Investigation of Drainage Problems around Chacha Area, North Shewa

Yonas Girma[1], Gizaw Desta[1], Tegenu Ahagrie[1], Fantahun Abegaz[2]
[1]Debrebirhan Agricultural Research Center P.O.Box 112, Debrebirhan, Ethiopia
[2]Ethiopian Agricultural Research Institute

Abstract

Production is augmented by increasing cultivated area and/or increasing the productivity of a unit land. However, rising productivity of the existing cultivated land is the most feasible option since arable land can not be indefinitely increased. Often it is observed that some cultivated lands are not being cropped at pick production seasons due to various reasons. The Chacha area is among such places where waterlogging has impaired production in the main rainfall season for which the mechanism was not known. The case for Chacha irrigation schemes was investigated by studying the soil properties, monitoring the ground water fluctuations with the seasons and ground configuration. The soil in the irrigation scheme was primarily clay textured and black in color with water holding capacity moderately high to high, low infiltration and low hydraulic conductivities (3-12 mm per day). Piezometer observation proved there existed high ground water table levels starting late June to early November 2006 and during late April and early May 2007. Based on the study results, it is recommended that the natural drainage capacity of the river be enhanced, since waterlogging was brought about by lack of sufficient drainage, in order to cultivate the area during the rainy season.

Key words: electrical conductivity, soil pH, water logging

Introduction

Production is said to be augmented by increasing cultivated area and/or increasing the productivity of a unit land. Even so, cultivated land can not be indefinitely increased. As a result rising land productivity is the most feasible option. Productive soil and crop management contributes towards productivity of land. However, often it is observed that some lands are not being cultivated at pick production seasons. For example, large portions of land in North Shewan plateau are currently not cultivated during rainy season due to waterlogging. The Chacha area is among such places where waterlogging has impaired production in the main rainfall season. This study focuses on the newly built irrigation scheme which has a serious waterlogging problem. The scheme is mainly covered by Vertisols where soil drainage is a problem. Vertisols owe their specific properties to the dominance of swelling clay minerals. Dry Vertisols may have a high infiltration rate but, when wetted, they become almost impermeable. Crops need a well drained root zone for optimum growth and productivity. The main objective of agricultural land drainage is therefore to remove excess water in order to enhance crop growth and improve crop yields there by improve the profitability of farming the land. However, drainage requires prior investigation of the source and type of waterlogging problem.

Agricultural drainage systems are systems which make it easier for water to flow from the land, so that agriculture can benefit from subsequent reduced water levels. Agricultural land drainage has two criteria. 1) Agricultural drainage criteria defined as criteria specifying the highest permissible level of the water table on or in the soil so that agricultural benefits are not reduced by the problem of waterlogging. 2) Technical drainage criteria are criteria to minimize costs if installation and operation of the drainage system (R.J. Oosterrbaan 1994).

The importance of land drainage is substantiated whether waterlogging happens each year or is it only a problem in very wet years. Obviously if it is a regular problem, and lasts for many weeks, then it is more important to do something about it. In this regard the problem of waterlogging in Chacha area is a regular phenomenon. The other important concept in land drainage is whether there is a sufficient outlet.

This is probably one of the most important factors to be considered. In some areas where the land is relatively flat, there are insufficient main drains to take away excess water quickly. A further complication is that often these are not deep enough, which limits the ability of the farmer to drain land on his own property. If this is the problem then the only solution is for landholders to have group drainage schemes that enable sufficiently deep and large main drain systems to be dug over a large area, and which are properly maintained so that no harm is done to the environment. Therefore, this experiment was intiated with the objective of of dentifying the sources and extent of excess water that cause water logging in Chacha irrigation scheme so that drainage options could be considered.

