Evaluation of double cropping and supplementary irrigation of chickpea using drainage water on Vertisols at Dembia district in North Gondar

Yirga Alemu[£] and Hanibal Lemma
[£]Email: yirgale@yahoo.com
Gondar Agricultural Research Centre, P.O.Box 1337, Gondar, Ethiopia.

Abstract

An experiment was carried out in 2006 and 2008 to evaluate double cropping and supplementary irrigation of chickpea using harvested drainage water on pellic Vertisols at Kola Diba research station in Dembia district. The study was aimed to investigate the effect of time of supplementary irrigation on the grain yield and supplementary water productivity of chickpea after the harvest of barley produced in the main season. Six supplemental water application periods (2 mm before planting and 11 mm at flowering; 13 mm at vegetative stage; 13 mm at flowering; 13 mm at pod filling stage; 6.5 mm at vegetative stage and 6.5 mm early pod filling; and without supplemental irrigation (control)) were evaluated in RCDB with three replications. Treatments received the same amount of water (13 mm). Result showed that applying 13 mm at vegetative stage, applying 2 mm before planting and 11mm at flowering stage, and applying 6.5 mm at vegetative stage and 6.5 mm at early pod filling stage gave significantly higher yield and water productivity compared to the control. Supplementing chickpea once at vegetative stage (one month after planting), when the chickpea forms branches, gave the highest yield of 1136 kg ha^{-1}. From the economical point of view, frequent irrigation however requires huge labour and time hence irrigating once at vegetative stage had paramount importance. It is concluded that supplementary irrigation particularly at time of planting and/or vegetative stage is recommended on Vertisols in Dembia plain to improve the productivity of chickpea under residual rainfed production system.

Keywords: Chickpea, supplementary irrigation, water harvesting, Vertisols.

Introduction

Chickpea (*Cicer arietinum L.*) meets its high water requirement from residual soil moisture in deep soil, which have been properly restored, with available soil moisture during the preceding rainy season. Chickpea is capable of drawing water from depths greater than 150 cm, but a major proportion of total extractable water comes from the top 60 cm of the soil profile that have the main concentration of active roots. Although chickpea is considered to

be better adapted to low moisture supply condition than many cool season cereals, Leather (1979) reported that its water requirement is higher than that of wheat. The consumptive use of water (ET) for chickpea depends on the soil moisture supply and the yield level. Singh and Bhushan (1979) reported that ET ranged from 110 to 204 mm to produce seed yield of between 900 and 3000 kg ha^{-1}. Within this range, there was a close correlation (r = 0.85) between the amount of water and the yield. Information on optimal scheduling of limited amounts of water to maximize yields is essential if irrigation water is to be used most efficiently. The various crop development stages possess different sensitivities to moisture stress (FAO, 1979; Ghahraman and Sepaskhah, 1997).

Drought tolerance is a desirable characteristic for some crops such as chickpea, which grows mainly on residual moisture. Ethiopia in general and Amhara region in particular has a good potential for chickpea production. One reason for this is presence of large coverage of Vertisols, which is about 10.38% of the total area of the region. The Amhara regional bureau of Agriculture and Rural Development (BoARD) is intending to exploit this untouched resource to its maximum by using different drainage, water harvesting and agronomic technologies. Currently chickpea is highly demanded in the international market. Due to this BoARD is pushing the local farmers to inter into production of quality chickpea so as to use the available market to increase the income source to the poor farmer and generate foreign currency for the country. The purpose of this research was to determine rational irrigation scheduling for chickpea with limited availability of water to obtain optimum yields. Therefore, this experiment was conducted to assess the reuse of drained water and double cropping potential from Vertisols for optimum supplementary irrigation of chickpea.

Materials and methods

Description of the study area

Dembia district is located in North Gondar zone of Amhara National Regional State. The district shares borders with Gondar town and Lay Armachiho in the North, Gondar Zuria in the East, Chilga and Alefa districts in the West and part of Lake Tana in the South. The

agro-ecology of Dembia is traditionally classified as Woina Dega. According to MoARD (1998) Dembia plain is classified as Tepid to cool moist plains. Dembia district characterized by mono-modal rainfall season extends from beginning of June to the mid of September with average annual rainfall of about 1095 mm. On an average, the length of the growing season (LGS) of crops is about 146 days. The mean annual potential evapotranspiration is about 1560 mm. Mean maximum and minimum annual temperatures are 27 ^{O}C and 13 ^{O}C, respectively and the mean annual temperature is 19 ^{O}C.

Experimental setup

The trial was conducted at Koladiba research site during 2006 to 2008. The average rainfall during the growing season, from end of September to the end of January, ranges from approximately 80-180 mm and the mean rainfall is 112 mm. The source of water for supplemental irrigation was drained from the Vertisol plot, using Broad Bed Maker (BBM), planted to barley during the main rainy season. The drainage water was collected in an earthen pond with surface area of 25 m^2, depth of 1 m, side slope of 2:1 and bottom area of 1 m^2. The pond has a storage capacity of 10.3 m^3. The harvested water was applied to supplement chickpea at different growth stages. Using a measuring can, 13 mm of drained water was applied at different growth stages. The different irrigation regimes were: applying 2 mm before planting and 11 mm at flowering stage, applying 13mm at vegetative stage, applying 13 mm at flowering stage, applying 6.5 mm at vegetative stage and 6.5 mm at early pod filling stage, and the traditional practice that is without supplementary irrigation was used as a control. The experimental design was randomized complete block design with three replications.

