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On Farm Participatory Evaluation and Demonstration of Vertisol Management Structures under Mechanized Farm in Adaba District, Southeastern Ethiopia

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ABSTRACT

The field experiment was conducted in 2015-2017 for two consecutive years to investigate the effects of different drainage systems on yield of bread wheat on the waterlogged Vertisols. The demonstration of this research was conducted with Mechanized farm at Hunte Oromia seed enterprise farm. The raised camber bed and flatbed was evaluated using Bread wheat as test crop. Camber beds were formed to make a raised profile of 4.8 m wide and 0.3 cm high from the furrow to the top of the bed and the flat bed was carried out with tractor drawn machine. The result revealed that bread wheat grown on improved drainage techniques under camber bed had better yield advantage as compared to farmers' practices (Flatbed). The highest biomass yield of 8 t ha^{-1}which is 60% higher over the farmers practice (flatbed) was recorded and the highest grain yield of 6.2 t ha^{-1} which is 55% higher over the famers' practice was obtained. In addition, farmers preference toward the technology was indicated that camber bed vertisol drainage system was selected on the bases of its yield advantage and their performance. Therefore, Camber bed land drainage technologies was recommended for further scaling up in mitigating drainage problem in Vertisol and reduce waterlogging at Adaba district and similar condition for production of bread wheat.

Keywords: Camber Bed; Bread; Wheat; Drainage; Yield; Vertisol; Farmers; Waterlogging; Flatbed; Scaling Up; Grain.

1. Introduction

Vertisols are characterized by their extensive cracking from the surface to depths of 50 cm or more with seasonal drying and also gilgai microrelief or subsoils showing slicker-sides or spheroid structures as evidence of seasonal expansion and contraction (Probert et al, 1987). These soils generally have a weak horizon differentiation. These soils are distributed around the 45°N latitudes, mainly in the tropical and subtropical areas of the world. Driessen & Dudal (1989) report an estimated 311 million ha of Vertisols or 2.4% of the global land area. Vertisols occupy about 105 million ha in Africa (Blokhuis, 1982) and about 12.6 million ha in Ethiopia. Vertisols are amongst the most common, high-potential soils in the highlands of Ethiopia, where over 88% of human and 77% of livestock are located (Erkossa, et al. 2005). However, the potential of these soils is not well exploited because of its heavy workability during dry season and high waterlogging condition during the main rainy season.

Farmers residing in Vertisols dominated areas have realized the adverse effects of waterlogging on crop productivity and have developed some traditional methods for overcoming the problem. Their strategy to utilize Vertisols has always been to plant late in the wet season, which means harvesting a single crop and leaving the land under-utilized or idle (Tedla et al., 1993). Generally, the traditional management of Vertisols in the Ethiopian highlands varies from place to place depending on the amount and duration of rainfall, extent of drainage problems, soil fertility and slope and farm size (Berhanu, 1985; Mesfin, 1998). Waterlogging resulted in poor aeration, lower soil microbial activities, loss and unavailability of plant nutrients and poor workability (Trough & Drew, 1982). Thus, these soils are vastly underutilized due to management difficulties using traditional cultivation practices (Mesfine, 1998).

During 2015-2017 as were evaluate (Cumber Bed, Broad Bed Furrow) variety and Agarfa districts of Bale Zone, Southeastern Ethiopia. The results revealed that the highest grain yield of 5.8 t ha^{-1} which is 45% higher over the famers' practice was obtained when the bread wheat was grown using Camber Bed (Negash et al., 2017). Among the technology evaluated for Vertisol drainage management, Cumber bed drainage system (i.e., constructed with 4.8 m wide and 0.3 m high in dimension) has successfully increased crop yields as compared with farmers' practice (flat beds). Though Camber bed drainage system is suitable for mechanized farming (i.e., can be constructed using tractor mounted implements); the evaluation done so far was conducted manually using man power. Therefore, pre-extension demonstration of the Camber bed drainage technology which was constructed with tractor drown implements (ditcher) was done so as to popularize the drainage technology for Vertisol drainage management system at Hunte (Oromia seed enterprise farm) in Adaba district, Southeastern Ethiopia.

