; Conway, 2005; Hurni et al., 2005; Nyssen et al., 2004). Consequently, repeated crop failure has been common experience in the region. In fact, farmers are not passive victims of drought. The farmers use a wide range of indigenous irrigation practices to overcome the problem of drought and to supplement their rain-fed agriculture. Moreover, the Government of Ethiopia is currently focused on

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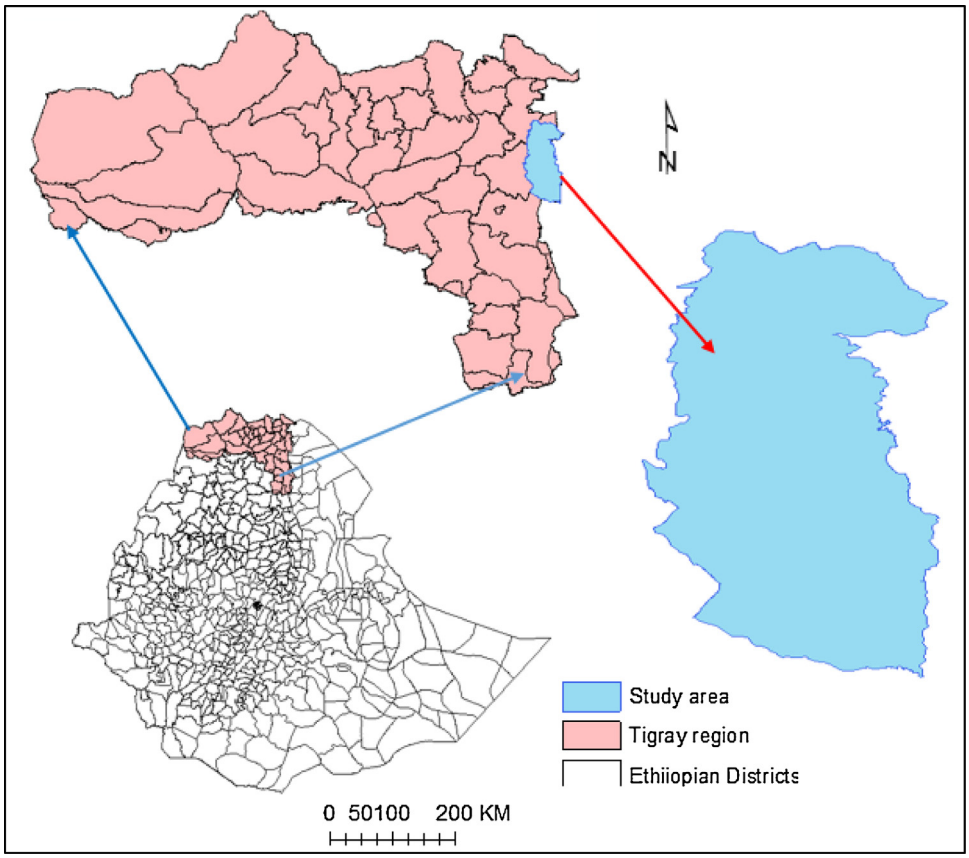

Fig. 1. Location map of the study area.

water resources development with special attention to water harvesting and small scale irrigation schemes in the semi-arid areas (Awlachew et al., 2006, 2011). Woldeab (2006) reported that surface irrigation from river diversions, spring development and pond systems is a common practice that has been used to irrigate small plots in the region. Currently, 125,000 ha of land is under irrigation using traditional methods (BoARD, 2011). The growth and transformation plan of the region indicated that irrigable land will be increased from 125,000 ha in 2011 to more than 350000 ha at the end of 2015 (GTP, 2011). The ultimate goal is to irrigate 50% of the total 1.5 million hectares of cultivated land in the coming years (Gebreslassie, 2014; Hagos et al., 2002). However, the attention given to agricultural water management by the irrigators as well as the government is very low. The pressure on the availability of water is likely to increase significantly as the requirement for food production and industrial use in couple with rapidly growing of the population is at increasing rate. Subsequently, improper on-farm irrigation management practices in the region may lead to erosion, poor water distribution, non-uniform crop growth, water logging, salinity, all of which decrease the yield per unit of land area and per unit of water applied (Eyasu, 2005). The conventional furrow irrigation practiced by farmers in the region is known to be less efficient particularly where there is shortage of irrigation water (Mulubrehan et al., 2014). Field application efficiency in most traditional irrigation schemes is still very low, typically less than 50% and often as low as 30% (FAO, 1995, 1997). Similarly water use efficiency of the traditional irrigation system is smaller compared to the well managed alternative methods of applications (Mintesinot, 2002; Horst et al., 2007; Mulubrehan et al., 2014).

In the context of improving water use efficiency, there is a growing interest in regulated deficit irrigation, an irrigation practice whereby water supply is reduced below maximum levels and yield stress is allowed with minimal effects on yield (Payero et al., 2006; Zhang et al., 2000, 2004; Aujla et al., 2005). Under conditions of scarce water supply and drought, deficit irrigation can lead to greater economic gains by maximizing yield per unit of water as well as by increasing of cultivable frequency or irrigable area (Abdullah et al., 2005; Bekele and Tilahun, 2007). For a given crop, farmers are inclined to use water efficiently, and water efficient crop selection also helps in getting optimum returns. This method is applicable by exposing the crops to a certain level of water stress during particular or the whole growing stages. Several literatures (e.g, Geerts and Raes, 2009; Ali et al., 2007; Du et al., 2010; Webber et al., 2006) shows that regulated deficit irrigation provides a means of reducing water consumption while minimizing adverse effects on the yield. Despite of its importance for semi-arid areas with limited water resources, such types of studies have not been practised in the region. As water resources is very much scares in the Tigray region, practicing deficit irrigation could help to increase agricultural production by expanding irrigable land with the given limited amount of water.

Therefore, this study aims at (i) determining the yield and water use efficiency of potato under deficit irrigation practices (ii) identify crop growth stages during which the crop can withstand water stress with limited effect on yield (iii) determining optimum irrigation schedule and crop requirement of potato for Atsibi Wemberta district and similar agro-climatology of Tigray region.

2. Materials and methods

2.1. Study area descriptions

The experimental site is located in the Northern Ethiopia, eastern zone of Tigray regional state and Atsibi Wemberta district

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