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Meteorological and Soil Characteristics in the Central Ethiopia

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Abstract: Crop production systems in the Central Ethiopia are mostly under rainfed condition. Although the mean amount of annual rainfall is still much for crop growth (400 to 800 mm), the crop production systems often suffer from severe drought stress resulting in unstable food security. This is in part due to erratic and fluctuated rainfall distribution patterns in the region. However, it is required to investigate soil infiltration characteristics, soil water holding capacity, and meteorological condition other than precipitation (ex. evaporation) in order to know how much rainfall can be utilized for crop growth. In the current study, changes in soil water content associated with irrigation or subsequent rainfall were monitored in both dry and rainy season in an experimental field established in the Central Ethiopia. Meteorological observation system was also established. In the dry season, the applied water did not reach down to 25 cm due to poor permeability associated with dry soil condition. In contrast, initial irrigation and subsequent rainfall increased soil water content and infiltrated into the depths in the rainy season. Even in the rainy season, evaporation affected on moistening of deeper soil depths associated with infiltration and redistribution. The meteorological observation revealed that intense solar radiation, high temperature, low relative humidity, and constant wind speed would accelerate evaporation from soil surface.

Keywords: Central Ethiopia, Infiltration, Micro meteorology, Soil water dynamics

1. Introduction

Crop production systems in the Central Ethiopia are mostly under rainfed condition. Although the mean amount of annual rainfall is still much for crop growth (400 to 800 mm), the crop production systems often suffer from severe drought stress resulting in unstable food security. This is in part due to erratic and fluctuated rainfall distribution patterns in the region. However, it is necessary to investigate soil infiltration characteristics, soil water holding capacity, and meteorological condition other than precipitation (ex. evaporation) in order to know how much rainfall can be utilized for crop growth. In the current study, characteristics of changes in soil water content associated with the infiltration and the meteorological condition is reported.

2. Materials and Methods

The experimental site is located in Adami-tulu Agricultural Research Center, Oromia region of the central Ethiopia (7˚52'N, 38˚43'E, 1649 m alt.). Rainy season is during June to September, and dry season is other months. Soil texture of the experimental field was Loamy Sand.

In an upland cropping field, a single pair of 1 m × 1 m monitoring plot was prepared. In each plot, changes in soil water content were recorded at a depth of 5, 15, 25, and 35 cm using ECH2O and Em50 (type EC5, Decagon Devices, Inc., Pullman, WA, USA). In Dec. 2007 (dry season), 45 mm of water was initially applied to the plots by a hand sprinkler, thereafter one plot was exposed to the atmosphere (thereafter termed as 'bare condition') and the other was covered by a plastic sheet (thereafter 'covered condition'). In June 2008 (rainy season), similar observation was undertaken, namely; 30 mm of water was applied to both plot, thereafter one plot was monitored under bare condition and the other was covered for initial 3 weeks, then the plastic sheet was removed (initially covered condition). Temperature, relative humidity, wind speed, solar radiation, and precipitation have been recorded since Feb. 2008 by HOBO Weather station (Onset Computer Co., Bourne, MA, USA).

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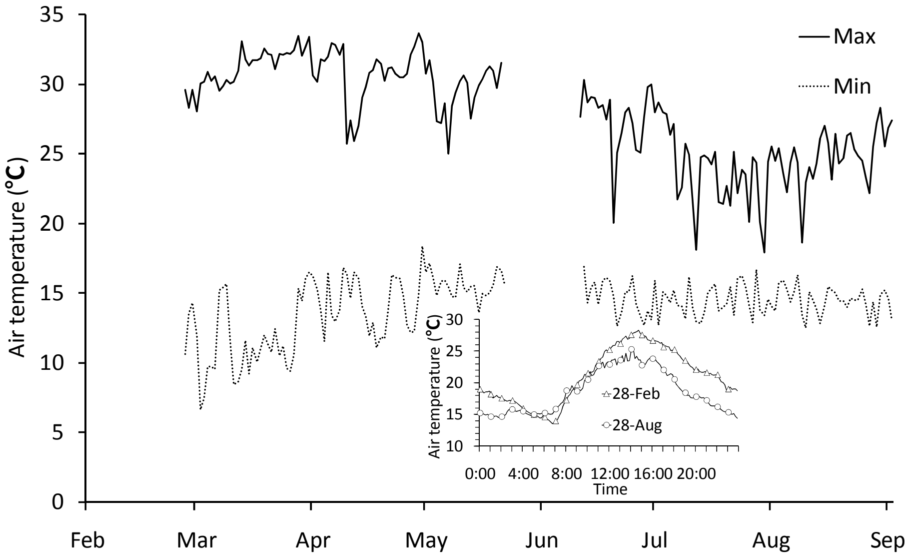

