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Crop water requirement determination of chickpea in the central vertisol areas of Ethiopia using FAO CROPWAT model

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Chickpea (*Cicer arntimum*) is one of the major grain legumes with an inimitable sources of dietary protein in the developing world where there is very scarce animal protein or unaffordable expensive otherwise. Ethiopia is considered as one of the secondary centers of genetic diversity for chickpea. The crop has been grown for multiple purposes since antiquity in the country. Chickpea production under residual moisture is a common practice in the central highland vertisol areas of Ethiopia. The importance of the crop in the Ethiopian diet has also been significant. Despite the huge importance of the crop as dietary item and land improvement, the yield and production of the crops is still blew the expected level in Ethiopia. Thus, producing chickpea either under full or supplemental irrigation could help in improving the productivity of the crop to contribute in increased production in the area. Determination of the crop water requirement of the crop for this particular growing area is therefore paramount importance for proper planning of chickpea production using supplemental irrigation. In view of this, the crop water requirement of chickpea was estimated using the FAO CROPWAT 8.1 Software and long term weather data record where the planting date is simulated to be 24 December. The assessment has showed that the net irrigation requirement of the crop is 37.2, 114.4, 205.2 and 79.8 mm during seedling, vegetative, late (maturity) growth stages of the crop, respectively. The irrigation requirement of the crop for a single growing season as revealed by the program is estimated to be 436.7 mm.

Key words: Chickpea, crop water requirement, vertisol.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an ancient legume crop believed to be originated in South East Turkey, and the adjoining part of Syria (Singh, 1997; Lev-Yadun et al., 2000). It is the fourth most important food legume with a total annual global production of 9.1 million M tones from 11.2 million ha (FAO, 2009). Besides being an important source of human and animal food, chickpea also plays an important role in the maintenance of soil fertility, particularly in the dry, rainfed areas (Saxena,et al 1996, Katerji et.al., 2001). In Ethiopia, chickpea is widely grown

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across the country and serves as a multi-purpose crop. It is one of the major grain legumes with an inimitable sources of dietary protein in the developing world where there is very scarce animal protein or unaffordable expensive otherwise. Ethiopia is considered as one of the secondary centers of genetic diversity for chickpea.

In many regions where food legumes are grown, the climate is characterized by extremely variable and often chronically deficient rainfall. In such environments both agricultural scientists and farmers seek to identify crop and soil management techniques which make the maximum use of this scarce resource (Cooper et al., 1998). Major chickpea producing countries (FAO, 2003), where the crop is generally planted after the main rainy season and grown on stored soil moisture, making terminal drought stress a primary constraint to productivity (Serraj et al., 2004).

Similarly, despite the huge importance of the crop as dietary item and land improvement, the yield and production of the crops is still blew the expected level in Ethiopia (Kassie et al., 2009). Among other factors, the use of irrigation practices to grow the crop is critically low in the country. Chickpea cultivation is solely dependent on the soil moisture reserve where planting is made late during the recession of the main rainy season to escape the water lodging conditions. But, the flowering and pod setting stages appear to be the most sensitive stages to water stress (Nayyar et al., 2006). Limited irrigation to adequately meet the crop needs at critical stages of growth and development may be crucial for realization of yield potential of chickpea varieties. Thus, to match, the ever increasing national demand, growing chickpea under irrigation has to be the top and urgent priority agenda.

In any planning attempt for exercising irrigation, determination of crop water requirement of crops is the primary job in the crop production industry. As the information on crop water requirement of chickpea is severely limited, the objective of this current was to estimate the optimum crop water requirement of the crop using a model, CROPWAT model.

The latest version of model, namely CROPWAT v8 includes a simple water balance model that allows the simulation of crop water stress conditions and estimations of yield reductions based on well-established methodologies for determination of evapotranspiration (FAO, 2006) and yield responses to water. This model utilizes soil, crop, and weather databases to simulate multiyear outcomes of climate change scenarios and various crop management strategies. The model also allows the development of recommendations for improved irrigation practices.

