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Determinants of Participation in Milk Value Addition by Dairy Producers in Asella Milk-Shed, Ethiopia

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Abstract
Dairy producers in Ethiopia practice mainly traditional milk processing methods, and also recognize the benefit of milk value addition to increase income, minimize postharvest losses and prolong shelf life. Contrary to the existing knowledge, producers' participation in the value addition is generally limited to few traditional products. The objective of this study was to examine determinants of participation in milk value addition practices by milk producers in Asella milk-shed. The respondent dairy farmers (n= 178) were selected randomly by employing multi stage sampling techniques; following purposeful selection of the study district and kebeles. Heckman's two stage model was used to assess determinants of participation in the decision and extent of participation in milk value addition practices at farm level. The present study indicated that 77% of the households had added value to their milk products. The results of the Heckman's two stage model showed that milk value addition decision is positively and significantly affected by perceived price of value added products, access to livestock extension services, family size and level of education by household heads. The decision to participate in milk value additions were negatively affected by the number of children under six years of age, household head's age, membership to primary dairy cooperatives and owning only cross breed cows. On the other hand, the volume of milk produced, amount of non-dairy income, and access to livestock extension services positively affected the extent of participation in milk value addition. The results suggest that the decision to participate in value addition and extent of value addition depends on household characteristics, perceived benefit of value addition, access to extension service and breed type. Hence, due attention should be given to enhance households' capacity to add value by creating awareness, strengthening extension service and productivity.

Key words: Heckman Two Stage; Milk-Shed, Value Addition

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INTRODUCTION
Ethiopia has a considerable potential for dairy production, and thus for dairy value chain development opportunities. The country has 59.48 million cattle of which 11.83 million are dairy cows (CSA, 2016). From the total cattle population, the Oromia regional state owns 40.6% and 40.8% of the cattle and milking cow population, respectively. In spite of this potential, the dairy sector is not well developed and thus economic benefit to dairy producers as well as value adding actors is yet to improve (Sarah, 2011).

According to CSA (2016), Ethiopia produces approximately 3.1 billion liters from 11.8 million milking cows. The average milk production per cow per day is only 1.37 liters, which elapses for about six months lactation period.

Despite the low production and productivity of milk in the country, value addition is still pertinent strategy as dairy product consumption is highly seasonal and as most farmers are far from market access for their milk. As reported by Berhanu et al. (2011), most farmers in Ethiopia add values to milk, using old age traditional methods to get products such as butter, cottage cheese, skimmed milk and whey (byproducts from cottage cheese).

There are several empirical evidences that show peculiar differences in the characteristics of Ethiopian dairy value addition exercises, recognizing spatial and temporal variations (Asfaw and Jabbar, 2008; Berhanu and Dirk, 2008; Kedija et al., 2008; Asfaw, 2009; Bereda et al., 2014). Although dairy producers in Ethiopia and the present study area (Asella milk-shed) have abundant indigenous knowledge on milk value addition practices, limited study appreciated the existence of differences within similar cultures and agro-ecologies. The purpose of the present study is to contribute to the knowledge base by assessing main drivers to milk value addition practices and quantify the levels of participation in Asella milk-shed.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Asella milk-shed located in Tiyoworeda (Fig. 1). Asella milk shed was selected purposively as it is one of potential dairy producing areas in the country. Asella milk-shed covers 18 kebeles (the smallest administrative structure) and 3 rural based towns, namely, Gonde, Kulumsa and Ketar (WARDO, 2013). Tiyoworeda has 18,850 male headed and 4,244 female headed farm households. Asella town is the capital of Tiyoworeda and is located about 175 kilometers south-east of Addis Ababa with a latitude of 7°57′N and longitude of 39°7′E. Asella milk shed is characterized by mid subtropical agro-ecology with annual temperature ranging from 5-28^{0}Cand elevation ranging from 1780-3100 ma.s.l.

Mixed farming is the dominant farming system prevailing in the study area. The major crops grown in the woreda include barley, wheat, teff, potato, faba beans, maize and field peas. The woreda is recognized as surplus producing woredas in the region, and also have high livestock production. The agro-climatic condition of the woreda is classified as 52% mid altitude (Woyinadega), 37% high altitude (dega) and 11% low altitude (Kola) (WARDO, 2013).

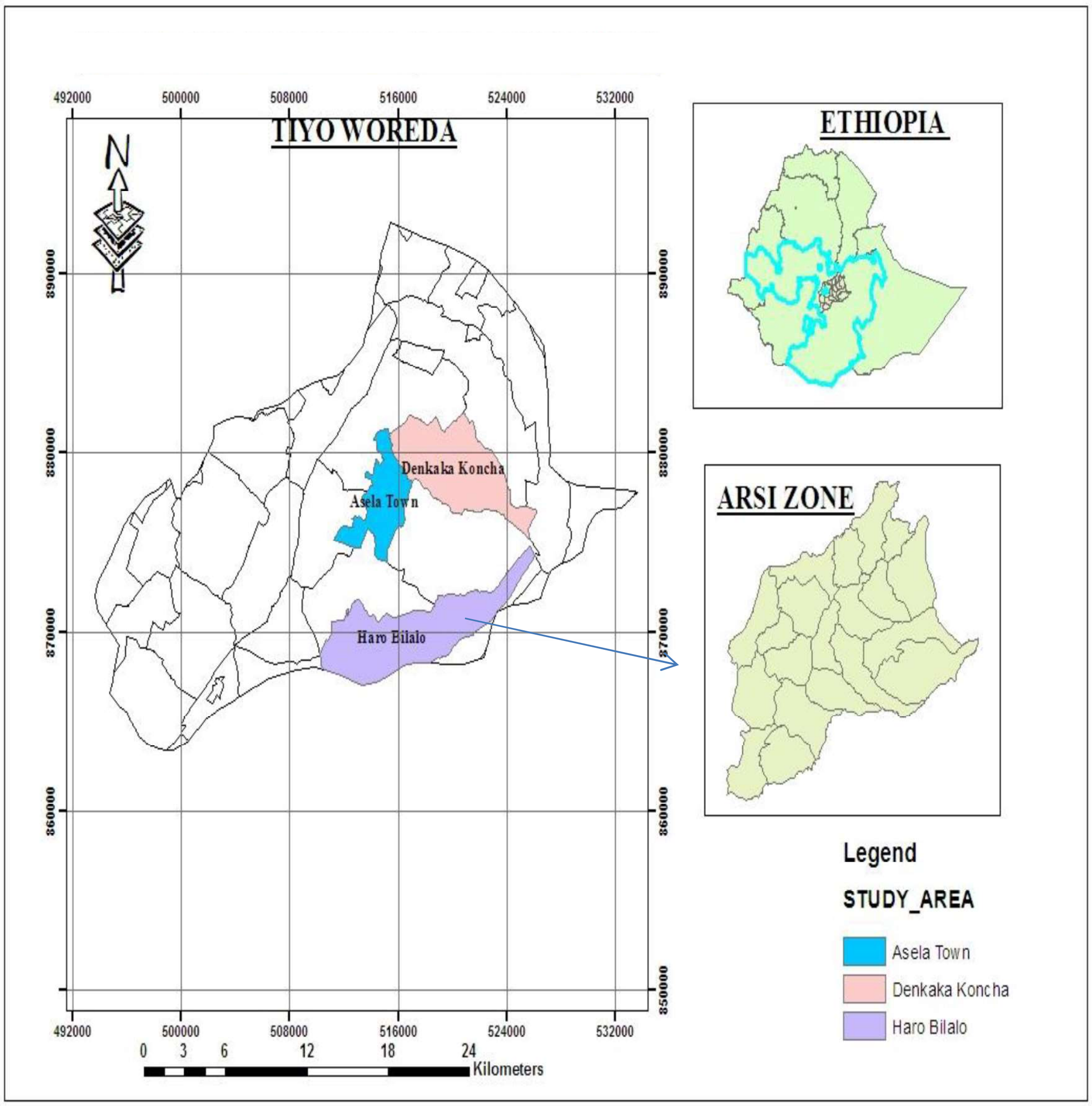

Figure 1. Map of the study area: Asella milk-shed

Data Collection
The study used both qualitative and quantitative data, which were obtained from primary and secondary sources. The primary data were collected from selected dairy producers with the use of structured questionnaire. The questionnaire was designed to collect data such as age, gender, religion, occupation, household size, educational attainment, frequency of contact with extension, availability of labor and equipment for value addition, price of value added milk, volume of milk produced, access to credit, training attendance, number and type of cows owned, distance to market place and milk processing factory. Secondary data were collected from records kept by agriculture office of the wereda and cooperative milk collection units and other literatures.

Sampling Technique and Sample Size
Three-stage sampling procedure was used to select the respondents. First, Asella milk-shed was selected purposively as it is one of potential dairy producing areas in the country. Second, the milk-shed was categorized into rural and urban and from which two rural kebelles and three urban kebelles with the largest number of milk producers were purposively selected. Third, the populations of smallholder dairy producers in the selected kebelles were stratified according to dairy cooperative membership status. Since the number of farmers who were members of nearby primary dairy cooperative in each Kebelle was small, all dairy farmers who were members of primary dairy cooperatives were selected while non-member dairy farmers were randomly selected. Finally, a total of 178 respondents were selected based on proportional probability sampling method.

Model Specification

Theoretical model
The general framework of utility or profit maximization is the theoretical base adopted for this study (Norris and Batie, 1987; Pryanishnikov and Katarina, 2003). The farmer'schoice of either adding value to milk or not depends on the actor's perception on the utility s/he is likely to derive from the practice. S/he decides to add value if the perceived utility from value addition is significantly greater than the one without value addition. Suppose that μ_v and μ_n represent farmer's utility for the two choices *v* and *n*. Then, the linear random utility model can be specified as:

$\mu_v = \beta_v X_i + \varepsilon_v$ and $\mu_n = \beta_n X_i + \varepsilon_n$

Where μ_v and μ_n are perceived utilities of value addition & non-value addition choices, respectively,

X_i= vector of explanatory variables that influence the perceived desirability of each choice,
β_v and β_n are utility shifters, and
ε_v & $\varepsilon_n$are error terms assumed to be independently & identically distributed (Greene, 2000).

In the case of milk value addition, if a dairy farmer decides to use option *v*, it follows that the perceived utility or benefit from option *v*is greater than the utility from other options (say *n*), i.e.,

$$\mu_{iv} = (\beta_v X_i + \varepsilon_v) \succ \mu_{in}(\beta_n X_i + \varepsilon_n), v \neq n$$

Empirical model
The farmer'sdesirethat leads to a particular choice was modeled in a logical sequence, starting with the decision to add value, and which is followed by a decision on the extent of the value addition. Thus, based on the nature of these decisions, the Heckman's two stage selection model whose estimation involves two stages was used to analyze the determinants of participation decision and level of participation at farmer level. Following Wooldridge (2002), these two successive equations, namely selection equation and outcome equation, respectively are presented as follows:

Selection equation: $y_{1i}^* = X_{1i}\beta_1 + \varepsilon_{1i}$

$$y_{1i} = 1 \quad if \quad y_{1i}^* \succ 0 \quad y_{1i} = 0 \quad if \quad y_{1i}^* \leq 0$$

Outcome equation $y_{2i}^* = X_{2i}\beta_2 + \varepsilon_{2i}$

$$y_{2i} = y_{2i}^* \quad if \quad y_{2i}^* \succ 0,$$

y_{2i}^* not observed if $y_{1i}^* \leq 0$

Where,
y_1 = Probability of participation in milk value addition
y_2 = extent of value addition/volume of milk value added,
x's= independent variables/household characteristics, β=parameters and ε = error term

The first stage of the model which assessed the decision to add or not to add value was a probit model whereas in the second stage OLS was used to analyze extent of value addition (Wooldridge, 2002). The reasoning behind the two stage approach is that the decision on the extent of milk value addition (the volume of value added milk) is usually preceded by a decision to engage in the process of value addition.

Maddala (1983) suggested the use of selection variable that can be assumed to affect largely the participation decision, but not the level of participation in the selection equation which enables the inverse Millis' ratio to predict correctly. Accordingly, this study used owning only cross breed cows as selection variables in probit model/selection equation. Owning only cross breed cow was expected to affect the milk value addition participation decision, but has no significant impact on level of participation in order to predict inverse Mill's ratio correctly. According to the model output, the Lambda (Inverse Mills Ratio) or selection bias correction factor has positive, but statistically insignificant impact on participation in milk value addition. There appears to be no unobserved factor that might affect both probability of dairy household milk value addition decision and volume of milk value added.

Prior to running the two stage Heckman model, both the continuous and discrete explanatory variables were checked for the existence of multi-collinearity problem. The technique of variance inflation factor (VIF) was employed to detect the problem of multi-collinearity for continuous explanatory variables (Chatterjee and Price, 1991). Likewise, the Phi (φ) statistic has been computed to check the existence of multi-collinearity problem for discrete explanatory variables, since variables under consideration have exactly two possible values (Arega, 2009).