Fig. 1. Temperature change in 2008.

3. Results and Discussion

The air temperature observed was characterized by large diurnal range in the dry season and small diurnal range in the rainy season with the mean daily air temperature ranging from 17 to 25 ˚C (**Fig. 1**). That is to say, the daily maximum air temperature in the dry season exceeded > 30 ˚C and decreased in the rainy season (20 to 25 ˚C). The daily minimum air temperature in the dry season reaches down to 10 ˚C, while the temperature in the rainy season is relatively constant (15 ˚C). The solar radiation in the dry season was considerably high (>25 MJ m^{-2}) (**Fig. 2**). In contrast, the solar radiation decreases in the rainy season. This is because the sun shine is interrupted by clouds in the rainy season (Fig. 2). Concomitant with this, the daily mean relative humidity was < 50% in the dry season and increased up to 80% in the rainy season (**Fig. 3**). The relative humidity was decreased in daytime and increased in nighttime (Fig. 3). The wind speed was moderate and constant (**Fig. 4**). The wind speed in dry season was relatively higher than that in rainy

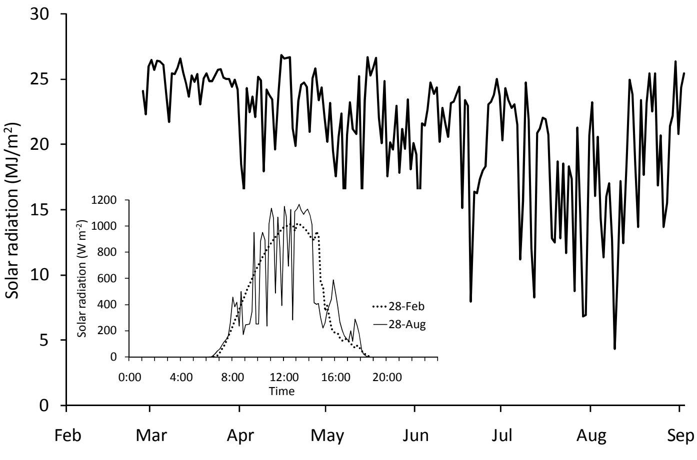

Fig. 2. Solar radiation in 2008.

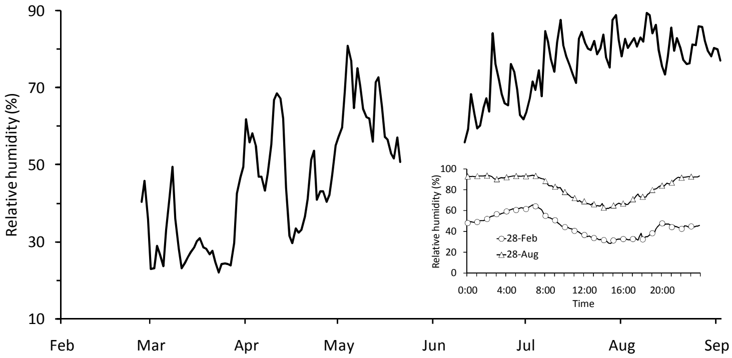

Fig. 3. Relative humidity in 2008.

season (Fig. 4).