MATERIALS AND METHODS

This study was conducted at DebreZeit Agricultural Research Center, located at Central highlands of Ethiopia and situated between 38’051’43’.63” to 39’004’58”E and 8’046’16.20” to 8’059’16.38”N, in the Western margin of the great East African Rift Valley (Figure 1).

Long term weather record (1973-2007) from DebreZeit Agricultural Research Center’s archive for precipitation, relative humidity, windy speed, minimum and maximum temperature have been used for this study for estimating the reference evaptranspiration of the study site. The soil physical properties of the study site were determined using the proper lab procedures. The FAO CROPWAT 8.1 program was employed for estimating the daily, monthly and seasonal crop water of the crop. The irrigation scheduling scenario for the crop was also developed based on the program, the FAO CROPWAT 8.1.

RESULTS AND DISCUSSION

The precipitation deficit during the selected (December 12 as planting date) growth stages for Chickpea is comparatively as high as 130 mm which is supposed to be more than one third of the crop water requirement of the crop (Figure 2). The least deficit in precipitation during this same period is 120 mm (in April). The model also revealed that during the main rainy season, the month of September need to be monitored as it exists moderated deficit (22 mm), that is, proper planning of agronomic practices (particularly planting date) is crucially important.

The highest crop water requirement of the crop is at around sixty days after planting (5.6 mm perday) or 56 mm perdecade (ten days sum). The crop water requirement on basis of stages: the initial stages requires 37.2 mm, while the subsequent stages, development, mid and late stages demand 114.4, 205.2 and 9.8 mm each respectively (Figure 3).

If one is to irrigate one hectare of land to grow Chickpea, the total irrigation water required will be around 4370 cubic meters of water for a single season.

Considering the planting date selected, the frequency of irrigation during initial has to be twice, three times during development, four times at mid stage and three times at late stage.

Once irrigation has started after the soil is irrigated to field capacity in this case, the soil moisture depletion level should be monitored properly. This is because lack of adequate soil moisture in the seedbed is a major hindrance to the establishment of chickpea crop. In addition, inadequate soil moisture can reduce seed germination, low down seedling growth and diminish yield in rainfed crops (Sharma, 1985). For instance, at the initial stage, the depletion level has to be as low as 40 mm per meter. In other words, after 25 days of the first cycle of irrigation, the soil moisture depletion level reaches 40 mm per meter. This corresponds to the remaining moisture in the soil is nearly 60% of the total available water. Thus, at this stage the next irrigation should be applied (Figure 4). Similarly, during flowering and yield formation, the soil moisture can be kept at 40% of the total available moisture.