The VIF and φ statistic results revealed that there is no problem of association among the discrete variable as VIF is below 10 and φ is below 0.5. Therefore, the proposed continuous and discrete explanatory variables were retained in the model. Finally, sixteen explanatory variables were used for the Heckman model.

Data analysis

The quantitative data were entered into IBM SPSS Statistics 20 computer software (IBM Corp., 2011) for ease of data management and were analyzed using STATA software version 15 (Stata Corp. 2017) whereas the qualitative data collected through FGD and interviews were analyzed using thematic and categorical interpretation.

Variables Definition

The dependent and explanatory variables included in the analysis and their postulated effects on participation and extent of milk value addition decision is discussed hereunder.

Dependent variables

Producers value addition decision (VAD_Dec): the decision either to process milk or not to process milk. It is dummy variable that takes either 1 (yes response) if the farmer processes or 0 (no response) if the farmer does not process milk.

Extent of value addition (Vol_VAD): volume of milk value added by the farmer. Continuous variable measured in liters of milk used for processing/value addition per day.

Independent variables

Age: defined as the age of the household head in years. It is a continuous variable. As the age of the household head increases their participation decision and extent of participation in milk processing is hypothesized to decline.

Gender: gender of the household head. Dummy (1=male, 0 = female). Women contribute more labor input in area of milking, milk value addition and marketing of dairy products. Thus, male headed households were expected to produce less amount of value added milk than female headed households.

Educational level (Educ): education level of the household head (continuous measured in number of years spent in formal school) and was expected to positively affect participation of farmer in milk value addition.

Number of children below 6 years age (Children): continuous variable measured in number of children whose age is below six years in the family. As the number of children under 6 years increases, the family's participation in value addition is hypothesized to decline due to increased consumption as the milk is preferable food for children in the household.

Household access to credit (Cred_acc): dummy (1= has access, 0= has no access). Farmer who has access to finance (credit) was hypothesized to participate in milk value addition more than a farmer who has no access to credit.

Access to livestock extension service (Ext_acc): dummy variable (1= has access, 0= has no access). It was hypothesized that access to extension services positively affects both participation decision and level of participation in milk value addition.

Distance to market place (Dist_mkt): continuous variable (measured in Km). The higher the distance from milk and milk products market place, the higher the participation in milk value addition.

Access to market information (Mkt_info): a dummy variable that takes either 1 (has access) or 0otherwise. It was expected to positively affect milk value addition decision and extent of participation.

Volume of milk produced (Vol_Prod): it is continuous variable measured in liters of milk produced per day and was hypothesized to affect milk value addition positively.

Cooperative membership (Coop_mem): a dummy variable that takes two values either 1 or 0 (i.e. member=1, non-member=0). Dairy producers who are member of a dairy cooperative are supposed to supply raw milk to the cooperative on a daily basis. Thus, they will have no or less surplus milk thus, cooperative membership was expected to negatively affect the farmer's participation and level of participation in milk value addition.

Perceived price of value added milk/ liter (PrFair): although it was hypothesized as a continuous variable (measured in Ethiopian Birr), due to farmers' difficulty of quantifying the monetary value of value added products, their opinion on price of value added products was used as one of independent variables. Price of value added milk products was expected to positively affect the farmers' participation decision and level participation in milk value addition.

Non-dairy farm income (Nond_Inc): continuous (in Ethiopian Birr) and was hypothesized to affect participation decision and extent of participation in milk value addition positively. Having sound non-dairy income sources was expected to encourage farmer's participation.

Availability of family labor for value addition (Labor): dummy variable (1=yes, 0=No). Households who have access to family labor tend to add value to milk.

Religion (Rel_dum): dummy variable (1=Orthodox Christians, 0=otherwise) and was meant to capture the effect of fasting on farmers participation in milk value addition. The tradition of fasting with over 200 days of fasting within the Ethiopian Orthodox community creates excess supply of milk as most orthodox Christians abstain from consuming products of animal origin which was hypothesized to positively affect farmers' participation in value addition.

Cow breed: According to Kuma et al. (2011) and Mamo et al., (2014), the number and type of cow breeds have affected participation decision and volume of milk value addition. But, since the number of cows owned is correlated with the volume of milk produced, the researcher used owning only cross breed cow as an explanatory variable to capture the effect of breed type owned on the farmer's participation in milk value addition. The milk from local cow breeds is rich in its fat content so that farmers tend to process it.

Hypothesis

Summaries of factors that were hypothesized to influence farmer's participation and the expected signs for the two dependent variables, value addition decision (VAD_Dec) and extent of participation i.e. volume of milk value added (Vol_VAD) is presented in Table 1.

RESULTS

Milk production in Asella milk-shed is largely subjected to value addition. Out of the total 178 sample households interviewed, 137 of them (77%) added value to the milk they produced while the remaining 23% (41 households) did not.

Milk value addition decision category

Households' likelihood of participation in milk value addition was found to be different among respondents with different socio-economic, demographic, institutional and genetic characteristics of the herd (Tables 2 and 3).

The age of dairy producers who were practicing milk value addition was significantly lower from age of dairy producers not practicing value addition. Education level measured in years of schooling and number of milking local breed cowsowned by value adding participants were higher than those not processing milk. The house hold size of value adding participants was significantly higher; besides, the distance to these households was more than the non-value adding counterparts.

Variables such as households access to livestock extension service and milk handling and processing technologies, availability of family labor for milk value addition and their opinion on the price of value added product were significantly different between the two groups (those processing and those selling fresh milk).

Table 1: Hypothesized determinants of farmer's participation decision and level of participation in farm level milk value addition and descriptive statistics of variables

Variable Name	Description	Mean (SD)	Expected signs VAD_Dec /Vol_VAD
Age	Age of the household head (years)	44.26 (8.44)	- /-
Educ	Education level of the household head (years)	6.03 (3.94)	+ /+
Gender	Sex of the HH head (1=Male, 0=Female)	0.76 (0.43)	- /-
Vol_Prod	Volume of milk produced per day (liter)	8.44 (8.52)	+ /+
PrFair	Is price of VAD products fair (1=Yes, 0=No)	0.63 (0.48)	+ /+
Ext_acc	Access to extension service (1=Yes,0=No)	0.49 (0.50)	+ /+
Labor	Availability of family labor (1=Yes,0=No)	0.56 (0.49)	+ /+
Mkt_info	Access to market information (1=Yes, 0=No)	0.76 (0.43)	+ /+
Nond_Inc	Non-dairy income per month (ETB)	622.2 (565.5)	+ /+
Famsize	Total family size of household (numbers)	5.54 (2.17)	+ /+
Chldren	Number of children under 6 years (numbers)	0.89 (0.81)	- /-
OLD	Number of people above 65 years (numbers)	0.19 (0.44)	- /-
Dist_mkt	Distance from market place (minutes of walk)	31.57 (23.38)	+ /+
Coop_mem	Cooperative membership (1=Yes,0=No)	0.34 (0.48)	- /-
Rel_dum	Religion of household head dummy (1=Orthodox Christian, 0=Non-Orthodox Christian)	0.75 (0.43)	+/+
Exoonly	Own only cross breed cow (1=Yes, 0=No)	0.49 (0.50)	-

Source: own survey data (2015), the numbers in the parenthesis are standard deviations of variables used in the model.

Table 2: Characteristics of sample householdsby milk value addition status (continuous variables)

Continous Variable	VAD Participants (137)		VAD Non-participants (41)		t-value
	Mean	St. Dev.	Mean	St. Dev.	
Age of HH Head (years)	43.61	8.08535	46.44	9.30873	1.8994**
Education level of HH Head (years)	6.4891	3.82353	4.512	3.97569	-2.8780***
Nondairy income (ETB)	651.09	614.424	525.9	344.826	-1.2461
Volume of milk produced/day (liters)	8.1734	9.04754	9.311	6.49393	0.7488
Family size of the household	5.832	2.19481	4.561	1.80345	-3.381***
Number of children <6 years of age	0.9124	0.83556	0.829	0.7383	-0.5734
Number of people above 65 years of age	0.2044	0.44173	0.171	0.43956	-0.4295
Number of local breed cows	1.1898	1.25166	0.024	0.1562	-5.9364***
Number of cross-breed cows	1.2993	1.38991	1.585	1.18270	1.1944
Distance to market place (minutes)	33.526	24.2654	25.03	18.9565	-2.0555**

*, ** and *** indicate significant difference at 10%, 5% and 1% probability levels, respectively.

Table 3: Characteristics of sample households (discrete variables)

Discerete Variable	VAD Participants (137)	VAD Non-participants (41)	Total (178)	Pearson chi^2
Religion				
Orthodox Christians	104 (75.9)	30 (73.17)	134 (75.28)	0.1275
Non-Orthodox Christians	33 (24.1)	11 (26.83)	44 (24.72)	
Gender				
Male	107 (78.1)	29 (70.73)	136 (76.4%)	0.9509
Female	30 (21.9)	12 (29.27)	42 (23.6%)	
Own only cross breed cow				
Yes	96 (70.07)	40 (97.56)	136 (76.4)	13.226***
No	41 (29.93)	1 (2.44)	42 (23.6)	
Access to market information				
Yes	103 (75.2)	33 (80.49)	136 (76.4%)	0.4927
No	34 (24.8)	8 (19.51)	42 (23.6%)	
Access to extension service				
Yes	77 (56.20)	11 (26.83)	88 (49.4%)	10.893 ***
No	60 (43.80)	30 (73.17)	90 (50.6%)	
Availability of labor (owned)				
Yes	88 (64.23)	12 (29.27)	100 (56.2%)	15.671***
No	49 (35.77)	29 (70.73)	78 (43.8%)	
Access to credit				
Yes	49 (35.77)	14 (34.15)	63 (35.4%)	0.0362
No	88 (64.23)	27 (65.85)	115 (64.6%)	
Cooperative membership				
Yes	49 (35.77)	12 (29.27)	61 (34.3%)	0.5915
No	88 (64.23)	29 (70.73)	117 (65.7%)	
Access processing equipment				
Yes	137 (100 %)	12 (29.3%)	149 (83.7%)	115.76***
No	0 (0 %)	29 (70.7%)	29 (16.3%)	
Type equipment owned				
Modern	21 (15.3%)	5 (41.7%)	26 (17.4%)	5.3135**
Traditional	116 (84.7%)	7 (58.3%)	123 (82.6%)	
Price of VAD product is fair				
Yes	105 (76.6%)	8 (19.5%)	113 (63.48)	44.429***
No	32 (23.4%)	33 (80.5%)	65 (36.5%)	

*** and ** indicate significant difference at 1% and 5% probability levels, respectively. Numbers in the bracket are percent of the sample households.

Milk value addition participants also differ from non-participants based on the number and type of breed of cows owned, perceived price of value added milk products, home distance from market and other socio-economic, demographic, institutional features. Moreover, more than 76% of respondents mentioned that they had access to market information mainly from neighbors (33%) and traders/consumers (20%).

Determinants of Dairy Farmers' Participation in Milk Value Addition

The results of the two stage Heckman model for the participation decision and level of participation revealed that the coefficient of Mills ratio (Lamda) is significant at the probability of less than 5% (i.e. p = 0.028, z = 2.19) (Tables 4 and 5). Moreover, the models goodness of fit and likelihood function were significant at Walda chi^2 (14) = 98.83 (p = 0.000).

The finding assures the appropriateness of the two stage Heckman model to avoid sample selection bias that could have been experienced as a result of existence of some unobservable farmer characteristics determining farmer's likelihood to add values to milk and thereby affecting the level of participation if probit model was used for the analysis (Berem et al., 2011).

Table 4: Results of first stage Heckman selection (probit) estimation of determinants of probability participation in farm level milk value addition.

Variables	Probability of participation in milk value addition (VAD_Dec)			
	Coef.	Std. Err.	P>z	dy/dx
Age of the household head (years)	-0.030	0.025	0.227	-0.003
Education level of the HH head (years)	**0.091***	0.051	0.073	0.010
Sex of the household head (1=M, 0=F)	0.436	0.420	0.300	0.058
Volume of milk produced per day (liter)	-0.002	0.021	0.940	-0.001
Is price of VAD products fair (1=yes, 0=no)	**1.803*****	0.367	0.000	0.313
Access to extension service (1=yes, 0=no)	**1.413*****	0.530	0.008	0.174
Availability of family labor (1=yes, 0=no)	0.525	0.381	0.168	0.062
Access to market information (1=yes, 0=no)	-0.352	0.446	0.430	-0.034
Non-dairy income per month (ETB)	0.001	0.001	0.164	0.001
Total family size of household (numbers)	**0.334*****	0.128	0.009	0.037
Number of children under 6 years of age	**-0.676****	0.269	0.012	-0.075
Number of people above 65 years of age	-0.597	0.371	0.108	-0.066
Distance from dairy market place (minutes)	0.003	0.008	0.707	0.001
Cooperative membership (1=yes, 0=no)	-0.489	0.543	0.368	-0.062
Religion (1=Orthodox Christian, 0=none)	0.416	0.414	0.315	0.055
Owned only crossbreed cow (1=Yes, 0=No)	**-1.60*****	0.565	0.005	-0.109
_cons	-0.412	1.425	0.772	

Number of observations **178**
Censored observations **41**
Uncensored observations **137**
Walda chi^2 (14) **= 98.83 (0.0000)*****, **z = 2.19,** rho = **0.92504,** sigma = **1.0060408**

Dependent variable is probability of participation; *, ** and *** indicate significant difference at 10%, 5% and 1% probability levels, respectively.