1.1. Study Objectives

The general objective of the study was to evaluate and demonstrate the effectiveness of different Vertisol management structures under mechanized farming conditions through on-farm participatory approaches in Adaba district, Southeastern Ethiopia. The specific objective of this research was: (1) To evaluate the effect of Camber bed drainage method on yield and yield components of bread wheat, (2) To generate recommendations and best practices for effective Vertisol management in similar agro-ecological zones, and (3) To build farmers' capacity and awareness through field demonstrations and participatory learning methods.

2. Methodology

2.1. Description of the Study Area

The study was conducted at Hunte (Oromia Seed enterprise farm) found at Adaba district of Southeastern Ethiopia. Based on Agro-climatic condition the area has three seasons, a short rainy season that extends from March to June, a long rainy season extending from July to October and a dry season that extends from November to February (NMA, 2010). On average, the annual rainfall in Adaba district is 913 mm. Temperatures in the high plain range between 10 and 30 degrees Celsius with an average of about 15 degrees. With increasing altitude, the climate gets colder and wetter.

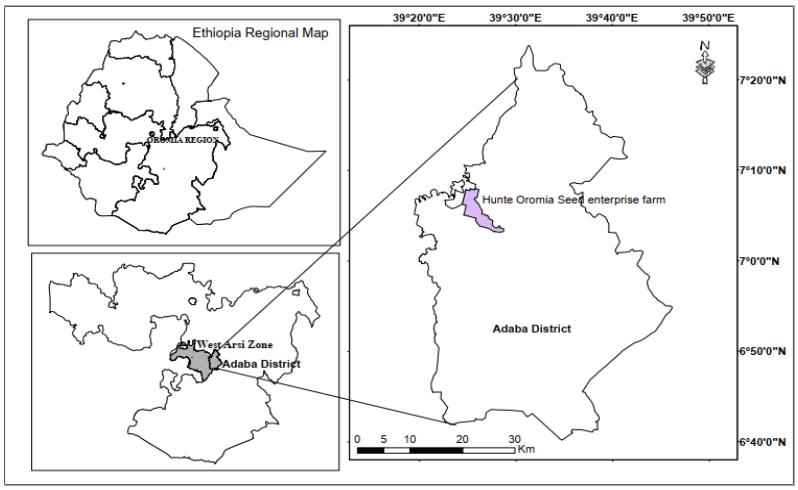

Figure 1. Map of the study Area

2.2. Land Preparation

Pre-extension demonstration of the technology was conducted at Hunte, Oromia Seed-Enterprise farm (replicated over two farm) for one year. A bread wheat Ogolcho variety were planted on camber bed land form and flatbed with equal area of 2500 m^2 (1/4ha) for both. Camber beds was formed to make a raised profile 4.8m wide and 0.3cm high from the furrow to the top of the bed. This was performed by adjusting tractor drown machine so called ditcher during land preparation. Also, farmers' practice land preparation was carried out with tractor drown machine. The recommended Seed rate used was 150kg/h and the recommended fertilizer rates used were 45 N kg/h and 20 P kg/h. Initial land preparation, crop management factors was the same for both seed bed methods.

Figure 2. Land preparation to form Camber Bed with tractor mounted implement

2.3. Farmers and Site Selection

Two farms one kilometer apart at Hunte (Oromia Seed-enterprise farm) were purposively selected based on severity of water-logging (typical Vertisol soil) adjacent to farmers field which are suitable for experience sharing for farmers. A total of sixty (60) farmers were selected for evaluation based on their interest towards technologies, those who have waterlogging problem in their farm. Technology evaluation by farmers was carried out from land preparation up to harvesting of the crop.

3. Data Collection Method

Effectiveness of the technology and farmers preference toward the technology were collected through supervision and organizing mini field day. Farmers' and experts' opinion was collected at the time of field visit. To collect their real feeling and opinion, group discussion was undertaken and checklist was used for interviewing. Finally, the collected data (quantitative data) was analyzed by using descriptive statistics mean and standard deviation.

Figure 3. Demonstration of Camber bed Vertisol drainage technology at Adaba district

4. Result and Discussion

4.1. Yield and yield component analysis

Effect of the technology on grain yield and yield components of bread wheat in the waterlogged Vertisol of Adaba is indicated in Table 1. As indicated in the Table there were mean yield and mean yield component differences between farmer practice and camber bed drainage systems. Accordingly, plants grown on camber beds had the highest Plant height (PH), number of seeds per spike (NSPS), spike length (SL), number of tiller (NT), above-ground biomass (BM) and grain yields (GY) and plant population per an area of 1 m^2 (Table 1).