The result of the infiltration experiment undertaken in the dry season is presented in **Figure 5**. In case of the experiment in the dry season, the soil profile was considerably dry with soil water content at 5 cm of depth being < 0.05 m^3 m^{-3}. For both bare and covered condition, the irrigation caused a steep rise of the soil water content at depth of 5 cm, and the soil water content at depth of 15 cm gradually increased (Fig. 5). However, the applied water did not reach down to 25 cm. The result indicates poor infiltration characteristics of the soil associated with dry initial condition. Since the soil water content at depth of 5 cm became constant for covered condition, dominant reason of decreases in the soil water content at depth of 5 cm observed for the bare condition is suggested to be evaporation.

The result of the infiltration observation undertaken in the rainy season is presented in **Figure 6**. In this case, the initial soil water content of the soil profile was > 0.15 m^3 m^{-3}. Initial irrigation and subsequent rainfall increased soil water content and infiltrated into the depths. For the bare condition, soil water content increased over a whole profile but did not exceed 0.40 m^3 m^{-3}. In contrast, the soil water contents at depths of 15, 25, and 35 cm were relatively constant ranging from 0.37 to 0.42 m^3 m^{-3} after the plastic sheet was removed, while the soil water content at depth of 5 cm was lower than that of deeper depths by more than 0.10 m^3 m^{-3}. A reason of the difference in soil water profiles between the bare and initially covered conditions is suggested to be as follows; for the initially covered condition, applied water was redistributed in the soil profile resulting in decreases in the

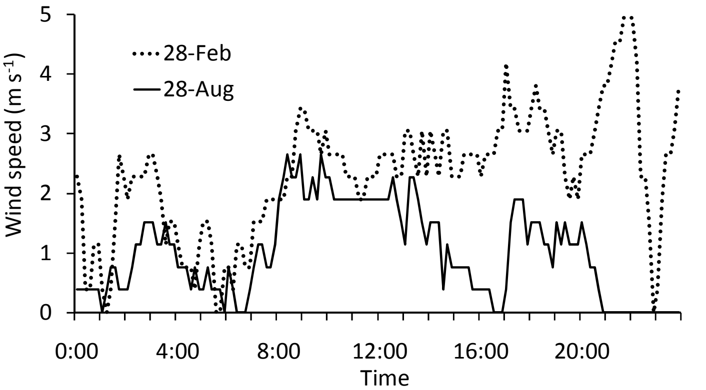

Fig. 4. Comparison of wind speed between dry (Feb.) and rainy (Aug.) seasons in 2008.