Several variables were hypothesized to influence dairy producers' participation in farm level milk value addition in Asella milk-shed (Table 4).

As it was expected, education level of household head, households access to livestock extension service, perceived price of value added milk products, family size of the household, number of children below six years of age and type of cow breed owned were found to influence dairy holders' decision to participate in the milk value addition activities. Other variables included in the model were non-significant. Perceived price of value added milk products, family size and access to livestock extension service influenced the dairy holders' decision to go for value addition positively at 1% significance level. Similarly, Education level of the household head was found to positively influence dairy holders milk value addition participation decision at 10% significance level while number of children under six years and owning only cross breed cows affected likelihood of participation in milk value addition negatively at 5% and 1% level of significance, respectively.

The better educated milk producers, as expected, participated more eagerly in the milk processing activity for they have a better access to information and more clarity about emerging marketing opportunities in the milk processed products. As the number of years spent in formal education by dairy holder increases by one, the likelihood of participation in milk value addition increases by 10% (p = 0.073). This result is in line with the findings of Berhanuet al. (2011) and Tadeleet al. (2014). Moreover, price of value added products positively influenced the probability of participation (p = 0.000) indicating increased price of processed milk products might enhance the dairy holders value addition practice.

As hypothesized, households' access to livestock extension services is positively associated with farmer's likelihood to add values to milk. This indicates that access to extension services increases the probability of adding values to milk by 17.37% (p = 0.008). This finding is in line with the results of both Kuma et al. (2011) and Tadele et al. (2014).

The marginal effect analysis also revealed that keeping all other exogenous variables at their mean level, as family size above 6 years age increases by one the probability of adding value to milk increases by 3.7 % (p = 0.09). The reason behind this is that dairy farmers with large family size have an opportunity to supply labor to process raw milk into butter or other value added milk products.

In addition, the decision to participate in milk value addition was also found to be influenced negatively by the number of children whose age is below six years in the household. The result shows that the probability of adding values to milk decreases by 7.5% (p = 0.012) as the number of children under six years of age increases by one unit. It was considered that the greater the number of children whose age is below six years, the lesser the probability of participation in milk processing due to the higher consumption of raw milk in the family. The results of Berhanuet al. (2011) is against this finding while the result of Tadele et al. (2014) supports. This might be because of similarity of study areas as both the current study and Tadele et al. (2014) were conducted in semi-urban areas while the study of Berhanu et al. (2011) in rural Ethiopia.

Moreover, households who owned only cross breed cows were found to participate less in milk value addition than those who owned local breed cows. The result showed that owning only cross breed cows decreases the probability of adding values to milk by more than 10%. More than 66% of the sample households preferred local breed cows for value addition for several reasons. Although exotic cows are known for their high milk yield so that there could be more surplus milk either to sell or process, local cows were found to be the most preferable for their fat rich milk. Consumers' preference for dairy products (such as butter) from local breed cows was reported to be high for its taste, fat content and other reasons.

Determinants of extent of participation in farm level milk value addition

The second stage of the analysis revealed that volume of milk produced per day, household access to livestock extension service and non-dairy income earned are positively associated and statistically significant with the level of value additional at 1% level of significance. On the other hand, age of the household head and cooperative membership influenced the volume of value added milk products negatively at 10% and 1% level of significances, respectively (Table 5).

Age of the household head was found to play a key role in determining the level of participation of a household in milk value addition. The older the household head, the lesser the volume of milk used for value addition. Keeping other explanatory variables at their mean level, as the household heads age increases by one year, the volume of milk value added declines by 0.026 liter. This could be because dairy holders through age become risk averse and arenot willing to venture into new fields or take part in activities that theyare not certain about. Furthermore, older members are less energetic and find it hard engaging in laborious activities. This finding is in line with the results of Berem et al. (2011) and Berhanu et al. (2011) while it contradicts with results of Tadele et al. (2014).

Volume of milk produced in liter per day is positively related and statistically significant with the level of value addition participation (Table 5). This indicates that, ceteris paribus, an increase in milk yield per day by a liter increases the volume of milk processed by 0.053 liter. This might be due to more surplus milk in the family following increased production that could be used for consumption or processed in to different value added products. This finding is in line with the results ofTadeleet al. (2014) while it contradicts with the finding of Berhanuet al. (2011).

Table **5**: Results of second-stage Heckman selection estimation of determinants of level of participation in farm level milk value addition

Variable	Volume of milk value added (Vol_VAD)		
	Coefficient	Std. Err.	P value
Age of the household head (years)	-0.026*	0.015	0.083
Education level of the HH head (years)	0.016	0.030	0.590
Gender of the household head (1=M, 0=F)	0.259	0.231	0.261
Volume of milk produced per day (liter)	**0.053*****	0.011	0.000
Is price of VAD products fair (1=yes, 0=no)	0.394	0.270	0.145
Access to extension service (1=yes, 0=no)	**1.076*****	0.260	0.000
Availability of family labor (1=yes, 0=no)	0.022	0.218	0.919
Access to market information (1=yes, 0=no)	-0.001	0.001	0.734
Non-dairy income per month (ETB)	**0.239*****	0.063	0.000
Total family size of household (numbers)	-0.079	0.124	0.519
Number of children under 6 years of age	-0.112	0.217	0.606
Number of people above 65 years of age	0.194	0.243	0.424
Distance from dairy market place (minutes)	0.005	0.005	0.289
Cooperative membership (1=yes, 0=no)	**-0.677*****	0.256	0.008
Religion (1= Orthodox Christian, 0=Otherwise)	-0.165	0.220	0.454
_cons	-0.377	0.866	0.663
mills lambda	**0.931****	0.425	**0.028**

Number of observations = **178**
Censored observations = **41**
Uncensored observations = **137**
Walda chi^2 (14) **= 98.83 (0.0000)*****, **z = 2.19,** rho = **0.92504,** sigma = **1.0060408**

Dependent variable is volume of value added milk (Vol_VAD in liters); *** indicate significant difference at 1% probability level.

Dairy holders' access to livestock extension service affected not only their participation decision in milk value addition, but also the volume of milk value added. Households who have access to extension service were better in terms of volume of milk they process i.e. farmers' extent of participation in milk value addition was positively and significantly influenced following their access to the service. The result of the second step analysis revealed that, ceteris paribus, as the status of households access to livestock extension service changes from 'No' to 'Yes' (from 0 to 1), the volume of milk value added increases by 1.07 liter per day. The finding of Tadele et al. (2014) is also in agreement with the present result.

Moreover, by keeping other independent variables constant, an increase in the households' monthly non-dairy income by 1 ETB increases the level of participation (volume of milk value added) by 0.24 liter per day. This might be due to the dairy farmers' ability to afford inputs for milk production and processing as a result of high non-dairy income. This result is consistent with findings of Tadeleet al. (2014).

Cooperative membership (Coop_mem) was another factor that was expected to affect dairy holders' participation decision as well as extent of participation in milk value addition. Dairy holders who were not member of primary dairy cooperative found to participate more eagerly in milk value addition than cooperative members. As the dairy farmer's status changes from non-cooperative member to member of cooperative, their level of participation in milk value addition decreased by 0.67 liter. This might be because cooperative members are supposed to sell raw milk everyday (as per their agreement) to the cooperative, being a member of dairy cooperative was found to negatively affect the dairy holders participation in milk value addition made at household level.

CONCLUSION

The results of the two stage Heckman model for the participation decision and level of participation revealed the decision to add value is positively and significantly influenced by the perceived price of value added products, dairy holders access to livestock extension service, family size and education level of the household head, while number of children below six years of age and owning only cross breed cows negatively affected the decision to go for value addition. Moreover, the extent of participation in milk value addition was significantly and positively influenced by the volume of milk produced per day, non-dairy income and access to livestock extension service while it was negatively influenced by age of the household head and membership to primary dairy cooperative. Although majority of dairy producers in the study area owned exotic cows, the milk from exotic cows was not exploited to the extent it ought to be, due to lack of capacity to produce commercial milk products. This is further associated with access to modern milk handling and processing equipment, ingredients, training, and technical support. Moreover, smallholder dairy producers complain the need for training on improved feed formulation and animal husbandry practices and scale up/out good practices so that maximum milk production is exploited to feed not only their family but also other consumers through marketing raw milk and value added dairy products.

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Determinants of Varietal Replacement of Haricot Bean by Farmers in *Boricha* District, Southern Ethiopia

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Abstract

Seed is a fundamental input in crop production, which plays a significant role in enhancing productivity. Associated with seed, the choice and the decision to replace crop varieties in use are critical to increase productivity. This study examined determinants of varietal replacement among farmers producing Haricot bean varieties in *Boricha* district. Four *kebele* administrations and 162 sample respondents were selected using a multi-stage sampling procedure and data were collected by using a structured questionnaire. The findings show that improved haricot bean varieties promoted by the extension system were released during the last 6 to 12 years. Farmers mainly grow old varieties and hence varietal replacement is low. From total sample respondents, 77% had grown varieties that were released from research centers in the past 6 to 12 years whereas the remaining 23% had grown Red *Wolaita*, which was released four and half decades ago and now considered as a local variety. Out of 162 farmers, 72% of sampled farmers replaced the old variety by *Hawassa Dume*, which was released in 2008 and is the most recent variety available in the district. The Logistic regression model showed that age of household head, size of landholding, market price of varieties used for replacement, livestock ownership measured in Tropical Livestock Unit (TLU), availability of recently released varieties, participation on extension demonstration, and perception about yield of varieties used for replacement significantly affected varietal replacement decisions. Hence, it is important to enhance resource endowment of households, improve access for recently released varieties, integrate growers with high value market and organize extension demonstration of improved varieties to facilitate varietal replacement.

Key words: Key words: Haricot bean; Logit; Meher; Varietal replacement
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INTRODUCTION

Haricot bean production plays an important role at household level as source of cash, nutrient dense food crop (poor man meat) and nitrogen fixer to replenish soil fertility. In 2013/14, the total pulses export volume of Ethiopia was 353,645 thousand tonnes and 251 million USD (Boere et al., 2015). The major export pulse crops in order of importance are haricot bean, horse bean and chickpea, which account for 35%, 26% and 23%, respectively, while the remaining share was covered by lentil, green mung beans and faba bean (Mulugeta, 2010). Numerous haricot bean varieties have been released from research centers that are currently in production in Ethiopia. According to Ethiopian Ministry of Agriculture (MoA, 2014), about 50 varieties of Haricot bean are under production. The pure red and white haricot beans are the most market demanded varieties (Ferris and Keganzi, 2008). The value of Haricot bran in terms of economic return and food security increases with the use of recently released varieties that have better yield and resistance to disease and moisture stress. Although there is a general understanding and recognition on the benefit of using improved varieties, the practice of varietal replacement is low in the study area. Varietal replacement is farmer's decision to change an adopted cultivar by a better one based on expected utility (Gemeda et al., 2001). As indicated by Oladele (2005) an understanding of factors influencing technological change including varietal uptake by potential clients in agriculture is vital to the design of policies and strategies.

In the study area, about four varieties of haricot bean namely *Hawassa Dume*, *Ibbado, Nasser* and Red *Wolaita* varieties are grown by smallholder farmers during 2014/15 main production season. The first three varieties cultivated currently were released in the last 12 years from research centers for their better yield, marketability or disease resistance, whereas Red *Wolaita* variety was released in 1974 and almost considered as a landrace.

Empirical evidence show that about 90% of the estimated annual seed requirement of 420,000 tonnes comes from farmers' own sources (Thijssen et al., 2008). IFPRI (2010) reported that the formal seed system, which supplies seed through public and private companies still, has a limited footprint in Ethiopia, covering the highest use at approximately 50 percent for maize and the lowest use at less than 10 percent for barley. Whereas the informal seed system (defined as farmers producing and exchanging their own seeds) is highly dominant except for hybrid maize seed.

Therefore, this research was undertaken with the objective of assessing why some farmers continue growing old varieties whereas others replaced their old varieties with recently released ones. The findings of the study would have a policy implication through creating insight and conducive environment for smallholder farmers' producing haricot bean and would like to replace better quality varieties through generating pertinent information for research and extension systems.

MATERIALS AND METHODS

The study was carried out in *Boricha* district, southern Ethiopia which is located between 6°04'N and 38°00'E to 7°00'N and 38°02'E. The district comprises 39 rural *kebele* administrations (Figure 1). The agriculture of the study area is rain fed crop-livestock production system characterized by maize-haricot bean-*Enset* farming system. The district has two cropping seasons, *belg* (short rainy season mostly from February to May*)* and *meher* (long rainy season mostly from June to October). Major crops grown in the study area are maize, haricot bean, coffee and root crops like *Enset* (*Enset ventricosum*), potato and sweet potato. The altitude of the area ranges from 1250 to 2000m above sea level and its mean annual rainfall ranges between 500 and 1242 mm. Concerning the monthly average temperature of the study area, it varies between 21.93^{o}c in July and 25.3^{o}c in February. Total area of the district is 603.45 square kilometers.

