On-farm evaluation of Vertisol management techniques at Bichena district in East Gojjam

Berihun Dubale[1£], Anteneh Abewa[1], Tadele Amare[1], Menelek Getaneh[1] and Birru Yitaferu[2]

[£]Email: berihun2010@gmail.com

[1]Adet Agricultural Research Centre, P.O. Box 08, Bahir Dar, Ethiopia

[2]Amhara Region Agricultural Research Institute, P.O. Box 527, Bahir Dar, Ethiopia

Abstract

In Ethiopia where little land is available for extensive crop production, intensifying production on the already available cultivated land becomes a necessity in order to feed the expanding population. One such way in which this could be achieved is proper management of Vertisols, whose potential has not yet been fully exploited for the main reasons of poor workability and poor drainage. There is tremendous possibility to increase the productivity of these soils through efficient management in combination with appropriate use of fertilizer and improved varieties. This study was undertaken to evaluate selected Vertisol management techniques (broad bed and furrow (BBF), ridge and furrow (RF), surface drainage ditches (SDD) and flat seedbed (FSB)) to select the best technique for scale-up in Northwestern Ethiopia. The trial was conducted in 2006 and 2007 involving two wheat crops (bread wheat and durum wheat). Results showed that the effects of Vertisol management techniques were crop and season dependent. In the 2006 cropping season, bread wheat responded positively to different Vertisol management techniques, though yield differences that warrant statistically significant differences were obtained only for BBF and RF when compared to SDD and FSB. In the 2007 cropping season, yield differences of bread wheat due to differences in methods of seedbed preparation were not significant. The results on durum wheat showed significant differences among drainage techniques for both 2006 and 2007 seasons. Performance of drainage techniques should, therefore, depend on both crop type and season. Durum wheat fields always need drained seed bed regardless of seasonal differences, whereas bread wheat fields should be drained depending upon the severity of water logging anticipated.

Key words: Drainage methods, Vertisols.

Introduction

Vertisols are among the most abundant soil orders in Ethiopia, occupying 12.7 million hectares of land and having extensive area coverage in the central highlands of Ethiopia (Astatke and Mohammed, 2001). They have high natural fertility, high water holding capacity and responds well to many of the crop requirements. Their abundance along with their good inherent fertility make these soils very important in the sense that they possess great potential for increasing production if properly managed to tackle the problems of water logging and poor workability. Vertisols have long been put into productive use in Ethiopia and the land use system ranges from cereal production (barley, wheat, tef) through pulse production (faba bean, field pea, lentil, chickpea) to extensive grazing (Syers *et al*., 2001). In the central highlands crops such as tef, barley, wheat, faba bean, field pea, chickpea, lentil, noug (*Guizotia abyssinica*) and linseed are often produced on Vertisols under drained conditions and on relatively better drained sites (Hailu and Asgellel, 1990).

The most widely practiced systems of Vertisol management in the central highlands include the construction of drainage system with the local '*maresha'* of narrow ridges and furrows at sowing called *'shurube'* and shallow drainage furrows at varying distances across the contour to achieve good drainage (Hailu and Asgellel, 1990). Another technique of achieving good drainage practiced by farmers of Enewari area in North Shewa is called *'lebesoshi'* where they use their hands to make broad beds and furrows (BBF) to protect crops from water logging in the rooting zone (Hailu and Asgellel, 1990). In order to relieve women of the painful drudgery making beds and furrows by hand, ILCA developed the low-cost oxen-drawn broad bed and furrow maker (BBM), which has been adopted by some 300 000 peasants in the central highlands (Paulos *et al*., 2001). At higher elevations of the central highlands exceeding 2400 m a.s.l., soil burning is practiced extensively in which case the clay fractions in the surface horizon bake into sand sized particles facilitating infiltration and improving drainage. Still another technique is the use of residual soil moisture for crop production in the late rainy season called '*amegn*'.