The data collected were grain yield of chickpea. The seasonal water use (rainfall and supplemental irrigation) was used to calculate water productivity of crops. The yield data were subjected to statistical analysis using SAS statistical package to assess effects of supplemental irrigation regimes on chickpea production. Whenever the variance analysis reveals significant treatment effect means were separated using LSD test at 5% probability level.

Results and discussion

Results showed that supplementary irrigation had significant effect on the grain yield of chickpea (Table 1). Supplementing chickpea applying 13 mm at vegetative stage, applying 2 mm before planting and 11mm at flowering stage, and applying 6.5 mm at vegetative stage and 6.5 mm at early pod filling stage gave significantly higher yield compared to the control (Table 1). However, since frequent irrigation requires high labour and time, irrigating once at vegetative stage is more economical and recommendable. Farmers, who have access to irrigation water from Megech River, used to irrigate chickpea twice at planting and vegetative stage. Hence, the result of this research, which is irrigating once at vegetative stage, is in a good conformity with farmers practice. Since the heavy clay soil holds adequate residual soil water until beginning of October, supplementary irrigation at planting is not necessary unless the farmers plant late in October and beyond.

Table 1. Effect of supplementary irrigation on the grain yield of chickpea on Vertisols at Dembia combined over years (2006 and 2008).

Treatment	Grain yield (t ha^{-1})	Yield increase (%)
Applying 13 mm at vegetative stage	1.14[a]	183
Applying 2 mm before planting & 11mm at flowering stage	1.02[a]	155
Applying 6.5 mm at vegetative stage & 6.5 mm at early pod filling stage	1.01[a]	152
Applying 13 mm at flowering stage	0.82[ab]	104
Applying 13 mm at early pod filling stage	0.94[ab]	134
Without supplementary irrigation (control)	0.40[b]	
CV (%)	46	

**Significantly different at probability level of 10%.*

The combined result showed that there was significance difference in water productivity between treatments (Table 2). The respective rainfall during the chickpea growing season was 176 and 107 mm in 2006 and 2008. The 2008 growing season rainfall was close to the last 20 years mean rainfall of 112 mm. Results showed that similar to the grain yield applying 13 mm at vegetative, applying 2 mm before planting and 11mm at flowering, and

applying 6.5 mm at vegetative and 6.5 mm early pod filling stage gave significantly higher water productivity compared to the control (Table 2).

The soil of the experimental field was deep black clay soil which forms wide cracks during dry season. Hence, irrigating early before the formation of cracks is very essential; otherwise the irrigated water could be lost through the deep and wide cracks. This was observed when irrigation was done late at flowering and pod filling stages. Similar to our result, the research conducted in India indicated that supplementary irrigation early during the vegetative growth stage and early pod filling stage on heavier and deep soils gave an increased yield (Sexenal, 1980). Supplemental irrigation to relieve the crop from moisture stress at critical growth stages has resulted in substantial yield increase in chickpea (Sexenal, 1980). Frequent low volume irrigation, in areas where temperature rise beyond the optimum during the development stage, has an advantage of lowering the soil and crop canopy temperature with favourable effect on nodulation and nitrogen fixation, and crop yield.

Table 2. Effect of supplementary irrigation on water productivity of chickpea on Vertisols at Dembia combined over years (2006 and 2008).

Treatment	Applied irrigation & rainfall water (m^3 ha^{-1}), 2006	Applied irrigation & rainfall water (m^3 ha^{-1}), 2008	Average water productivity (kg m^{-3})
Applying 13 mm at vegetative	1890	1200	0.73 ^{A}
Applying 2mm before planting and 11mm at flowering	1890	1200	0.71 ^{A}
Applying 6.5 mm at vegetative and 6.5 mm early pod filling stage	1890	1200	0.66 ^{A}
Applying 13 mm at flowering stage	1890	1200	0.51 ^{AB}
Applying 13 mm at early pod filling stage	1890	1200	0.62 ^{AB}
Without supplementary irrigation (control)	1760	1070	0.28 ^{B}
CV (%)			29

**Significantly different at probability level of 10%.*

Conclusion and Recommendations

Most farmers in Dembia plain grow chickpea on residual moisture after harvesting early maturing tef, barley or in a fallow land. Generally, they did not supplement irrigation water as they do not have access to irrigation water. However, due to the nature of Vertisols and plain topography draining excess soil water is a must for better rainfed crop production. Harvesting and reusing the drained water for double or supplementary irrigation is, therefore, considered to maximize the potential of Vertisol production.

Chickpea production in Dembia area requires 388 mm of water throughout the growing season. However, the mean rainfall in the growing season is 112 mm. However, both the residual soil water and rainfall could not meet the water requirement of chickpea. Therefore, supplemental irrigation is essential. Supplementary irrigation of chickpea showed significant difference on yield of chickpea compared to the usual un-supplemented chickpea production in the locality. Supplementing chickpea with 13 mm of water once at vegetative stage (nearly one month after planting) gave the highest yield. Hence it is advised that farmers in Dembia should use supplementary irrigation once at vegetative stage for maximum productivity of chickpea. Since we used fixed amount of irrigation it is not possible to show water yield production function, hence further research is required to accurately determine the amount of supplementary irrigation for maximum chickpea production in Dembia.

References

Leather, J.W. 1979. Water requirement of crops in India, India department of agriculture.

Sing, G. and Bhushan, L.S. 1979. Water use, water use efficiency and yield of dry land chickpea as influenced by P fertilization and stored water and crop season rainfall. Agricultural water management 2:299-305.

Sexenal, M.C. 1980. Recent advances in chickpea agronomy. Workshop on chickpea improvement, 28 Feb-2 Mar 1979, Hhydrabad, ICRISAT, Patencheru, India.