Multi-stage sampling procedures were followed to select the study *kebele*s and sample households. In the first stage, the district was purposely selected based on high production and wide area coverage of haricot bean. In the second stage, the 39 rural *kebele* administrations were stratified in to two groups based on proximity (those *Kebele*s found in a radius of 15 kilometer categorized as nearest and otherwise as farthest) to the district agricultural office, which distributes certified seeds to farmers. The reason why *kebele* administrations grouping undertaken was to include farmers from nearest and farthest area from certified seed source. From each group, two *kebele*s were randomly selected and total of 162 Haricot bean farmers were selected based on probability proportional to size-sampling techniques.

Data were collected using a structured questionnaire and pre-tested on five farmers outside the sample *kebele* to avoid the problem of contamination. Besides the researchers, trained field enumerators were involved in primary data collection. Furthermore, farm visit, direct observation and informal interviews were made. Secondary data were collected from documents of central statistics agency, district office of agriculture annual reports, published articles and unpublished sources.

Data Analysis

The data were summarized by descriptive statistics and econometrics model. By following Gujarati (2004), logistic regression model were used to analyze determinats of varietal replacement of haricot bean by farmers. All analyses were performed by using STATA 13 software.

Definition of variables used

Farmers are categorized as "varietal replacers" if they grew varieties released from research centers in the last 6 to 12 years specifically those varieties such as *Hawassa Dume*, *Ibbado and Nasser* in 2014 *meher* season and "non-replacers" are those who are producing older varieties released earlier than 12 years.

Dependent variable: status of varietal replacement. It takes value of '1' if the farmers used a variety released from research centres in the last 12 years and '0' otherwise.

The following explanatory variables were included in the econometric model based on empirical review of literature:

Education status: It is measured in number of years the respondent attained in formal education and '0' is recorded if no formal education is reported (Krishna et al., 2008).

Farming experience: It is measured in number of years of experience in haricot bean production.

Farm size: It represents the total owned and cultivated land by household. It is expected to be positively associated with the decision to adopt new varieties for replacement.

Farm income: It refers to the total annual earnings of the family from sale of agricultural products and measured in Birr (Ethiopian currency).

Livestock ownership in TLU: It is measured in terms of Tropical Livestock Unit (TLU) in which all livestock owned by farm households were converted to standard values by using conversion factors developed by Storck et al. (1991).

Participation on off-farm /non-farm activities: This variable refers to participation of the respondents in income generating activities out of own farm or non-farm activities. It is dummy variable and defined as whether farmers participate on non-farm and or off-farm activities.

Perception on market price of output: It is dummy variable and takes value 1 if farmers perceived recently released varieties are more marketable with high price and 0 otherwise.

Frequency of contact with extension agent(s): This refers to the number of contacts per year that the respondent made with extension agents. Here, the frequency of contact between the extension agent and the farmers is hypothesized to be the potential force, which accelerates the effective dissemination of adequate agricultural information to the farmers.

Participation in demonstration: It is measured in terms of the number of times the farmer has participated in demonstration.

Cooking quality: This variable refers to whether varieties adopted for replacement are superior over old varieties in terms of compatibility with local dishes like "Kocho" and porridge. It is measured as 1 if the superior and 0 if it is inferior.

Yield of recently released varieties: This variable is measured in dummy variable and take value of'1' if farmers evaluate recently released varieties as more yielding and '0' otherwise.

Access to variety: It is access to new varieties that were released from research centers within the last12 years and available for production. It takes value of '1' if the farmer has access to variety in terms of availability and accessibility and '0' otherwise (Alene et al., 2000).

RESULTS AND DISCUSSION

Socioeconomic characteristics of sample farmers

The respondent farmers in this study were about 49 years old on the average (Table 1). The variety replacers and non-replacers mean age was 38.04 and 50.00 years, respectively. There is a significant mean age difference between variety replacers and non-replacers at 1% significance level (t-value, -6.05). The mean schooling years for variety replacers and non-replacers were 3.42 and 1.24, respectively, and were significantly different (t- value= 4.09, P<0.01). The finding revealed that, exposure to formal education assumed to increase farmers' ability to obtain, process, and use information relevant to the utilization of certified seed of improved haricot bean varieties and replace the same with careful analysis of utilities. Education is therefore expected to increase the probability of utilization of recent varieties.

The mean participation value of household head in extension demonstration was 0.96 days per a year. Variety replacers significantly differed with non-replacers concerning participation in extension demonstration (t= -4.30, P < 0.01). Krishna et al. (2008) also reported that participation in extension events has been positively associated with adoption of new technology.

The mean of years of experience in haricot bean farming was 9.91 and 6.78 for variety replacers and non-replacers, respectively. There was significant difference in mean experience years between variety replacers and non-replacers (t-test=3.57) (Table 2). Experience of the farmer is likely to have a range of influences on utilization of agricultural technologies. A more experienced grower may have a lower level of uncertainty about the technology's performance (Oladele and Wakatsuk, 2011; Tiamiyu et al., 2009). Farmers with higher experience appear to have often full information and better knowledge and able to evaluate the advantage of the technology.

Table 1: Summary of the socio-economic characteristics of households

Variable definitions	Mean	Min	Max	t-value
Age of household head (yrs)	40.85 (11.77)	22	88	6.05
Educational status of household head	2.90 (3.01)	0	13	4.09
Haricot bean farming experience (yrs)	9.17 (4.87)	4	30	3.57
Frequency of contact with development agent	1.22 (1.65)	0	8	3.95
Frequency of participation in demonstration	0.96 (1.30)	0	5	4.30
Livestock holding (TLU)	2.70 (2.16)	0.01	10	6.82
Land holding (hectare)	0.87 (0.58)	0.15	3.25	6.03
Cash income from sale of farm products(Birr)[1]	3933(3906)	750	20850	3.06

Numbers in parenthesis represent standard deviation

[1]Birr refers to Ethiopian currency, 1USD=19.76 during survey period

Table 2. Comparison of replacer and non-replacer groups

Categorical variables	Non-replacer	Replacer	χ^2
Sex of household head (Male)	85.7	83.6	0.117ns
Perception on seed affordability	39.2	83.5	32.99***
Continuous variables			**T-value**
Age of household head	49.7 (11.1)	36.12 (9.3)	8.21***
Family size	5.67 (2.19)	6.28 (2.52)	1.54*
Experience on haricot bean production	6.91 (4.4)	10.40 (5.24)	4.20***
Number of field demonstration attendance	0.5 (0.12)	1.21 (0.13)	3.37***
Number of seed extension contact	1.02 (0.19)	2.70 (0.190	5.61***
Distance from certified seed distributors	13.14 (9.87)	22.33 (8.95)	5.97***
Cultivated landholding	0.40 (0.30)	0.72 (0.47)	4.60***
TLU	0.94 (0.81)	3.67 (2.08)	9.44***

Note: *** and * significant at 1 and 10% significance level respectively

Among others, agricultural extension services affect farmers' decision to improved technology. Farmers in the study area had contacts with extension agents for 1.2 days in the average per year, which is very low, and there is a need to strengthen extension services.

Mean land holding of farmers was 0.87 hectare, which is below the national average of 1 hectare. The mean cash income from sale of farm products was 3933 Birr and the difference in income among the studied farmers was big with a range from 750 to 20850 Birr. Moreover, 61% of respondent farmers participated on off-farm activities and generated additional income other than their own farm. Out of the total respondents, 59% perceived that newly released varieties of haricot bean are more yielding than old varieties. About 64% of the respondents perceived that recently released varieties are easily accessible.

Replacer and non-replacer households

The category wise analysis of respondents based on replacement decision indicated that there is a statistical difference between the two groups in their household related characteristics (age, family size, experience in haricot bean farming), access to institutional service (attendance in field demonstration, number of seed extension contact), resource endowment (cultivated land, TLU) and proximity to certified seed distributors (Table 2). Except sex of the household head, all variables considered to compare the two groups were statistically significant. The two groups' perception of seed affordability to replace variety was also statistically significant.

Varietal Attributes: Four Haricot bean varieties, namely, *Hawassa Dume* (SNNPR-120), *Ibbado* (AFR-712), *Nasir* (Dicta-105) and Red *Wolaita* were the dominant varieties under production during the 2014/15 cropping season in the study area. The response of variety replacers was significantly different from non-replacers on three most important factors: perceived market price for the new variety, yield and cooking quality ($p<0.01$). The majority of the replacer group (83.8%) perceived new variety fetch high price in market as compared to old variety ($\chi2=39.39$). Similarly, replacers perceived the new varieties are better in yield ($\chi2=12.90$) and cooking quality ($\chi2=19.48$) (Table 3) than the non-replaces. The positive perceptions by replacer farmers on the traits of new varieties would influence their decision to replace the old by new ones.

Further discussion with key informants held at *Kebele* level revealed that, *Hawassa Dume* variety is a high yielder but less preferred for household consumption due to its poor cooking quality with local dishes. Although farmers perceive the new varieties to be superior in yield, they may continue growing the old varieties for their cooking quality. For instance, the discussants revealed that the old variety Red *Wolaita* gives less yields but it has superior cooking quality and suitable to be consumed with *kocho* as well as with maize.

Table 3. Perception of farmers on variety replacement traits

Major variety replacement traits		Variety replacement category				Chi-square
		Replacers		Non-replacers		
		Count	%	Count	%	
Market price of new varieties	High	88	83.81	22	38.6	39.39***
	Low	17	16.19	35	61.4	
Yield of new varieties Per hectare?	High	83	66.94	13	34.21	12.90***
	Low	41	33.06	25	65.79	
Cooking quality of new varieties over old	Superior	105	84.68	19	50	19.48***
	Inferior	19	15.32	19	50	

***, significant at 1%.

Varietal replacement pattern: Respondent farmers have grown Red *Wolaita* (64.20%), *Nasser* (14.81), *Ibbado* (9.88%), *Awash Melka* (2.47%) and local variety *Wahe* (8.64) in the last five years. During the 2014/15 *meher* season, respondent farmers grew *Hawassa Dume* (71.67%), *Nasser* (3.09%), *Ibbado* (1.85) and Red *Wolaita* variety (23.46 %). The findings show that there is a reduction in the type of improved variety portfolio (i.e. 5 to 4) as well as considerable replacement of old variety with recently released haricot bean overtime (40.74%).

Determinants of Varietal Replacement

Among 13 variables included in the model, seven variables significantly affected variety replacement decision by farmers (Table 5). The Pearson Goodness-of-fit chi Square (483.60) value shows, the logit model properly fit the data included in the analysis. The finding revealed that, the age of household head negatively and significantly influenced the likelihood of replacing the old with recently released haricot bean varieties ($P<0.01$) (Table 4). Similarly, Oladele and Wakatsuki (2011) reported that age negatively influenced replacement and adoption of rice varieties in Nigeria and Ghana. Land holding of respondent households had positive and significant influence on variety replacement decision ($p<0.1$) (Table 4). This implies that those farmers with larger land holding are more likely to use recently released varieties to replace the older varieties. The result is in agreement with Katengeza et al. (2012). Moreover, it is frequently argued that farmers with larger farms are more likely to replace an improved variety compared with those who owned smaller land as they can afford to devote part of their fields (sometimes the less productive parts) to try out new technologies and practices (Ghimire et al., 2012).

Market price of the Haricot bean varieties used for replacement positively and significantly affected varietal replacement ($p<0.1$) (Table 4). Those farmers who perceive higher market prices for the new Haricot bean varieties compared with the varieties that they were growing before more likely replace with new varieties. This clearly shows that, there is a need to link Haricot bean growers with high valued markets like Ethiopian commodity exchange to facilitate varietal replacement decision. The result is in line with Oladele and Wakatsuki (2011) that found market price influence positively replacement of improved rice varieties.

Livestock ownership of household in TLU is positively and significantly ($p<0.1$) related with varietal replacement decision (Table 4). Those farmers who owned larger livestock are more likely to replace old varieties with new ones. Livestock are important as income sources and draft power in the study area. The result is in accordance with the study of Katengeza et al. (2012) who found that, livestock ownership positively influence the adoption of improved maize varieties in Malawi.

Participation in extension demonstration is an essential means to introduce a new technologies, and practices and diffuse information to farmers. Participation on demonstration significantly was related with variety replacement (at $p<0.05$ probability level) (Table 4), which indicate that those farmers who participate on demonstration are more likely to have better information and as a result replace the old varieties with the new. Katengeza et al. (2012) also found that those household heads who participated on demonstration more likely adopt improved maize variety in drought prone area.