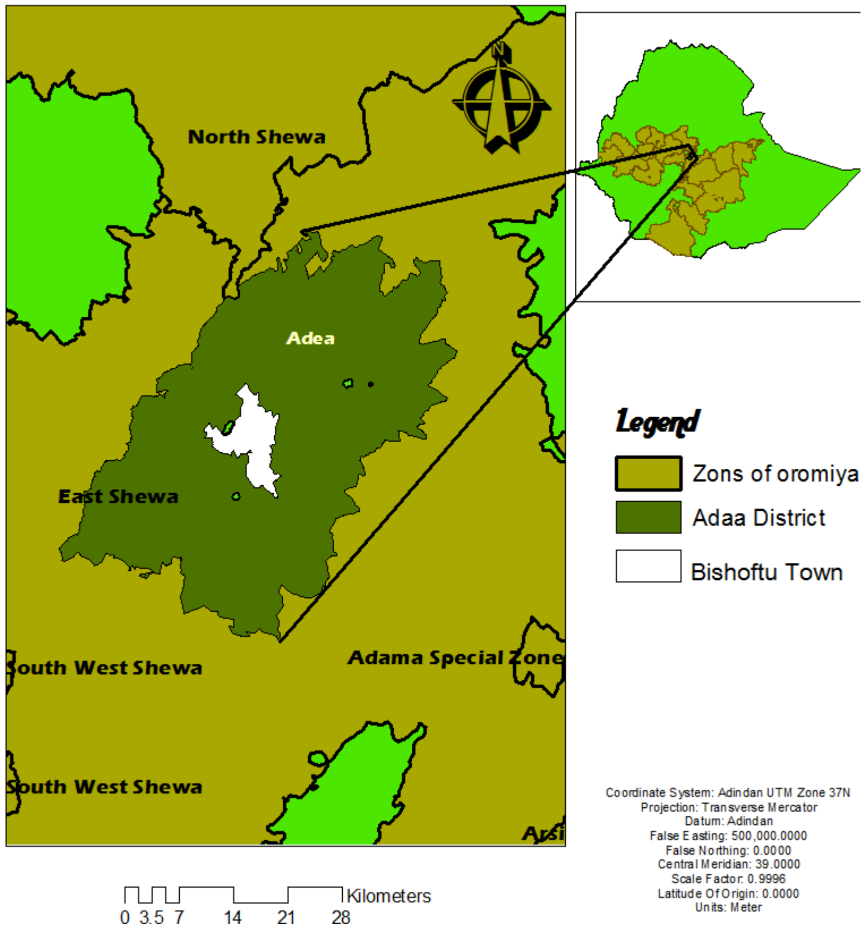

Figure 1. Location map of Adaa District and Bishoftu Town, West Shoa Zone, Oromia.

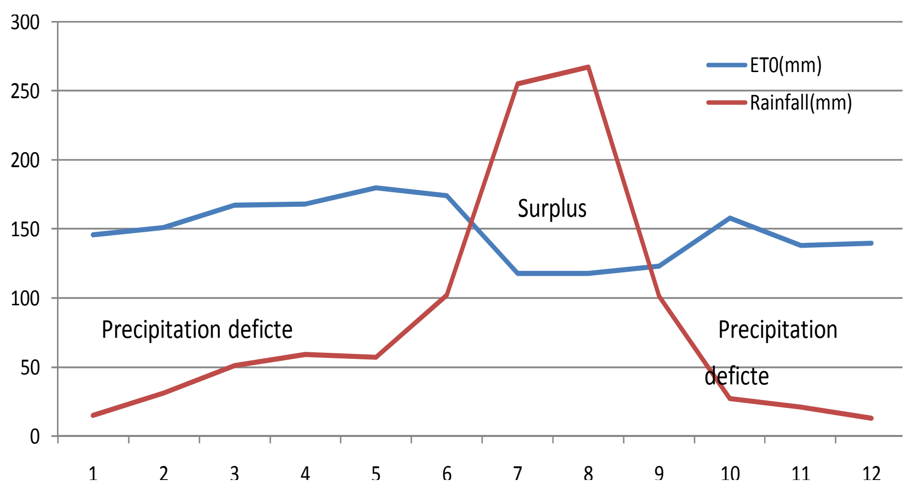

Figure 2. Precipitation Vs. reference evapotranspiration.

In an effort to assess the supplementary water need for the rainfed, considering the planting dates: July 1, 15, 30 and August, 1, 15, 30, the irrigation requirement varies from 134 to 372 mm in tier respective orders (Table 1).

