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Approaches of Agroforestry Management in the Central Ethiopia

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Abstract: Life of the people in the central rift valley areas of Ethiopia depends on mixed agriculture with main focus of livestock followed by crop production. Overexploitation such as overgrazing and deforestation for fuel wood harvesting and crop production resulted in significant degradation of natural resources in the region. A farmer research group (FRG) has initiated to disseminate the agroforestry in the region for conservation and remediation of the natural resources. As the first step to establish an appropriate management system of the agroforestry suitable for the regional climate and social condition, it is required to collect practical information concerning selection of tree species and determination of planting density. In the current study, a trial site of the agroforestry was set up in the region, survival rate of trees integrated was examined, and the effect of agroforestry on micro meteorology was observed. *Acacia salicina* showed the highest survival rate, and it is revealed that the agroforestry at the trial site had a potential to mitigate evaporation and extreme increasing of temperature. The FRG organized in the current study has enhanced the farmers' capacity to utilize their inherent experience for innovative actions in the agroforestry management. Through those participatory approaches of farmers, strategies for sustainable production system of the agroforestry will be developed.

Keywords: Agroforestry, Ethiopia, Micro meteorology, Participatory approaches of farmers, Rift valley area

1. Introduction

Central rift valley areas in Ethiopia is classified as semi-arid with annual rainfall ranging from 500 to 700 mm, high temperature, high wind speed, and less biodiversity, while the life of the people depends on mixed agriculture with main focus of livestock followed by crop production. Natural resource in the area is scarce and fragile. Therefore, overexploitation such as overgrazing, deforestation, and subsequent soil erosion is a major cause for the deprived condition resulting in the livelihood of rural people being significantly affected (IIRR, 2002). In Ethiopia, wood harvesting exceeds the replanting which leads to the decline of forest resource (Ethiopia Forestry Strategy, 2001). The forest coverage in Ethiopia was 40 % in 1900's, dropped down to 16 % in 1950's and only 2 – 3 % in 1990's. In Oromia state, one of the states of Ethiopia which dominantly covers the central rift valley area, 60 to 100 thousand ha of forest are depleted every year for fire wood, charcoal and land clearance for crop production thus affecting the soil surface vegetation and the whole ecosystem in the area (EFAP, 1994). Therefore, it is suggested that combining crop production with tree planting (i.e. agroforestry) would result in an effective measure for conservation and remediation of the natural resources. In order to solve these problems we have organized a farmer research group (FRG) and initiated to disseminate the agroforestry in the region. However, appropriate management system of the agroforestry suitable for the regional climate and social condition has not been established due to lack of practical information. In the current study our approaches in the agroforestry management, particularly addressing to planting trees, are discussed based on physical environment observation.

2. Material and Method

The study site is located in the central rift valley of the Oromia state (7˚49'N and 38˚42'E). The mean annual rainfall, mean annual maximum temperature, and mean annual minimum temperature in the area over the past 20 years were 704 mm, 27.8 ˚C, and 13.4 ˚C, respectively. Soil type of the site is loamy

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sand. The site was under repeated maize cultivation before the study. In 2005, around 180 seedlings were randomly transplanted in 18.8 m × 15.8 m area with 1 m spacing after planting holes with 30 cm diameter and 60 cm depth were made. Major tree species established was *Acacia salicina* (40 %) followed by *Casuarina equisetifolia* (25 %), *Azadirachta indica* (22 %), and *Grevillea robusta* (13 %). Those species were selected after observational evaluation made on farmers' agricultural land to assess their contribution and adaptability to the agroforestry. Trees were aligned east to west to allow sunlight for the crops. Supplemental irrigation was undertaken when required.

Survival rate was observed for each species in June 2006. Both inside and outside the agroforestry, air temperature, relative humidity, solar radiation, and albedo were recorded in the dry season (December, 2007) and rainy season (August-September, 2008) in order to quantify differences in the environment between inside and outside agroforestry and to assess the effect of the agroforestry on micro-meteorology. The air temperature and relative humidity sensor used was TR-3110 (T&D Co., Japan) and the data was recorded by a data logger (TR-72U, T&D Co., Japan) and installed at a height of 1.5 m with a solar radiation sealed. Solar radiation and albedo were measured using the pyranometer with the light meter (LI-200SA and LI-250A, LI-COR, USA).

3. Results and Discussion

The highest survival rate was observed for *Acacia salicina* (91.5 %), followed by *Azadirachta indica* (87.5 %), *Casuarina equisetifolia* (86.4 %), and *Grevillea robusta* (83.3 %) (**Table 1**). Major reason of variability in the observed survival rate between species is suggested to be differences in drought tolerance of the species.

Table 1. Survival rate of tree species established in the central rift valley, Ethiopia.

Name of species	Number of planted (trees)	Number of dead trees (trees)	Survival rate (%)
Acacia salicina	71	6	91.5
Casuarina equisetifolia	44	6	86.4
Azadirachta indica	40	4	87.5
Grevillea robusta	24	4	83.3

Table 2. The effect of agroforestry established in the central rift valley on receiving and reflecting solar radiation.

		Radiation W/m^2	Reflection W/m^2	Albedo
Dry season (14:00-15:30 Dec. 10, 2007)	Inside	325	64	0.25
	Outside	717	152	0.21
Rainy season (15:10-15:35 Sep. 1, 2008)	Inside	332	84	0.29
	Outside	801	162	0.20

The solar radiation inside the agroforestry was less than a half of that observed outside, indicating that around 41 to 45 % of the solar radiation reached inside the agroforestry (**Table 2**). In contrast with this, relatively larger albedo was observed inside of the agroforestry in both dry and rainy season compared to the outside resulting in reduced ground temperature and, in particular, evaporation from soil surface.