Materials and methods

The Study area is located near Chacha town between $9^0$31'21" and $9^0$32'33" N and $39^0$27'9" and $39^0$28'57" E has an annual rainfall of 984 mm. Its maximum humidity reaches to 90 %. The topography is dominantly flat with a slope of 2%. There is a recently built irrigation scheme by Co-SEARAR facing waterlogging problem during the main rainy season. The design flood is about 90 lit/sec of 10 year return period (Co-SEARAR, 2002).Crop production commences after the recession of flood. This phenomenon has been the case for years. Currently, cultivation is performed once in a year in the irrigated areas as in the rain fed system.

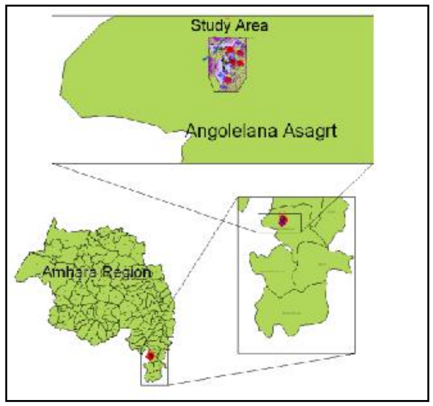

Figure 1. Chacha, the study area

Six profiles (see locations in figure 2) were opened within and around the scheme to see soil properties. Moreover, topographic investigations were performed to study the cause of waterlogging problem in Chacha area. Water tables react to the various recharge and discharge components that characterize a ground water system and is therefore constantly changing. Therefore, the highest and lowest water table heights, as well as the mean for the year are important in any drainage investigation. For this reason, water level measurements were taken at intervals of one week using PVC piezometer wells. The piezometers were installed by digging a hole using a 10 cm diameter auger until an impervious layer is reached or sufficiently deep to study the water table fluctuation. Then, a perforated 5 cm diameter PVC tubes were inserted filing the gap with coarse sand. The tubes were made to rise above the ground level to prevent surface water entrance. Finally, the mouth of each tube was cased in a metal pipe with screw opening to safeguard it from any mechanical damage by people or animals. The piezometers were situated in the plane containing the irrigation scheme in two rows one in a higher elevation and the second in a lower elevation along the river coarse.

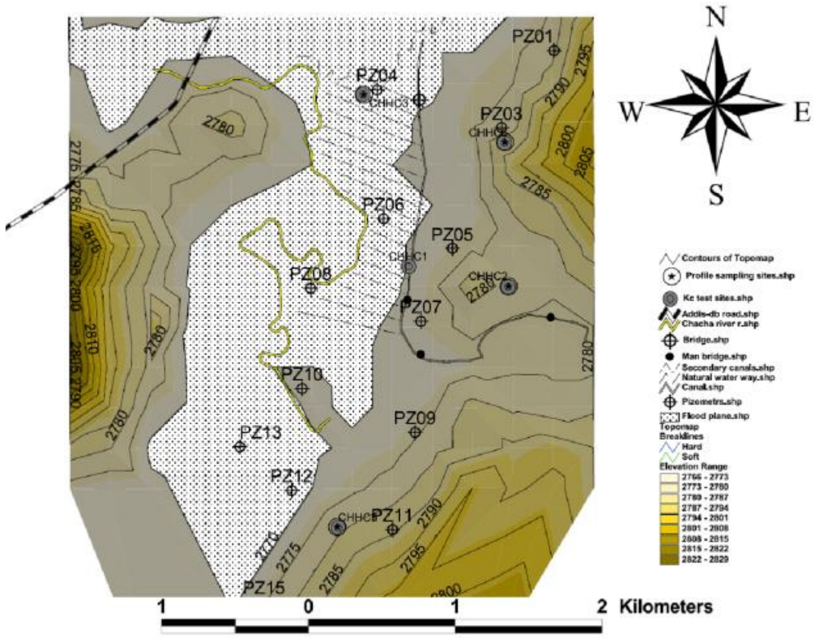

Figure 2. Details of the study area

An inverse auger-hole test was conducted to evaluate the hydraulic conductivity in the irrigation scheme and in the surrounding farms at different elevation and soil type. Five sites were selected in which the tests were performed. Hydraulic conductivity in a inverse auger hole method is given by Kh= 1.15r tan □ where Kh, r and tan □ are hydraulic conductivity, radius of auger hole and slope of time vs log (water level +r) graph.