There is ample evidence that substantial increase in crop yield can be achieved on Vertisols if excess surface soil water is drained off and appropriate cropping and soil fertility practice is employed. For instance, research conducted at Sheno and Ginchi in the central highlands of the country indicated that yield of crop can be increased by using improved drainage methods, mainly camber beds 6-8m wide and Nitrogen and Phosphorus fertilizer application (Hailu and Asgellel, 1990). Still another experiment conducted at Sheno to drain excess soil water by using parallel surface drainage ditches of different spacing (3, 6, 9, 12, and 15 meters) showed that increased mean yields were obtained from spacing of drainage ditches at intervals of 3m and 6m, respectively (Hailu and Asgellel, 1990).

Since Vertisols are known to vary widely in their physical and chemical behaviour, they require specific type of soil and water management strategies suited not only to the climate, but also to the type of farming or natural resource use, the terrain and the prevailing socio-economic conditions (Syers *et al*., 2001). Several studies have so far been conducted on Vertisols in Ethiopia but have all been carried out in the central highlands and almost little or no study, related to the management techniques that best fit the prevailing physical and socio-economic environment, has been conducted in the Northwestern part of the country despite an appreciably high area coverage of Vertisols in the region. It has been tried to introduce the BBF system; but the uptake of the technology by farmers is found to be very low. This study was, therefore, conducted in order to carry out on-farm evaluation of different Vertisol management techniques that are generally referred to have showed promising performances by different researches.

Materials and methods

The study area

The study site is located in Northwestern Ethiopia in East Gojjam at Bichena district, at about 10.470 N latitude and 38.230 E longitude and at an altitude of 2560 m above sea level. The site receives 1174.1 mm of annual rainfall on uni-modal basis that is distributed uniformly over the growing season (May to October) and peaks in July (Table 1). The physiography of the site is dominated by plains where about 85% of the soils are Vertisols. Major crops grown include tef, chickpea, wheat, and grass pea where tef and wheat are main season crops on relatively drained sites and chickpea and grass pea are crops grown on residual moisture after the main rainy season is over. There is generally low level of arable farming at the site mainly due to Vertisol related management problems.

Table 1. Monthly rainfall data (mm) of study site during the study period.

Month	Year	
	2006	2007
January	0.1	0.0
February	3.0	0.0
March	49.4	31.5
April	76.0	20.4
May	94.0	122.4
June	142.5	171.5
July	410.9	272.5
August	94.4	242.0
September	154.5	144.0
October	6.5	0.0
November	4.5	0.0
December	0.0	0.0
Sum	1035.8	1004.3

Experimental setup

Four Vertisol management techniques (Broad Beds and Furrows (BBF), Ridges and Furrows (RF), Surface Drainage Ditches (SDD), and Flat Seed Beds (FSB)) were evaluated in RCBD with three replications. BBF refers to 80 cm wide beds separated by 30 cm wide furrows, RF refers to 60 cm wide ridges and 30 cm wide furrows, SDD refers to 30 cm wide surface drainage ditches at 3m intervals, FSB refers where no furrow or ditch was constructed. Variety HAR1685 of bread wheat and DZ2023 of durum wheat were used for the study.

Results and discussion

Mean values for nearly all measured agronomic parameters of the first season (2006) showed that there exist significant differences among drainage techniques for both durum and bread wheat varieties. However, in 2007, results showed non-significant differences for bread wheat while the differences were significant for durum wheat.

Bread wheat

In the 2006 cropping season significantly higher grain yields were recorded for BBF and RF with yield advantages of 0.67 and 0.65 tons ha^{-1} over SDD and 0.74 and 0.72 tons ha^{-1} over FSB, respectively (Table 2). This could be due to the improved drainage in these beds. A similar study in Delanta Dawunt, North Wello, revealed that BBF with 100 cm bed width gave 51.4% yield advantage over the un-drained plots (Fassil and Eyebru, 2008).

In the 2007 cropping season significant differences between treatments were not observed (Table 2). This is explained by differences in rainfall amount and distribution observed during the study period (Table 1). In 2006, total annual rainfall amount received was 1035.8 mm with 410.9 mm of which was received in July during which planting took place. As a result, severe water logging that occurred in this month affected seed germination and consequently crop yield. In contrast, 2007 received 1004.3 mm of annual rainfall with 272.5 mm of which was received in July. This is considerably lower (by about 34%) than the preceding season. Therefore, the water logging effect in the second season was not strong enough to bring about treatment differences.