In dry season (December, 2007), extremely high temperature (up to 35 ˚C) and low relative humidity

(down to 3 %) were recorded outside the agroforestry at the daytime, while moderate temperature (up to 27 ˚C) and humidity (down to 10 %) observed inside (**Fig. 1**). Contrasting this, air temperature outside the agroforestry decreased below 10 ˚C at night-time, while it was warmer inside the agroforestry (Fig. 1). Differences in the temperature during the daytime were due to differences in the amount of solar radiation between the inside and the outside (Table 2), and it is suggested that the canopy of trees reduced long wave radiation from the ground to the atmosphere during night-time.

In the rainy season (August, 2008), daily maximum air temperature observed in the agroforestry was lower by around 27 ˚C than that observed at outside the agroforestry, while there was less difference in the daily minimum air temperature between outside and inside the agroforestry (**Fig. 2**). Although the daily maximum temperature of outside in dry season is higher than that in rainy season, daily mean temperature in dry season is lower than that in rainy season due to decreased daily minimum temperature. It is of note that only slight differences in the daily mean air temperature were observed at inside the agroforestry between the dry and rainy seasons.

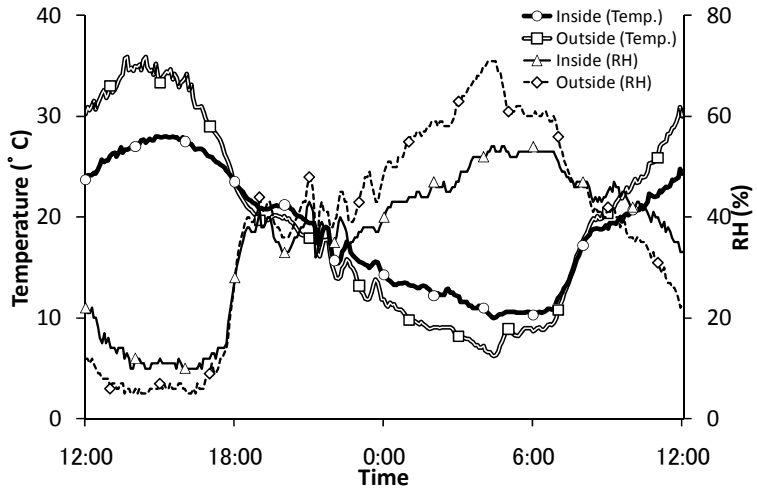

Fig. 1. Comparison of changes in air temperature and relative humidity (RH) between inside and outside the agroforestry observed on December 14-15, 2007.

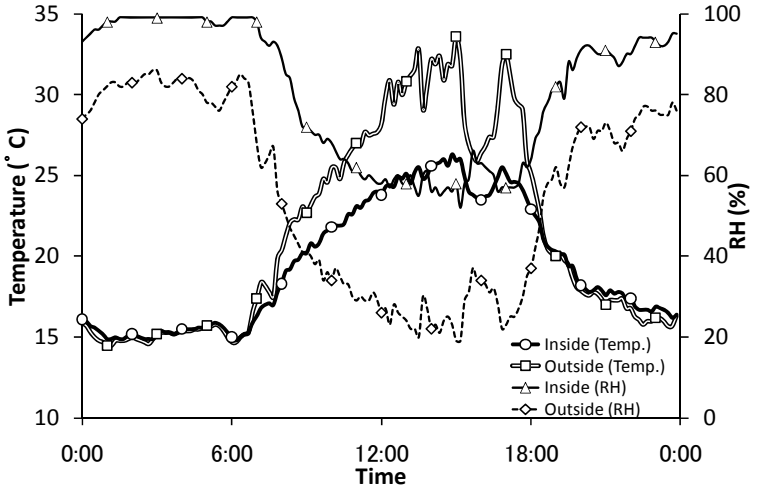

Fig. 2. Comparison of changes in air temperature and relative humidity (RH) between inside and outside the agroforestry observed on August 30, 2008.

However, there is a concern that the amount of solar radiation inside the agroforestry would be insufficient for crop production due to high planting density.

4. Conclusions

In the central rift valley area, farmers had depended only on natural vegetation or commercial fuel wood and charcoal for domestic consumption. It is widely acknowledged that bringing about the process and conditions that enable agroforestry technology to be productively used by the poor is extremely difficult in developing countries like Ethiopia, where limited and ever shrinking land resource is ongoing by human population growth. Even in such difficulties however, there seems a tiny pocket of success from which we can derive lessons. For instance, the farmer's research group (FRG) we organized in the study has enhanced the farmers' capacity to utilize their inherent experience for innovative actions in the agroforestry management. Agroforestry is new experience for the farmers and by this work they will find its benefit through the practices. Indeed, there were wide agroforestry advantages investigated in the current study that calls our attention to plant trees. In the current study, it is revealed that the agroforestry at the trial site had a potential to mitigate evaporation and extreme increasing of temperature. The results from the current study will be used for determination of an adequate planting density. Other benefit of the agroforestry is expected to be increasing soil organic matter resulting from the biomass, low competition of fertilizer extraction between trees and crops, and high quality building materials due to upright growth of trees. Establishment of the agroforestry in the central rift valley could also potentially influence rehabilitation of the natural environment including carbon sequestration.

Finally it is strongly recommended to set strategies of on farm sustainable production and distribution of tree seedlings by farmer to farmer. It is also important to establish cost and labor sharing system and this can be achieved through participatory approaches of farmers.

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