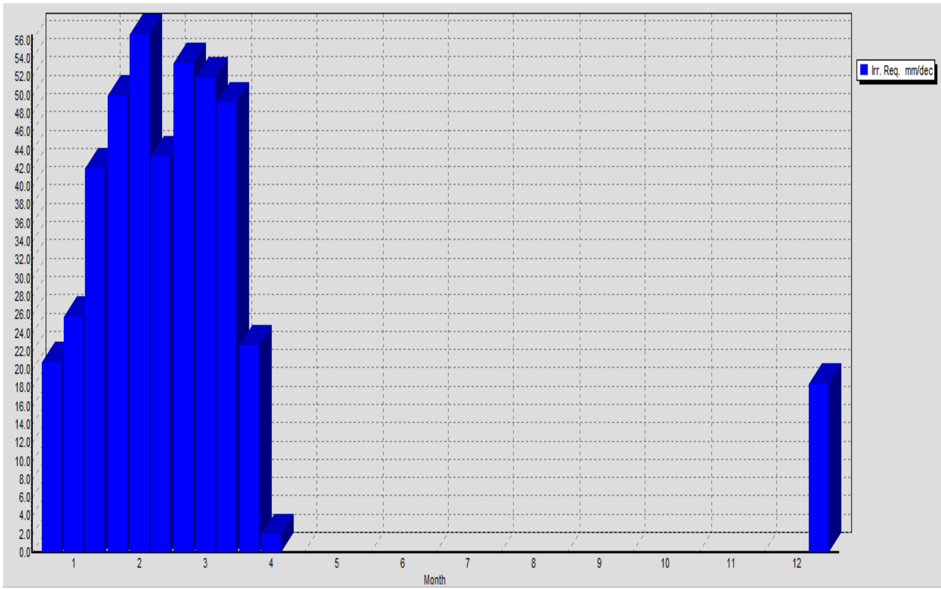

Figure 3. Crop water requirement of chickpea after planting (FAO CROPWAT model.

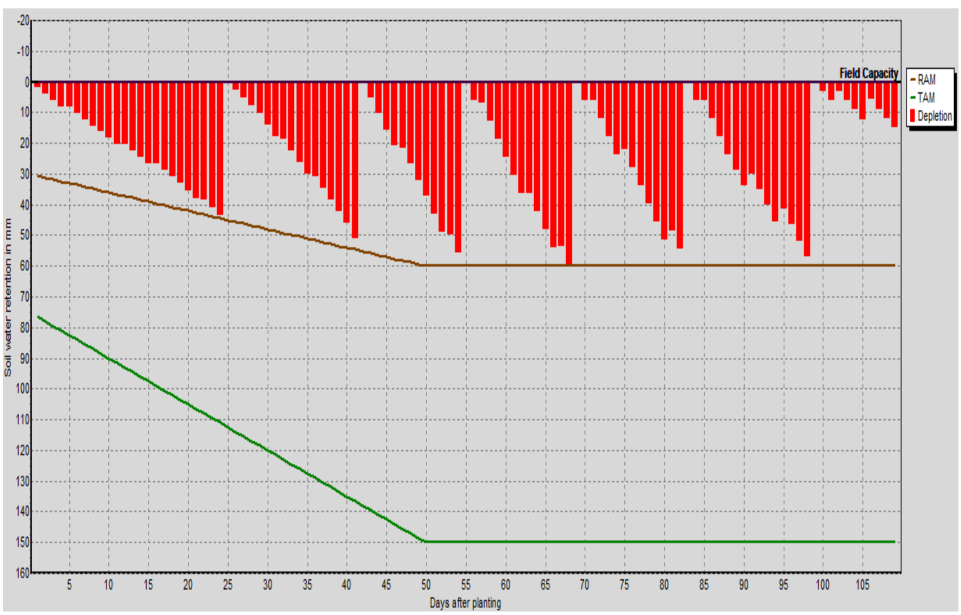

Figure 4. Irrigation scheduling scenarios for chickpea.

Table 1. Crop water requirement under different planting dates.

Planting dates	Irrigation requirement (mm)
01-Jul	134
15-Jul	212
30-Jul	282
15-Aug	336
30-Aug	372

This result may indicate that planting after 30th July should be properly attended if the crop is to grow only under rainfed conditions.

Conclusions

The crop water demand of chickpea for a single is season with reasonable full irrigation can be as high as

437 mm or 4370 cubic m of water for a ha. The optimum soil moisture depletion level for the vegetative stages should not exceed 60% of the total available water and 40% for flowering and yield formation. The model also reveals that irrigating twice to field capacity during vegetative; three to four times during the rest of the stages is optimum. Planting date for the main rainy season should also be monitored with possible care. Under full irrigation scenarios, the agronomic practices (planting dates) and other physiological aspects have to be integrated with either variable, particularly temperature, as some of the growth stages (flowering and grain setting) are sensitive to higher temperature. As this is only preliminary information from the model, field validation of these results should be a follow up work of this study.

Conflict of Interest

The authors have not declared any conflict of interest.

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