Table 1. Average yield and yield component of cumber bed and farmer practice

Treatments	PH (cm)	SL (cm)	NSPS	NT	BM (t ha^{-1})	GY (t ha^{-1})	Plant/m^2
Camber bed	105	8.9	49.2	4	8	6.2	532
Farmer practice	86	6.4	33.5	2	5	4.0	380
Difference/advantage					**3 (60%)**	**2.2 (55%)**	

Generally, bread wheat grown on improved drainage techniques camber bed had better yield advantage as compared to farmers' practices. That means farmers' practices had the lowest yield and yield components, which is due to water logging effect on crop performance.

The highest bread wheat biomass yield of 8 t ha^{-1} which is 60% higher over the farmers' practice (flatbed), was recorded under camber bed planting methods. Similarly, the highest grain yield of 6.2 t ha^{-1} which is 55% higher over the famers' practice was obtained when the bread wheat was grown using camber bed land management. The application of raised camber bed practices gave significantly higher values of plant height, spike length, number of tiller and spike length over farmer practice (Table 1).

4.2. Farmers preference of the technology

Mini-field day was organized to collect the preference of the technology by the farmers and other stakeholders at the end of the season. Accordingly, a total of 60 (46 male, 14 female) participants consisting of farmers, extension

agents, experts and researchers were participated on the field day event. Yield advantage, crop performance and drainage condition were criteria's set by participants to aid selection process of the best technology. The feedback of the field day participants toward the technology are as indicated in Table 2.

Table 2. Participants Feedback (N=60)

Seedbed Methods	Cost effectiveness of the technology		Improved soil drainage condition		Crop performance		Yield advantage	
	N	%	N	%	N	%	N	%
Cumber Bed	35	41.7	50	83.3	52	86.7	55	91.7
Flat Bed (farmer practice)	25	58.3	10	16.7	8	13.3	5	8

From farmer's feedback assessment, it is revealed that the yield of wheat crop planted on camber bed is much advantageous than flatbed. Farmers' were also reported that Camber bed enhances good soil drainage condition and better crop performance. Even though the cost effectiveness of the Flat bed is higher, farmers prefer Cumber bed because of the problem of water logging. Generally, 90% of the participants were selected raised camber bed as Vertisol drainage management technology options.

5. Conclusion

Pre-extension demonstration of camber bed technology Vertisol management was conducted in Adaba district of West Arsi zone with the objectives of evaluating the technology and creates linkage & awareness for bread wheat crop production. The result of the study revealed that camber bed land form have showed advantage over others farmer practice in terms of its yield and yield component as compared to flatbed. In addition, feedback from farmers during field day point out that camber bed technology was selected in terms of good soil drainage, better crop performance and cost effectiveness. Therefore, camber bed Vertisol drainage were recommend for further scale up/out for Adaba district and other similar agro-ecologies. Therefore, agricultural development office, research organization, NGOs, private sector and other organization will promote and disseminate to end user so as to boost bread wheat production and productivity where there is poor soil drainage and waterlogging are problem.

6. Recommendations

1) Scale up the camber bed drainage technology across other Vertisol-dominated and waterlogging-prone areas in Adaba district and similar agro-ecologies to improve bread wheat productivity under mechanized farming systems.

2) Promote farmer training and awareness programs to enhance the adoption of camber bed drainage systems by demonstrating their benefits in yield improvement, especially through participatory field days and experience-sharing platforms.

3) Conduct long-term evaluations of camber bed systems under different crop rotations and seasonal variability to assess sustainability, soil health impact, and economic returns over time.

4) Explore integration with other soil and water management practices, such as conservation tillage or controlled traffic farming, to further enhance efficiency under mechanized conditions.

5) Facilitate policy support and incentives to encourage mechanized Vertisol management technologies through government and development programs, especially for scaling in areas with poor drainage and high agricultural potential.

Declarations

Source of Funding

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Competing Interests Statement

The authors declare that they have no conflict of interest.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

Both the authors took part in literature review, analysis, and manuscript writing equally.

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