Table 2. Effect of Vertisol management techniques on the grain yield of bread wheat at Bichena in 2006 and 2007.

Treatment	Grain yield (t ha^{-1}) in 2006	Yield advantage (%)	Grain yield (tons ha^{-1}) in 2007	Yield advantage (%)
BBF	4.09^{a*}	22.46	2.37	---
RF	4.07^{a}	21.86	2.69	---
SDD	3.42^{b}	2.40	3.13	---
FSB	3.34^{b}	---	3.74	---
CV (%)	7.6		17.03	

**Means followed by the same letters are not significantly different at p≤0.05.*

Durum wheat

In the 2006 season all drainage techniques gave significantly higher grain yield over the FSB, but there were no significant differences between them (Table 3). In 2007 significant differences between treatments were observed where BBF and RF gave significantly higher yields, but were not significantly different from FSB. This explains that durum wheat is more sensitive to water logging than bread wheat.

Table 3. Effect of Vertisol management techniques on the grain yield of durum wheat at Bichena in 2006 and 2007.

Treatment	Grain yield (tons ha^{-1}) in 2006	Yield advantage (%)	Grain yield (tons ha^{-1}) in 2007	Yield advantage (%)
BBF	4.57a	27.30	3.80^{a}	40.22
RF	4.65a	29.53	2.66ab	---
SDD	4.38a	22.00	1.54b	---
FSB	3.59b	---	2.71ab	---
CV (%)	9.02		24.61	

**Means followed by the same letters are not significantly different at $p \leq 0.05$.*

Conclusion and Recommendations

In general, in this study, raised beds showed better performance and relatively higher yield than the flat seedbeds. Since crop performance was visually observable from crop stand, farmers also showed appreciation and interest to these management techniques. In 2006, BBF showed 0.74 tons ha^{-1} and 0.98 tons ha^{-1} yield advantages over the flat seedbed for bread wheat and durum wheat, respectively. In 2007, BBF gave yield advantage over other methods for durum wheat, even though differences remained non-significant for bread wheat.

BBF was identified to be best Vertisol management technique followed by RF and SDD. However, the response was dependent upon season and crop type. The rainfall in July 2006 was heavier than in 2007. Consequently, water logging was severe in 2006 and both crops responded significantly to drainage methods. However, in 2007 only durum wheat showed significant differences among drainage techniques, which is an indication that both crops are not equally sensitive to water logging. Durum wheat should always be provided with drainage methods regardless of seasonal differences to be more sensitive than bread wheat to water logging. Drainage requirements are, therefore, dependent upon crop type and the season.

References

Abiye A. and Mohammed, J. 2001. Low-cost animal-drawn implements for Verisol management and strategies for land use intensification. In: The Sustainable Management of Vertisols. International Water Management Institute (IWMI), Thailand. Pp. 189-201.

Fassil Kebede and Eyebru Bekelle. 2008. Tillage Effect on Soil Moisture Storage and Wheat Yield on the Vertisols of North Central Highlands of Ethiopia. Ethiopian Journal of Environmental Studies and Management Vol.1 No.2 ------pp.

Hailu Regassa and Asgellil Dibabe. 1990. Properties and management of Vertisols in the Central Zone of Ethiopia. In: The Proceedings of the Second Natural Resources Conservation Conference. 10-13 May 1990. Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia. Pp. 26-33.

Paulos, D., Asgelil, D., Asfaw, Z., Gezahege, A. and Abebe, K. 2001. Advances in Vertisol management in Ethiopian highlands. Proceedings of The International Symposium on Vertisol Management. 28 November to 1 December 2000. Ethiopian Agricultural Research Organization (EARO), Debre Zeit, Ethiopia.

Syers, J.K., First, W.T., Peningde, V. and Phibion, N. 2001. The sustainable management of Vertisol. International Water Management Institute (IWMI), Thailand.