Table 4. Determinants of varietal replacement

Variables	Coefficient	Std. Errors	P-value	Odds ratio
Constant	-1.563	1.754	0.373	0.209
Age of household head (years)	-0.110***	0.036	0.002	0.895
Haricot bean farming experience (years)	-0.028	0.104	0.785	0.971
Land size (Hectares)	1.572*	0.851	0.065	4.818
Appropriate price for the yield of new varieties (Yes=1)	1.447*	0.780	0.064	4.250
Livestock ownership (TLU)	0.749*	0.424	0.077	2.116
Educational status (Formal schooling)	0.293	0.227	0.196	1.341
Extension contact (Days)	0.235	0.362	0.516	1.266
Cooking quality of new varieties (Yes=1)	1.387	0.902	0.124	4.003
Timely available of new varieties (Yes=1)	1.743**	0.835	0.037	5.717
Participation on demonstration (Days)	1.609**	0.628	0.011	4.998
Participation on off/non-farm (Yes=1)	-0.978	1.126	0.385	0.376
Cash from sale of farm products (Birr)	0.0001	0.000	0.451	1.000
Better yield of new varieties (Yes=1)	2.903***	0.960	0.003	18.24
Pearson Goodness-of-fit chi Square = 483.60	Degree of freedom=148			
Correctly predicted overall sample= 93.21	LR chi2 (13) = 123.54			
Correctly predicted variety replacers= 95.97,				
Correctly predicted variety non-replacers= 84.21	Pseudo R2= 0.6999			

Note: ***, ** and * significant at 1, 5 and 10% significance level respectively
Source: Model output (2015)

How haricot bean growers perceived yield per hectare obtained from use of recently released varieties was found to positively and significantly influence varietal replacement decision(at $p<0.01$ probability level) (Table 4). The significant influence of higher yield on adoption of new varieties were reported on various crops including sweet potato in Boloso Sore, Ethiopia (Endrias, 2003), soybean in Nigeria (Ojiako et al., 2007), and subsistence-oriented farmers in Punjab (Smale and Nazli, 2014).

The variables such as extension contact, haricot bean farming experience, educational status, contact with development agent, participation on non/off farm income, annual income and cooking quality did not have significant effect on variety replacement against our prior expectations. This may be due to farmers' production objectives and weak extension service for Haricot bean. In the study area there are about three extension workers per a *kebele* and all farmers have access to extension services, although, farmers differ in exploiting the extension services delivered. Therefore, it is justified to conclude that factors other than extension service affected varietal replacement in the study area. The other crucial variable but that has insignificant relationship with varietal replacement adoption was cooking quality. The result obtained by Timu et. al (2014), showed that ease of cooking positively influenced the adoption of improved sorghum in Kenya. One of the reasons for less influence of cooking quality in replacement of haricot varieties could be due to the reason that farmers mainly produce the crop not for own consumption but to sell. However, the discussions with key informants, revealed that farmers prefer to grow Red *Wolaita* variety (improved but old) for its taste and high compatibility with *Kocho*, a local dish made from *Enset* (*Enset ventricosum*). Recently released variety specially *Hawassa Dume* is meant for market but not home consumption by farmers and evaluation for cooking quality did not appear as a strong determinant for deciding on variety replacement.

Other insignificant variable was educational status of households. In studies related with improved variety adoption, education found to be significantly influencing factors (Timu et.al, 2014; Zegaye et. al., 2001). Whereas, Geta (2003) found that education has insignificant influence on adoption of improved sweet potato varieties.

CONCLUSIONS AND RECOMMENDATIONS

This paper critically examined determinants of haricot bean varietal replacement by farmers in *Boricha* district; Ethiopia. Those varieties released from different organizations have better productivity, less prone to diseases and lodging. The finding of the study showed that, age of household head ($p<0.01\%$)

negatively and significantly influenced varietal replacement decision. Whereas, land holding ($p<0.1\%$), perceived appropriateness of market price ($p<0.1\%$), livestock ownership in TLU (0.1%), availability of recently released varieties ($p<0.05\%$), participation of household head in field demonstration ($p<0.05\%$) and perception of farmers about yield of recently released haricot bean varieties ($p<0.01\%$) significantly and positively influenced varietal replacement decisions. Thus, timely availing improved varieties by creating linkage among stakeholders is important. Field demonstrations in both Farmers Training Centers and farmers' field are very important to evaluate and compare the attributes of the newly released varieties and build the confidence of farmers to replace the old ones.

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Effect of Landscape Positions on Soil Properties in an Agricultural Land A Transect Study in the Main Rift Valley Area of Ethiopia

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Abstract

This study addressed the effects of landscape positions on morphological, physicochemical properties of soils in the Main Rift Valley of Ethiopia. Three landscape positions: upper, middle and lower; and three profile horizons: A, B and buried Ab were considered along a transect line. Nine soil profiles; three in each landscape position, were opened, described and samples collected from each of the observed diagnostic horizon and analyzed. The average thickness of the A- horizon was 34 cm in the upper, 10 cm in the middle and 50 cm in the lower landscape positions. Gravels and high sand fractions (average, 41.4%) dominated the B-horizons, indicating the low rate of weathering. The clay fractions and soil bulk density ($p<0.001$), available water capacity (AWC) ($p=0.050$), soil organic carbon (SOC) and total N ($p= 0.004$ and 0.025, respectively), Available P ($p=0.004$), Exchangeable Ca^{2+} ($p=0.019$) and CEC ($p=0.010$) varied significantly with horizons. Landscape positions also influenced the textural fractions of clay, bulk density, AWC, SOC, total N, available P, exchangeable Ca^{2+} and CEC. However, the SOC concentration across the profiles were low due to the combination of lower inputs because of less biomass return on harvested land, increased aeration by tillage and crop residue collection for fire. The low available P might be due to the high P-fixation behavior of andosols. Continuous cultivation without appropriate soil management practices has resulted in more complex and non-systematic patterns of soil nutrient distribution. Thus, landscape level management practices are required to replenish soil nutrients for sustainable agriculture.

Key words: Soil fertility; Soil Catena; Topographic gradient; Andosols; Ethiopia
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INTRODUCTION

Knowledge on the morphology, physical and chemical characteristics of the soils of a given landscape is vital to enhance sustainable environmental management and crop productivity (Assen and Yilma, 2010). The distribution of soils and their characteristics, among other forming factors, is affected by topography (Jenny, 1980). Topography influences soil properties through its effects on geomorphological, hydrological and biogeochemical processes (Webster et al., 2011). It determines both the vertical redistribution of elements within soil profiles through leaching and laterally along slope gradients (Laekemariam et al., 2016).

Consequently, some studies relate variations in soil properties to topographic attributes (e.g., Yimer et al., 2006; Dessalegn et al., 2014). Also, land use and soil management practices affect soil quality and spatial variability (Yimer et al., 2007). Fisher and Binkley (2000) observed a strong relationship between topographical position and soil properties due to the down slope transport of water and nutrients. Some morphological properties such as solum and Pedon thicknesses, clay content, organic carbon, CEC and exchangeable cations varied on various slope positions (Brubaker et al., 1993; Dessalegn et al., 2014; Negasa et al., 2017). McKenzie and Ryan (1999) found 78% of total P, 54% of total C and between 26 and 64% variations in soil moisture due to terrain attributes. Topographic attributes are also central to many ecological characteristics through their influence on both soil moisture and soil chemistry and thereby affecting plant communities and their distribution on the landscape (Yimer et al., 2006).

Several studies have been made to characterize soils of the Ethiopian highlands (e.g., Lundgren, 1971; Assen and Yilma, 2010). Yimer et al. (2006) reported soil property variations along topographic and elevation gradients over the wide ranges of mountain slopes and topographic aspects in the south eastern highlands of the country. Other studies in Ethiopia also revealed trends of variation in many of the soil properties, which are associated with soil-topography processes and land use histories (Lemenih et al., 2005; Negasa et al., 2017). The soil–landscape relationship has been used as a model to explain the soil genesis (Huggett, 1998) and as attribute for site index assessment (Hägglund and Lundmark, 1977). Present day physico-chemical models used in soil management also require detailed information on the spatial distribution of soil properties (Pennock and De

Jong, 1990). Giesler et al. (1998) described the strong spatial variability of the soil chemistry at landscape scales induced by topographic variation. Various reports (e.g. Nyssen et al., 2015; Zhao et al., 2015) also indicated that SOC, TN, avail. P, depth to seasonal water table and hydrological conditions varied with topography and slope positions. The characteristics and predictable soil-landscape position associations occur as a result of the influence of topography on pedogenesis processes (Yimer et al., 2006). The distribution of physical and chemical soil properties are of interest because of their direct and indirect influences on productivity, which has implications for site-specific fertility management.

The spatial distribution of soils in the Main Rift Valley area of Ethiopia (MRVE) is poorly described (Erikson and Stern, 1987) and only little work has been done on the soil geography of the MRVE (Lundgren, 1971; Fritzsche et al., 2007). Thus, a systematic description of present soil properties in relation to the current landscape and agricultural practice is critically required (Lemenih et al., 2005; Fritzsche et al., 2007; Yimer and Abdelkadir, 2011). Moreover, understanding the dynamics and distribution of the soil characteristics as influenced by landscape features is critical for assessing the effect of future land use changes on soil use and management (Agbenin and Tiessen, 1995).

Sustainable management practices that are based on the understanding of the soil-landscape systems are not available for most parts of Ethiopia (Assen and Yilma, 2010). More specifically, there has been no detailed information concerning the soil-topographic relationships and characteristics of soils developed from volcanic ash (pumic materials) on cultivated landscape in MRVE. It has become a special and interesting area for analysis of soil properties in relation to cultivation and landscape position studies. Knowing the physical and chemical qualities of the soil would help the smallholder farmers to avoid blanket fertilizer application (Elias, 2017) for all soil types and determine the potentials and limitations of soils for agricultural productions. The study area is one of the most intensively cultivated areas in the country due to high population pressure. There is, therefore, a need to assess the relationship between landscape position and soil properties for sound management of land resources and enhance sustainable crop productivity in the rift valley area of the country. The objective of the present study was to assess the effect of landscape positions on selected morphological, physical and chemical properties of cultivated soil (andosols) in the MRVE. The outcome of the present study may provide appropriate information to researchers and development practitioners for sustainable management of cultivated andosols across different landscape positions.

MATERIALS AND METHODS

Description of the study area

This study was undertaken at Lango sub-catchment which is part of the MRVE. The Lango sub catchment (study area) lies to the northeast of Hawassa town at about 15 km south of Shashemene town, south central Ethiopia. It is located between 7° 03' 30" N - 7° 07' 40" N and 38° 34' 44" E - 38° 39' 00" E (Fig. 1). Very steep mountain chains, hills, and gently undulating slopes are dominant topographic features.

The study area has a sub-humid tropical climate with a highly variable mean annual rainfall ranging from 1200 to 1244 mm (Kebede et al., 2013). The study area and the surrounding environs are characterized by a bi-modal precipitation distribution pattern with the main precipitation (66% of mean annual total) occurring from June to September/October and small rain (34% of mean annual total) from March to May while November to February are dry months (Kebede et al., 2013). The mean annual temperature is 26.6 °C. The major land uses and land cover of the study area include cultivation, grazing, forestlands, rock outcrops and marshy areas.

The cultivation lands are mainly used for rotational cultivation of maize (*Zea mays*) and *tef* (*Eragrostis tef*) with sweet potato (*Ipomoea batatus*) and free grazing in crop fields commonly practiced after harvest. Crop residues after harvest have been left in fields and used as animal feeds. Animal dungs and residues are not usually collected for cooking. Montane forest species such as *Celtis africana, Cordia africana, Croton macrostachys, Albizia gumifera, Podocarpus gracilor, Milletia* sp. and *Phonix* spp. are the most dominant tree species (Eriksson and Stern, 1978).