Result and Discussion

The soil in the irrigation scheme was primarily clay textured and black in color. The water holding capacity is moderately high to high (180-240 mm/m) with low infiltration (Co-SEARAR, 2002). The soil reaction was in the near neutral to basic range (table 1). Hydraulic conductivities were found to be 3 cm day^{-}, 238.5 cm day^{-1}, 11.9 cm day^{-1}, 9 cm day^{-1} and 6 cm day^{-1} for tests 1, 2, 3, 4, and 5 respectively.

Tests 1, 3, 4, and 5 conducted with in the irrigation scheme were with values were less than 10 cm per day. These areas entertain a huge amount of water by the rain and flood. Test 2 however, which was conducted at higher elevation and different soil type was with high conductivity. This area represents the farms which are currently being cultivated in the rainy season.

Table 1. Soil properties by profile and depth.

Field No	Depth [cm]	pH 1:2.5	EC [dSm^{-1}]
Profile One	0-20	6.40	0.089
	20-50	6.84	0.055
	50-75	8.90	0.251
	75-140	7.88	0.172
	>140	9.10	0.333
Profile Two	0-20	6.44	0.035
	20-60	7.14	0.079
	60-80	6.93	0.165
	>80	7.84	0.084
Profile Three	0-15	5.58	0.155
	15-50	6.48	0.115
	50-95	8.13	0.063
	95-120	8.96	0.182
	>120	8.86	0.109
Profile Four	0-25	6.48	0.115
	25-47	6.48	0.056
	47-63	6.69	0.043
	63-98	6.88	0.058
	98-130	6.36	0.088
	>130	7.50	0.058
Profile Five	0-10	5.38	0.091
	10-50	6.24	0.045
	50-80	6.88	0.071
	80-130	7.48	0.189
	130-160	7.25	0.221
	>160	7.25	0.149
Profile Six	0-12	6.22	0.045
	12-60	6.95	0.063
	60-90	7.81	0.130
	90-110	9.01	0.190
	>110	9.04	0.178

Excess water may occur on the surface or deeper in the soil profile. These are manifested in the form of surface ponding often combined with waterlogging of the top soil or rootzone waterlogging due to impaired percolation or high water tables. Piezometer observation proved there existed high ground water table levels starting late June to early November 2006 and during late April and early May 2007. It is also depicted that some land was inundated during August to September.

For most perennial crops the root zone is said to be 1.5 m. Having this as a critical water table depth, crop production during March, April, early May, late June, July August, September, October and early November will face waterlogged condition. However, since the commonly produced crops are cereals and crop yields and water table depth relationship for clay soils minimum yield decrease is at a depth of 1 meter (Smedema and Rycroft, 1983), crop production is expected to be hampered mostly in July, August, September and early October. Lands which were submerged and with high water levels were with in the Chacha irrigation project area. It is evident from the observation that it was difficult to cultivate the farms with in the above stated times with out proper drainage system installed.