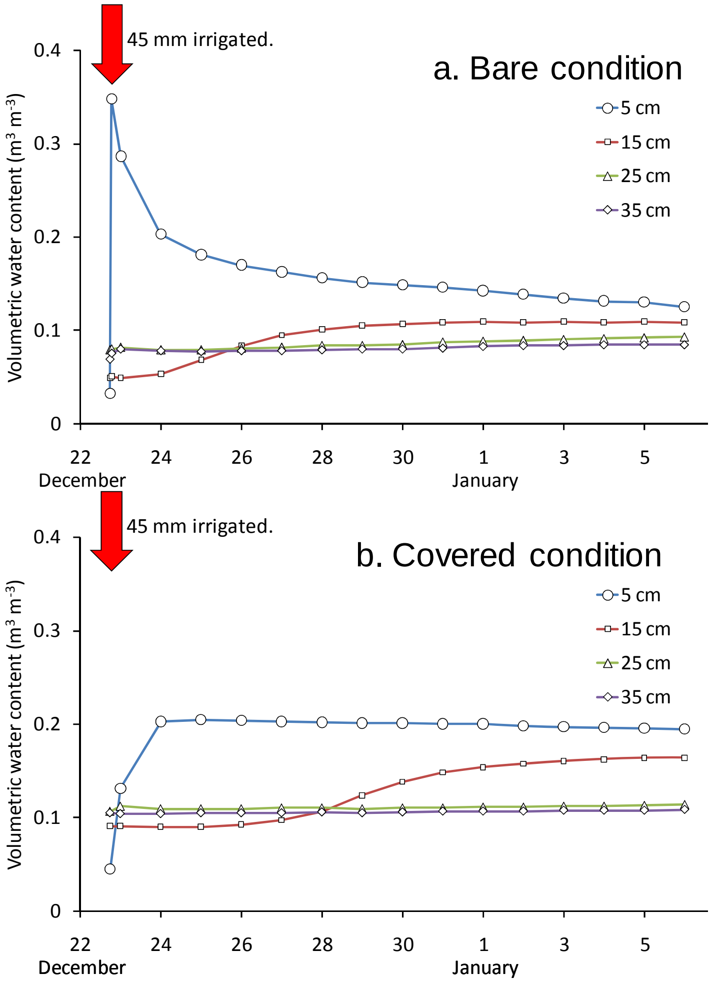

Fig. 5. Comparison of changes in soil water content associated with irrigation between bare (a) and covered (b) conditions observed in dry season from 2007 to 2008.

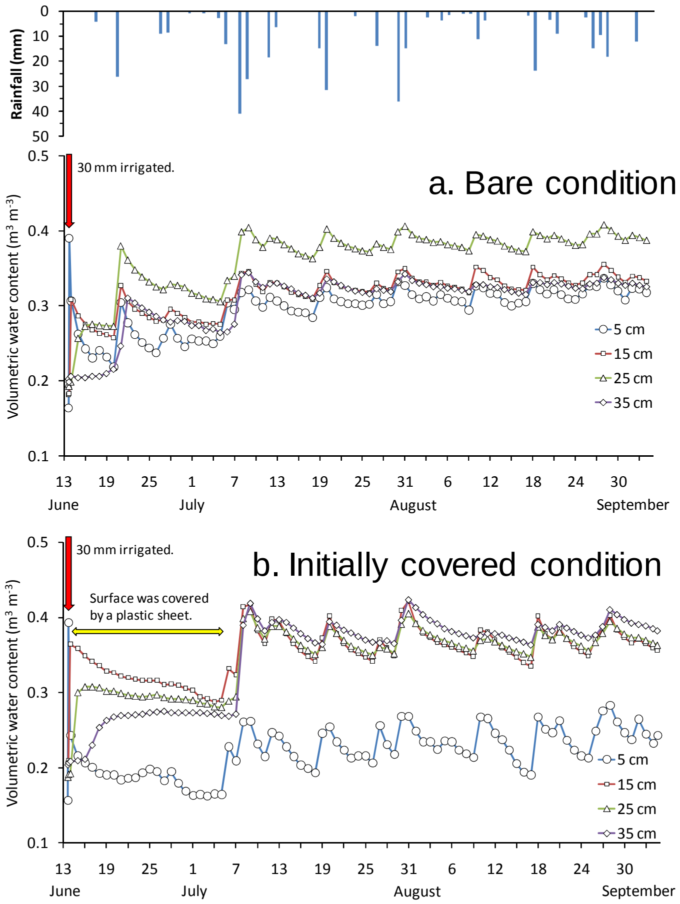

Fig. 6. Comparison of changes in soil water content associated with irrigation and subsequent rainfall between bare (a) and initially covered (b) conditions observed in rainy season of 2008.

soil water content at the shallower depth (i.e. 5 cm) and increases at deeper depths under a condition without evaporation (Hillel, 2000). Therefore, the soil water content at deeper depths remained high repeating increases and decreases by the evaporation and rainfall, even after the plastic sheet was removed. For bare condition, the water infiltrated into the soil profiles was immediately extracted by the evaporation before increasing soil water content in deeper depths sufficiently.

4. Conclusions

The infiltration experiment showed contrast results between dry and wet seasons. The results of the current study suggest that low soil permeability of upland cropping fields of the Central Ethiopia associated with low soil water content results in the difficulty of rainwater to wet the soil profile at the onset of the rainy season. Comparison of changes in soil water contents between the bared and covered conditions, particularly observation in the rainy season indicates that the evaporation affects on redistribution of water in the soil profile before moistening deeper depths sufficiently. Intense solar radiation, high temperature, low relative humidity and constant wind speed would accelerate evaporation from soil surface. Concomitant with this, the results also suggest a potential of mulching to retain water in the soils.

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