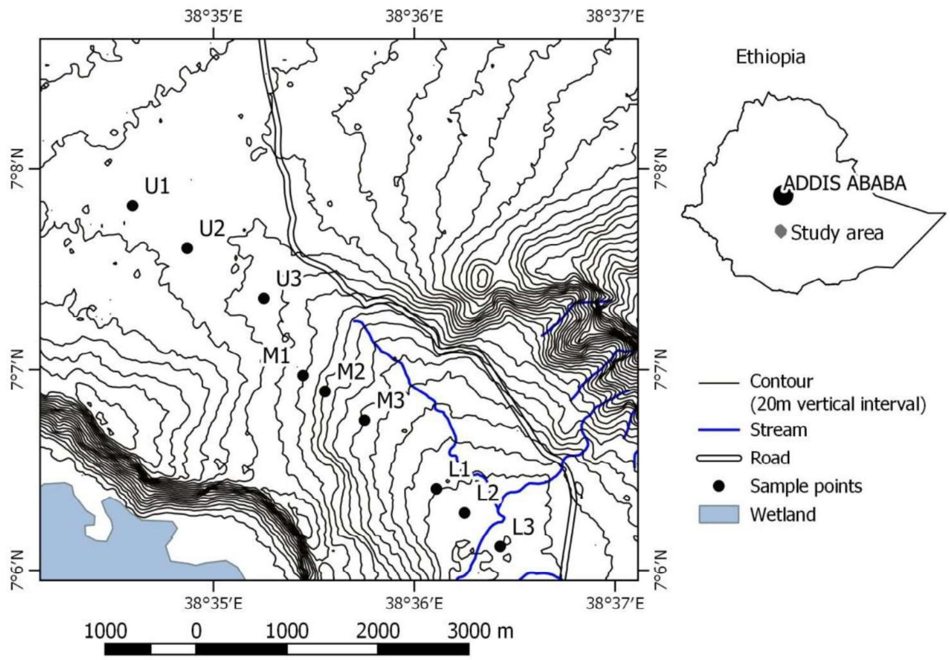

Figure 1. Location map of the study area with representative soil profiles (source for contour: "The STRM 30DEM 1 Arc second data product was retrieved from the online Data Pool, courtesy of the NASA Land Processes Distributed Active Archive Center (LP DAAC), USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota, https://lpdaac.usgs.gov/data_access/data_pool

Geologically, the Rift Valley area of Ethiopia, generally, consists of rocks of volcanic origin such as alkaline (basalts), acidic (rhyolites and ignimbrites, pumice, volcanic ash) and tuff, riverine and lacustrine alluvium (Makin et al., 1975; Fritzsche et al., 2007). The soil type in the MRVE is closely related to parent material (pumice/volcanic ash), its degree of weathering (Makin et al., 1975) and topography. The mainly explosive activities of numerous eruptions taking place during the Quaternary period have distributed volcanic materials (pumice/volcanic ash) over larger parts of the study area. These volcanic materials are known to be highly susceptible to climatic weathering and provide favorable physical and chemical conditions for plant growth and subsequent development of andosols (Barois et al., 1998). Andosols formation depends essentially on the rapid chemical weathering of porous, permeable, fine grained parent materials containing 'volcanic glass' in the presence of organic matter (Barois et al., 1998; FAO-ISRIC, 2001).

Methods

Since intensive soil-surveys are very expensive, a smaller sub catchment, the Lango sub-catchment (ca. 2500 ha) was chosen as a reference for the surrounding pumic (volcanic ash parent material) dominated agricultural landscape. A stratified purposive sampling procedure (Agbenin and Tiessen, 1995) was adopted where three landscape positions [upper, middle and lower] assuming to represent changes in geomorphology and soil characteristics on agricultural landscapes were selected (Fig. 1). At each agricultural landscape position, three representative profiles were opened in each landscape position. The profiles were characterized by genetic horizons and described according to the standard soil profile description and classification procedures (FAO, 2006). A total of twenty nine disturbed soil samples were collected from recognized genetic horizons, air-dried, gently crushed to pass a 2-mm sieve, and used for the analysis of selected soil characteristics. Twenty-nine separate core soil samples were also collected for soil bulk density determination. Additional samples from six of the A-horizons, two from each landscape position, were also collected for andic property determination.

The pipette method was used in the analysis of soil particle size classes (Soil Survey Staff, 1996). The USDA particle size classification was adopted to determine the percentages of sand (2.0-0.05 mm), silt (0.05-0.002mm) and clay (<0.002mm). Bulk density was determined from core samples after drying the samples at 105 °C for 24hours (Landon 1991). The soil moisture constants, the field capacity (FC at 1/3 bar pressure) and permanent wilting point (PWP, at 15-bar pressure)] was determined from the undisturbed soil samples and available water content (AWC) was found by subtracting

PWP from FC (Landon, 1991). The SOC (%) concentration was determined according to the Walkley and Black method (Schnitzer, 1982) and total nitrogen (TN, %) was analyzed using the Kjeldahal procedure (Bremner and Mulvaney, 1982). Calcium and magnesium were determined by atomic absorption spectrophotometer (AAS) while sodium and potassium were determined by the flame emission spectrophotometer (Black et al., 1965). The base saturation was obtained by dividing sum of exchangeable bases by CEC soil expressed as percentages. Available P was analyzed according to the method described by Olsen et al. (1954). Soil pH was measured with a combination electrode in a 1:2.5 soil to water suspension. Cation exchange capacity (CEC) was determined titrimetrically by distillation of ammonium displaced by sodium (Chapman, 1965). All soil samples were analyzed at Water Works Design, Addis Ababa.

Statistical analysis

The obtained analytical data were grouped and summarized according to the landscape positions and recognized genetic soil horizons. Statistical differences were tested using two-way analysis of variance (ANOVA) following the general linear model (GLM) procedure of SPSS Version 16.0 for Windows. Tukey's honest significance difference (HSD) test was used for mean separation when the analysis of variance showed statistically significant differences ($p < 0.05$).

RESULTS AND DISCUSSION

Morphological and physical characteristics of soils as influenced by landscape position and horizon

The morphology of the surface horizons of andosols of the study area was marked by black (10YR 2/1, moist) to very dark brown (7.5YR 2.5/2, moist). As expected on young volcanic deposits, soil textural fractions are generally coarser ranging from sandy loam - loam to silt loam textures; moderate fine to medium granular structure; none sticky/none plastic to slightly sticky/ slightly plastic (wet), friable (moist), soft (dry) and smeary consistency. For most profiles, the average thickness of the A- horizon along the transect was highly variable ranging from about 34 cm in the upper to 10 cm in the middle and 50 cm in the lower landscape positions (Fig. 2). On the middle positions, nearly all soil profiles have become shallow depths. This was resulted from the interplay between pulverization during cultivation and slope steepness accelerating rainwater erosion, and mixed with the underlying coarser C-horizon. Similarly, Dessalegn et al. (2014) indicated that differences in the detachment and transportation of particle-sizes, whereby transport of course-size particles (sand) is low whilst that of fine- and medium-size particles are high resulting in significant variations in the distribution of textural fractions along the landscape.

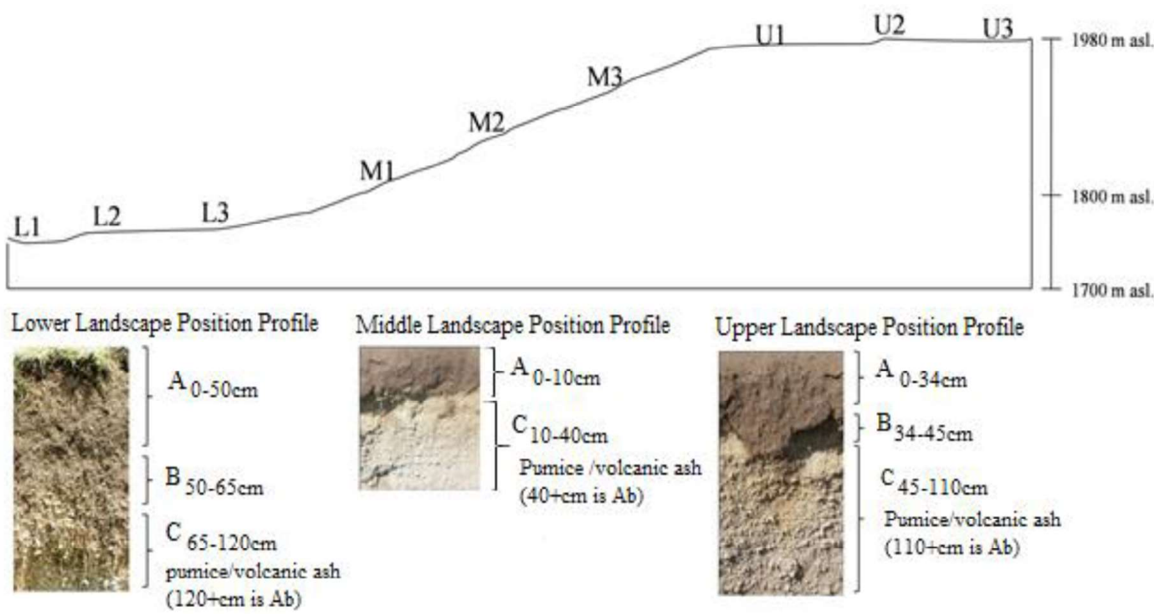

Figure 2. Sketch showing the soil-landscape relation in the study area

Gravels and high sand fractions (average, 41.4%) dominated the B-horizons, indicating the low rate of weathering. The presence of higher proportion of sand fractions and higher silt:clay (si/c) ratio of more than 1.0 in the A- and B - horizons across the landscapes (Tables 1 and 2) indicated the soils were less weathered and rich in weatherable minerals (Tegene, 1995). It was only in the buried Ab-horizon the ratio showed lower mean value (0.69±0.07; Table 2) than the overlying horizons, which is an indication of higher clay fraction concentration due to weathering of parent materials before buried by volcanic ashes. The range of Si/C ratio for highly weathered soils is less than 0.15 (Brady and Weil, 2002). The clay fractions varied significantly with horizons ($p < 0.001$) and landscape positions ($p = 0.008$, Table 1). The low clay fraction throughout the overlying horizons (A and B) reflects the young age of andosols while the oldest buried horizon have a considerably higher clay fraction (39.6±1.41; Table 2) than the overlying younger horizons.

The clay fractions varied significantly with horizons ($p < 0.001$) and landscape positions ($p = 0.008$, Table 1) which could be probably attributed to the effects of long term weathering of clay rich minerals before volcanic eruption took place and movement of fine fractions from the overlying horizons. The higher clay fraction (37.1±3.27, Table 2) at the lower landscape position compared with others could also be attributed to selective removal of fine earth fractions during water erosion leaving behind the coarser ones. Hoyos and Comerford (2005) reported that clay content and surface thickness increased from the middle to the lower landscape positions.

Landscape position ($p = 0.001$), horizon ($p < 0.001$, Table 1) and their combined effects ($p = 0.033$) have significantly affected the values of soil bulk density (BD). The values of soil bulk density were found to be higher (1.12±0.06 g cm^{-3}) in the middle and lower in the upper and lower landscape positions (0.90±0.05 and 0.90±0.03, respectively; Table 2). Similarly, it was lower in the sourface A-horizon (0.89±0.03) compared with the other hrizons. The significantly higher BD value in the middle position could be related to the abundance of coarser fragments and compaction due to animal trampling. The lower BD values in the upper and lower landscape positions and at the A-horizon could be ascribed to the relatively higher clay fractions and SOC concentrations in the respective landscapes and soil horizons (Selassie et al., 2015).

Table 1. Two-way ANOVA for soil textural fractions (sand, silt and clay, %), bulk density (Bd, g cm^{-3}), silt to clay ratios (Si:C), percent pore space (% P) and Available water content (AWC) (%) of soils in the study area

Source of Variation	df	Sand		Silt		Clay		Bd		Si:C		%P		AWC	
		MS	*p*	MS	*p*	MS	*p*	MS	*p*	MS	*p*	MS	*p*	MS	*p*
Position (P)	8	48439.53	0.05	93.12	0.031	74.09	0.008	0.092	0.001	0.281	0.365	38.423	0.140	676.448	<0.001
Horizon (H)	2	218.55	0.004	31.68	0.266	788.64	<0.001	0.111	<0.001	1.761	0.006	86.609	0.019	151.446	0.050
P × H	4	152.02	0.096	20.10	0.483	101.53	0.187	0.029	0.033	0.482	0.164	28.247	0.214	21.050	0.774
Error	20	66.63		22.371		59.28		0.009		0.265		17.704		47.166	

Table 2. Soil physical properties at different landscape positions and soil horizons (Mean ± SE)

Properties	Positions			Horizons		
	Upper	Middle	Lower	A	B	AB
Sand	41.9±2.46[ab]	47.4±4.50[a]	30.2±3.32[b]	44.8±3.22[a]	45.8±4.15[a]	33.6±1.72[b]
Silt	29.6±1.59[b]	27.1±1.55[b]	32.7±1.44[a]	30.5±1.40[a]	30.7±1.32[a]	26.8±2.27[a]
Clay	28.5±3.39[a]	25.5±4.10[a]	37.1±3.27[b]	24.7±2.27[a]	23.5±4.20[a]	39.6±1.41[b]
Bd	0.90±0.05[b]	1.12±0.06[a]	0.90±0.03[b]	0.89±0.03[b]	1.06±0.05[a]	1.09±0.05[a]
Si/C	1.02±0.14[a]	1.27±0.22[a]	1.31±0.24[a]	1.35±0.12[a]	1.55±0.31[a]	0.69±0.07[b]
%pore	55.77±1.83[a]	56.98±1.97[a]	59.97±1.03[a]	60.51±1.36[a]	56.88±1.43[ab]	54.68±1.63[b]
AWC	43.57±1.73[b]	38.24±2.54[b]	55.60±2.52[a]	50.45±2.73[a]	31.38±3.74[b]	56.93±2.87[a]

Means followed by the same letter(s) across rows are not significantly different (p = 0.05) with respect to landscape positions and horizons.

The available water content (AWC) varied significantly with landscape position ($p < 0.001$) and horizons ($p = 0.050$, Table 1). AWC was the highest in the lower landscape position (55.6±2.52) and at the buried Ab-horizon (56.93±2.87) followed by the A-horizon (Table 2). The AWC showed a non-systematic pattern of distribution both with landscape positions and horizons ascribed to variations in the combined effects of soil organic carbon (SOC) and clay fractions distribution. This result is in accordance with Hoyos and Comerford (2005) findings ascertaining characteristics such as high SOC and clay contents have a positive effect on higher water holding capacity of andosols. The A- horizons of andosols have excellent structure and porosity (≥55%) that make them resistant to erosion. Such conditions further permit good aeration and high moisture holding capacities. Frei (1978) reported the ability of andosols for supplying sufficient water at least for 100 days in the dry seasons.