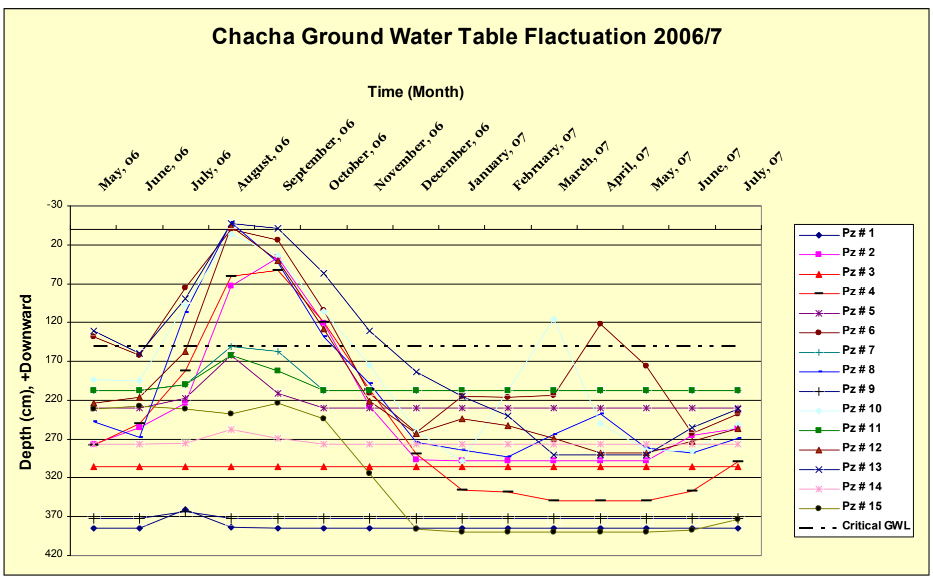

Figure 3. Water table fluctuation in the 15 piezometers

The Chacha irrigation project was established in the flood plane of Chacha river basin around Chacha town. The river Chacha originates in the eastern high lands of the wereda, Megezez area. It also drains the flood plane of the nearby plateau. There are reports of frequent flooding in Chacha town. The rainfall amount in the experimental year was relatively lower than the previous years. In the rainy season the plane is often flooded as a result the scheme is submerged. As seen in fig 1, the scheme has similar elevation as its surrounding and the down stream of the river. This makes draining the water very difficult. Hence, it could be easily seen that utilization of the scheme in the rainy season is still difficult even with the presence of drainage system.

In the light of the experiment results, the cause of waterlogging in the scheme is believed to be attributed to high water tables caused by floods coming from the upper lying lands. Poor drainage system of the area as a whole and due to topographic condition, the rainwater cannot smoothly discharge, and the accumulated runoff remains stagnant in low laying retention areas and surrounding the river thereby creating severe waterlogging problem.

The reason of long lasting waterlogging situation in the area is owing to inadequate drainage capacity of the river, meaning lack of enough inlets to the receiving water bodies and natural drains helped in creating drainage congestion. Waterlogged pastures over winter and early spring are a common sight on many farms in high rainfall areas.

The Chacha river water has a good quality for irrigation in terms of its electric conductivity.

Conclusion and Recommendation

In conclusion, the Chacha irrigation area was characterized by black heavy clay soil which was regularly inundated during the main rainy season. The area has low hydraulic conductivity and infiltration capacity. It is situated on a flat flood pain drained by the river Chacha. It had water tables above and close to the surface during March, April, early May, late June, July August, September, October and early November. Cultivation was practiced after the rains when the natural drains reduce the water table.

Based on the study results, it is recommended that the natural drainage capacity of the river be enhanced, since waterlogging was brought about by lack of sufficient drainage, in order to cultivate the area during the rainy season. The enhancement must concentrate on the receiving water bodies or ways found to the west of the town. However, it may require huge investment. Without this, surface or subsurface drainage could not result in making the area produce more than it is currently doing. Therefore, the current production system should prevail taking note of the expected flood and waterlogging period.

References

Co-SEARAR, 2002. Design report on irrigation infrastructure of Chacha diversion irrigation project.

Ridder, de N.A., 1994. Groundwater Investigations. In: H.P. Ritzema (ed). Drainage Principles and Applications. 2nd edition. ILRI Publication 16.

Oosterrbaan R.J., 1994. Agricultural Drainage Driteria. In: H.P. Ritzema (ed). Drainage Principles and Applications. 2nd edition. ILRI Publication 16.

Smedema, L.K., and D.W. Rycroft 1983.Land Drainage: Planing and Design of Agricultural Drainage Systems. Batsford, London.