Chemical soil properties of soils as influenced by landscape position and horizons

Soil pH (H_2O)

The soil pH showed significant variation with landscape positions ($p = 0.035$) and horizons ($p = 0.017$; Table 3). It was high in the lower landscape position (6.50±0.11) and at the buried Ab-horizon (6.70±0.22). The soil pH showed a steady increase with depth throughout the profiles (Table 4). The increase in soil pH at the lower slope position could be attributed to the accumulation of bases that are presumed to have been moved laterally by erosion and vertically through leaching effects across the profiles in each landscape position. Ovalles and Collins (1986) have reported high correlation of soil pH with landscape position. Generally, the pH of andosols in the study area remained within the acceptable range for most crops even though its lower end is moderately acidic for some crops according to the explanation of Landon (1991).

Table 3. Two-way ANOA for SOC, TN, C/N ratios and available P and pH of soils of the study area

Source of variation	df	SOC		TN		C/N		Avail. P		pH	
		MS	*p*	MS	*p*	MS	*p*	MS	*p*	MS	*p*
Position (P)	2	2.334	0.015	0.022	0.028	0.579	0.930	13.341	0.037	1.168	0.035
Horizon (H)	2	3.350	0.004	0.023	0.025	5.088	0.536	36.426	0.004	1.484	0.017
P × H	4	1.124	0.072	0.005	0.400	2.065	0.899	1.440	0.876	0.131	0.775
Error	20	0.444		0.005		7.910		4.832		0.29	

Soil Organic Carbon (SOC, %,), total nitrogen (TN, %) and C/N ratio

There were significant differences in SOC and TN with landscape positions (p = 0.015 and 0.028, respectively). SOC was high in the lower landscape position (2.28±0.28) and low in the middle position (1.12±0.14, Tables 3 and 4). Similarly, Guzman and Al-Kaisi (2011) have observed the greatest SOC concentrations at the lower landscape positions, followed by the upper and the least at the middle positions, which was attributed to SOC distribution and losses due to soil erosion and deposition effects by slope position. Total N followed the SOC trend and was found to be higher (0.9±0.03, Table 4) at the lower than in the middle and upper landscape positions.

There were also significant differences in SOC and TN with soil horizons (p = 0.004 and 0.025, respectively, Table 3). The mean SOC was found to be higher in the surface horizon (2.48±0.29) compared with the B and Ab- horizons (Table 4), showing a decreasing trend with depth. Because of the high inputs (e.g. crop residues after harvest and root biomass) at the surface, SOC level generally declines with depth (Li and Zhao, 2001). However, residue mulching may not always improve SOC in all soils because positive effects depend on the quality and quantity of residue applied, management duration, tillage system, site-specific soil properties and climate (Blanco-Canqui and Lal, 2007). In the study area, animal excreta and crop residues were not widely used for fuel. On the other hand, in some areas of Ethiopia, where the tree cover has been removed, up to 90 per cent of the animal dung is used as fuel (Yimer and Abdelkadir, 2011).

Table 4. Mean SOC (%), TN (%), C/N ratios, Avail. P (ppm), pH (H_2O), exchangeable (Exc.) cations (cmolc kg^{-1}soil), CEC (cmolc kg^{-1} soil) and percent base saturation (PBS, %) (Mean ± SE)

Properties	Positions			Horizons		
	Upper	Middle	Lower	A	B	Ab
SOC	1.89±0.36 ^{ab}	1.12±0.14 ^{b}	2.28±0.28^{a}	2.48±0.29 ^{a}	1.49±0.23 ^{b}	1.27±0.25 ^{b}
Tot. N	0.16±0.03^{b}	0.20±0.01^{b}	0.90 ±0.03 ^{a}	0.21±0.03 ^{a}	0.13±0.03 ^{ab}	0.11±0.02 ^{b}
C/N	12.60±1.01 ^{a}	12.4±0.80 ^{a}	12.2±0.66 ^{a}	12.08±0.54 ^{a}	11.86±0.79 ^{a}	13.22±1.34 ^{a}
Avail. P	3.45±0.84 ^{ab}	1.85±0.77 ^{b}	4.52±0.86 ^{a}	5.40±0.89 ^{a}	1.98±0.45 ^{b}	2.04±0.43 ^{b}
pH (H_2O)	6.30±0.16 ^{ab}	5.9±0.31 ^{a}	6.50±0.11 ^{a}	6.03±0.13 ^{b}	6.15±0.23 ^{ab}	6.70±0.22 ^{a}
Exc. Na	0.54±0.05 ^{a}	0.61±0.12 ^{a}	0.55±0.07 ^{a}	0.50±0.04 ^{a}	0.59±0.13 ^{a}	0.62±0.06 ^{a}
Exc. K	0.97±0.11 ^{a}	0.94±0.16 ^{a}	1.01±0.13 ^{a}	1.02±0.12 ^{a}	0.85±0.16 ^{a}	1.04±0.14 ^{a}
Exc.Ca	12.40±1.13 ^{c}	7.17±0.85 ^{b}	15.93±1.04 ^{a}	14.31±1.60 ^{a}	12.17±1.52 ^{b}	9.77±0.78 ^{b}
Exc. Mg	2.38±0.25^{ab}	2.02±0.17 ^{b}	3.99±0.65 ^{a}	2.50±0.32 ^{a}	2.41±0.31 ^{a}	3.19±0.64 ^{a}
CEC	23.28±3.09 ^{a}	20.91±0.69 ^{a}	24.20±1.11 ^{a}	25.85±1.78 ^{a}	20.83±1.15 ^{ab}	20.16±0.91 ^{b}
PBS	68.60±5.30 ^{b}	56.25±6.65 ^{b}	91.36±2.41 ^{a}	72.75±7.15 ^{a}	76.63±6.85 ^{a}	72.78±5.65 ^{a}

Means followed by the same letter(s) across rows are not significantly different (p = 0.05) with respect to landscape positions and horizons.

However, the SOC concentration across landscape positions and horizons was generally found to be low according to Landon (1991) rating for agricultural soils. The generally lower SOC and total N contents in the studied landscapes could mainly be attributed to the high rates of oxidation of soil organic matter due to tillage and to the loss of topsoil by water erosion (Selassie et al., 2015; Elias, 2017). Stable isotopic studies show that N is becoming limited in dry lands of Ethiopia (e.g., the rift valley areas) due to substantial losses via volatilization in that ^{15}N is closely related to aridity (e.g. Terwilliger et al., 2008). In addition, a combination of lower SOC inputs because of less biomass carbon return on harvested land, increased aeration by tillage and crop residue collecting partly causes the reduction of SOC and TN in cultivated soils (Girma, 1998). Since SOC mediates many of the chemical, physical and biological processes of soil, the extensive degradation of large areas and subsequent loss of SOC, would undoubtedly alter the capacity of the soil to perform successfully.

The C/N ratio did not show any variation with landscape positions (p = 0.930) and horizons (p = 0.536, Table 3).

Across the landscape positions and horizons, the C/N ratios ranged between 11.9:1 and 13.2:1 (Table 4), the median for most soils being near 12:1 (Brady and Weil, 2002). The narrow variations in C/N ratios across landscape positions and horizons suggest less variability in the degree of humification of organic matter. Ratios of above 11.0 show the stability of the clay humus complexes while the lower values suggest advanced stages of humification (Wada, 1985). According to Assen and Yilma (2010) a C/N ratio of about 10:1 suggests relatively better decomposition rate, serving as index of improved nitrogen availability to plants and possibilities to incorporate crop residues to the soil without having any adverse effect of nitrogen immobilization. In the buried horizon, the C/N ratio was slightly higher than the rest of the horizons that might be due to the long time accumulated undecomposed material rich in carbon in to the soil before the volcanic eruption took place in the MRVE.

Available phosphorus (Avail. P; ppm) Exchangeable Bases, CEC (cmolc$^{(+)}$/kg soils) and Percentage Base Saturation (PBS)

Available phosphorus showed significant variation with landscape positions and horizons (p = 0.037 and p = 0.004, respectively; Tables 4 and 5); higher in the lower position and A-horizons (5.40±0.89) than the rest of positions and horizons. Such increase in available P with downward landscape positions and horizons as suggested by Weinert and Mazurek (1984) could be related to the faster process of mineralization and mobilizing of phosphorous favored by the oxidation due to the relatively higher temperature and frequent pulverization of farmlands. Also higher mean annual precipitation may have had an influence on leaching and indirectly through promoting biomass production giving more organic materials for mineralization. Prüeß et al. (1992) argued that the amounts of SOC distribution in the soil and landscape positions are the main factors of controlling available P and other soil fertility parameters. However, compared to the ratings for some tropical soils (Landon, 1991); the contents of available P are generally low to medium, which could be related to the P-fixation by Al and Fe (Zewdie, 1999). Consequently, low available P in the soils became one of the major soil fertility limiting factors to crop production in the study area and elsewhere where there is a similar soil type and landscape characteristic.

Among the exchangeable complexes, exchangeable Ca^{2+} showed variation with landscape positions ($p < 0.001$) and horizons (p = 0.019, Tables 4 and 5). It was higher in the lower position (15.93±1.04) followed by the upper compared with the middle landscape position. The middle landscape tended to lose significant Ca^{2+} because the topsoil is constantly eroded. The A-horizons have higher Ca^{2+} followed by the B-horizons compared with the Ab. Exchangeable calcium in a soil has an important relation to soil pH and to the availability of several nutrient elements (Thompson and Troeh, 1993). Throughout the studied horizons, Ca^{2+} remained to be high but declined with depth, attributed to the parallel decline in SOC with soil depth.

Table 5. Two-way ANOVA for base cations (exc. Na, K, Ca and Mg), CEC and Percent Base Saturations (PBS, %)

Source of variation	df	Exc. Na		Exc. K		Exc. Ca		Exc. Mg		CEC		PBS	
		MS	*p*	MS	*p*	MS	*p*	MS	*p*	MS	*p*	MS	*p*
Position (P)	2	0.017	0.729	0.023	0.891	152.066	<0.001	7.861	0.009	29.668	0.266	2840.647	<0.001
Horizon (H)	2	0.035	0.536	0.106	0.589	32.429	0.019	1.232	0.409	124.261	0.010	83.259	0.630
P × H	4	0.090	0.199	0.146	0.568	16.170	0.082	0.963	0.581	14.727	0.600	500.950	0.051
Error	20	0.054		0.195		6.678		1.316		20.974		175.908	

The second principal base cation in the exchange complex of andosols of the study area was Mg^{2+}, which significantly varied with landscape positions (p = 0.009). It was higher in the lower (3.99±0.65) than in the upper and middle landscape positions (Tables 4 and 5). Though not significant, Mg^{2+} also showed an increasing tendency with horizon and became higher in the Ab-horizon. The high concentrations of Mg^{2+} in the subsurface horizons compared to the surface horizon soils may be due to the effect of weathering and leaching of elements over time. The concentration of Ca^{2+} and Mg^{2+} generally follow the pH trend, in agreement with the findings of Young and Hammer (2000). The range in Mg^{2+} contents of the studied soils across the landscape positions and horizons were higher than the critical level of 0.5 cmol kg^{-1} reported for both tropical and temperate soils (Landon, 1991). Although the variation was not significant, exchangeable Na^+ showed an increasing trend with horizons with a recorded value of 0.62 cmolc kg^{-1} soil. Exchangeable potassium (K^+) is within a range of 0.94 to 1.01 and 0.85 to 1.04 $cmol_c$ kg^{-1} soil, respectively, with landscape positions and horizons. Exchangeable K^+ didn't show systematic pattern of variability with landscape positions and horizons.

The variation in CEC was significant with horizon (p = 0.010, Table 5), but not with landscape positions (p = 0.266). The highest CEC (25.85±1.78 $cmol_c$ kg^{-1} soil) was recorded in the A-horizon followed by the B-and the lowest (20.16±0.91) at the Ab-horizon (Table 4). Although the differences were not significant, CEC was higher in the lower landscape compared with the middle and upper positions. According to the Landon's (1991) ratings, the investigated soils have a medium level (25-40) of CEC for agricultural crop productions. The medium to high CEC values may be attributed to the predominance of high surface area clay minerals such as allophane and imegolite (Wada, 1985; Southard and Southard, 1989; Tegene, 1995). CEC of a soil is determined by the relative amount and/or of two main colloidal substances; humus and clay (Gao and Change, 1996).

The percent base saturation (PBS) varied with landscape position ($p < 0.001$; Table 5) with the highest at the lower landscape position (91.36±2.41) which could be attributed to the exchange sites with less amounts of organic matter (carbon) and more base cations leading to higher base saturation. The investigated soil across the landscapes and horizons had high PBS of greater than 56 percent. Except the soil profiles at the middle landscape position, the rest had high (greater than 60%) base saturation values and were generally considered fertile according to Landon (1991) ratings.

CONCLUSIONS

The studied soil in the Main Rift Valley area of Ethiopia showed marked variations in most of their physical and chemical properties with landscape positions and horizons. Most of the soil nutrients considered in the study was generally low due to lower organic matter inputs, which in turn were associated with less biomass return on harvested land, increased aeration by tillage, soil erosion and high P-fixation behaviors of andosols. Continuous intensive cultivation without appropriate soil management practices have also contributed for lower levels of soil nutrient distribution across the landscape positions. The lower levels of soil fertility indicators across the landscape reveal the need for improved land and water management strategies. Thus, based on the current study, emphases should be placed on promoting site-specific sustainable land management practices for soil nutrient improvement and thereby better agricultural productivity. Otherwise, the soils are likely to undergo accelerated degradation and rapid productivity losses.

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Teleconnection between Atlantic Ocean and Local Hydroclimate: Case of Lake Hawassa and Abaya in Ethiopian Rift Valley Basin

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Abstract

Large scale atmospheric circulations exist over wide areas that affect regional climate conditions in adjacent or remote regions. Important aspect of climate change and variability is how these teleconnections are related to and influence local hydroclimate. In this regard, the hydroclimatic condition of East-Africa has frequently shown to have teleconnection with Indian and Pacific Oceans with little focus on the influence of Atlantic Ocean. This study investigated the likely association of Atlantic Ocean with the hydro-climate of two selected lakes in Ethiopian Rift Valley Basin (Lake Hawassa and Lake Abaya). The study employed three statistical techniques: Pettit's homogeneity test to compare significant points of change across time; coherence analysis to measure the frequency and strength of the association; and principal component analysis to identify patterns of variations. The homogeneity test revealed that the water level of Lake Hawassa and Abaya have experienced significant regime shifts at and around the period in which sea surface temperature (SST) of Atlantic Ocean significantly shifted. On the other hand, the coherence analysis confirmed that the local hydrology has significant coherence ($p<0.01$) with the corresponding sea surface anomalies of Atlantic Ocean. In addition, the principal component analysis traces out the role of Atlantic Ocean and Indian Ocean to significantly act in the same direction of influence. The findings provide strong bases to consider sea surface temperature of Atlantic Ocean as one of the potential predictor of local hydroclimate in East Africa in general and Ethiopia in particular.

Key words: Coherence analysis; Lake level variability; Principal component analysis; Regime shift index; Sea surface temperature
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INTRODUCTION

The nature and cause of East African hydroclimate variability is a subject of heightened concern because of the frequent flood and drought events with far-reaching economic and social consequences that are linked to oceanic phenomena. Large scale atmospheric circulations exist over wide areas that affect regional climate conditions in adjacent or remote regions. These anomalies are called teleconnections and refer to the climate anomalies being related to each other at large distance. They served as a building block for the understanding of climate variability. These are striking features of the Earth climate system (Herein et al., 2017). They transmit climate signals over very long distances to remote ecosystems (Gu and Philander, 1997; Alexander et al., 2004). An important aspect of climate change and variability is how these teleconnections are related to and influence local climate and ecosystems such as lakes (Ghanbari et al., 2009). The climate variability manifests itself on the local hydrology such as the dynamics of Lake Surfaces. For instance, Lake Victoria water level dropped by 1.1 meters in ten year averages out of which 45% is caused by climate variability (Kull, 2006).

In this regard, Indian and Pacific Oceans are shown to have remote connection with East African rainfall (Hastenrath et al., 1993; Ogallo et al., 1994; Latif et al., 1999; Saji et al., 1999; Black et al., 2003). Whereas Chiang and Sobel (2002) reported that El Niño-Southern Oscillation (ENSO) impacts Africa through Tropical Atlantic, Alexander et al. (2002) reported that this happens via Indian Ocean teleconnections. Other researchers considered Indian Ocean Dipole (IOD, representing Indian Ocean) and El Niño-Southern Oscillation (ENSO, representing Pacific Ocean) are separate modes of variability (Yamagata et al., 2003; Behera et al., 2003). Teleconnection of large scale variability of Atlantic Ocean to the local hydroclimate of East Africa in general and Ethiopia in particular is much less understood. This study attempted to investigate the fingerprints of Atlantic Ocean to the local hydroclimate by considering two selected lakes in the Ethiopian Rift Valley Lakes Basin (Lake Hawassa and Abaya).

MATERIALS AND METHODS

Description of the study area

Rift Valley Lakes Basin is one of the eleven major river basins in Ethiopia with a total area of approximately 52,000km^2 (MoWR, 2010). The basin is characterized by a chain of lakes varying in size, hydrological and hydrogeological settings (Alemayehu et al., 2006). The basin constitutes eight lakes: Lake Ziway, Lake Langano, Lake Abiyata, Lake Shalla, Lake Hawassa, Lake Abaya, Lake Chamo, and Lake Beseka (Fig. 1*)* where all are located south-west of the Ethiopian capital Addis Ababa.

Available data

The three major groups of data that were used in this study include: the local hydrology in terms of monthly lake level variability acquired from Ministry of Water, Irrigation, and Electricity; the local climate in terms of variability in rainfall acquired from Ethiopian Meteorological Agency; the sea surface temperature indices of the three Oceans acquired from NOAA (National Oceanic and Atmospheric Administration). The three oceanic indices include TNA (Tropical Northern Atlantic Index representing surface temperature variation at Atlantic Ocean in the region 5.5N to 23.5N and 15W to 57.5W); NINO3.4 index for surface temperature variation at Pacific Ocean in the region 5N to 5S and 120W to 170W); and DMI index for Indian Ocean. The period1986-2006 was considered due to the availability of common data shared by each of the study units.

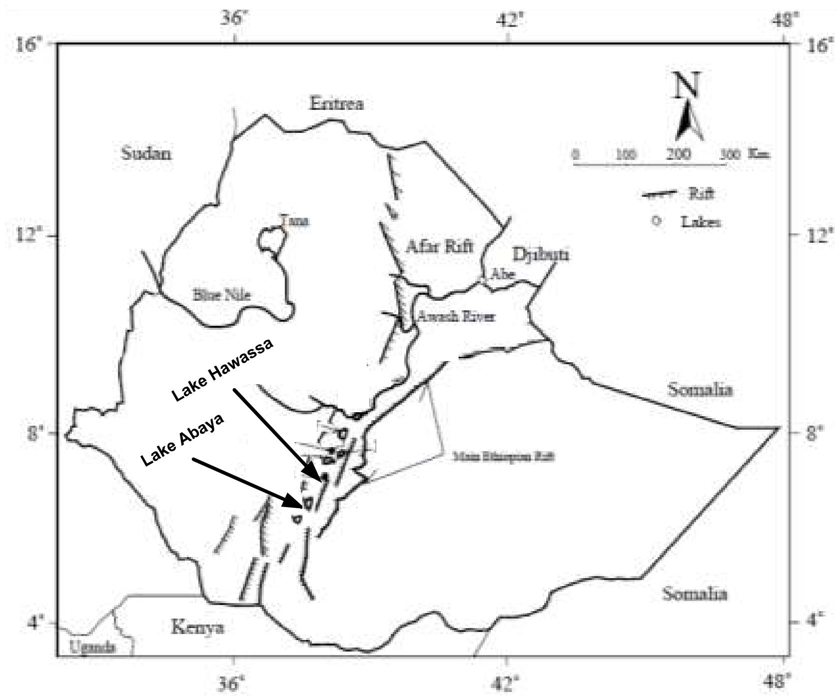

Figure 1. Location of Ethiopian Rift Valley lakes [Modified after Alemayehu et al. 2006]

Detection of regime shift (Pettit´s Homogeneity test)

In order to detect the significant regime shifts, the data sets were considered as a sequence of random variables $X_1, X_2, \ldots, X_T$ and said to have a change-point at τif X_t for t=1,…, τhave a common distribution function $F_1(x)$ and X_t for t =τ+1, …, T have a common distribution function $F_2(x)$, and $F_1(x) \neq F_2(x)$. The null hypothesis of "no change", H: τ=T is tested against the alternative hypothesis of "change", A: $1 \leq \tau < T$, using a non-parametric statistic.

Let $D_{ij} = sgn\,(X_i - X_j)$ where *sgn* (*x*) =1 if x >0; 0 if x=0; -1 if x <0, then consider

$X_{t,T} = \sum_{i=1}^{t} \sum_{j=i+1}^{T} D_{ij}.$ ………….…..………..… *(1)*

The statistic $U_{t,T}$ is then considered for values of t with $1 \leq t < T$ using the statistics:

$K_T = \max_{1 \leq t < T} |U_{t,T}|$ …………………………..… *(2)*

and for changes in one direction, the statistics

$K_T^{+} = \max_{1 \leq t < T} U_{t,T}$ ………………………….……..… *(3)*

$K_T^{-} = -\min_{1 \le t < T} U_{t,T}$ …………………..……..… *(4)*

Equivalently, the approximate significance probability p_{OA} associated with the value k+ of K_T^{+} is given by

p_{OA}=exp [-2$(k^{+})^2\{S_T(T^2 - TS_T)\}^{-1}$] …………… *(5)*

This approximation is conservative in that $p_{OA} \ge p$, where p is the exact significance probability.

Coherence analysis

The coherence, which is a measure of the correlation between two time series at each frequency, was made following Jenkins and Watts (1968) and Bloomfield (1976). A total of 252 pairs of monthly time series data of lake level variations and oceanic water surface temperature were analyzed for their coherence. Prior to the actual analysis, the time series data were de-trended using linear regression and autocorrelations were also removed by differencing techniques with order 1.

The cross-spectrum is then defined from the covariance function C_{xy}:

$$\Gamma_{xy}(\omega) = \sum_{\tau=-\infty}^{\infty} C_{xy} exp\{-2\pi i\tau\omega\},\ \omega \in \left[-\frac{1}{2}, \ldots, \frac{1}{2}\right] \text{….. (6)}$$

This is a complex function where the power is:

$$A_{xy}(\omega)^2 = Re(\Gamma_{xy}(\omega))^2 + \text{Im}(\Gamma_{xy}(\omega))^2 \text{……… (7)}$$

and the phase information is:

$$\Phi_{xy}(\omega) = tan^{-1}\left(\frac{\text{Im}((\Gamma_{xy}(\omega))}{Re(\Gamma_{xy}(\omega))}\right)^2 \text{…………………….(8)}$$

where $A_{xy}(\omega)$ is the modulus of the complex-valued cross spectrum, and $\Gamma_{xx}(\omega)$ and $\Gamma_{yy}(\omega)$ are the power spectra of processes x(t) and y(t) (Von Storch and Zwiers, 1999).
The coherence spectrum is then calculated as:

$$K_{xy}(\omega) = \frac{|A_{xy}(\omega)|^2}{\Gamma_{xx}(\omega)\Gamma_{yy}(\omega)} \text{………………… (9)}$$

Estimated coherences are considered significant at the 99% and 95% level of confidence when they are larger than the critical value T. In this study, Daniell´s window was used as smoothing techniques with window span of 5.

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was employed by including time series of the lake level and rainfall time series data of other four lakes in the rift valley basin (Ziway, Langano, Abiyata, and Chamo) for the short rainy season (October-November-December) for this period is usually reported to experience teleconnections (Camberlin et al., 2009; Schreck and Fredrick, 2004).

With this method, the variables were transformed in a multivariate data set, $X_1, X_2, \ldots, X_p$, into new variables, $Y_1, Y_2, \ldots, Y_p$ which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$Y_1 = a_{11}X_1 + a_{12}X_2 + \ldots + a_{1p}X_p \text{ …………… (10)}$$

$$Y_2 = a_{21}X_1 + a_{22}X_2 + \ldots + a_{2p}X_p$$

$$Y_p = a_{p1}X_1 + a_{p2}X_2 + \ldots + a_{pp}X_p$$

with the coefficients being chosen so that $Y_1, Y_2, \ldots, Y_p$ account for decreasing proportions of the total variance of the original variables, $X_1, X_2, \ldots, X_p$ (Everitt et al., 2001).

RESULTS AND DISCUSSION

Regime shift analysis

Lake Hawassa experienced regime shift in the annual average lake level in the year 1995-96 (from 20.44m to 21.14m), whereas Lake Abaya in the year 1993-94 (from 0.95m to 2.2m relative to the local bench mark) (Fig. 2). Correspondingly, the water surface temperature of Atlantic Ocean experienced the shift in the year 1994-95 (from -0.118 to 0.325 of the unit less index). The one year lag of Lake Abaya and an equivalent advance of Lake Hawassa from the driving teleconnection could be due to the local conditions on one hand and the involvement of other Oceans in influencing the circulation on the other hand. Similar justification could be applied for the contrasting results in the year 2000 and 2005. In addition, the 2004-2005 droughts (Ebei et al., 2008) that were associated to Indian Ocean (Hastenrath et al., 2007) might distort the teleconnection patterns. Generally, the result provides evidence to the likely linkage of local hydrology to the large scale phenomena of Atlantic Ocean in addition to the other Oceans.

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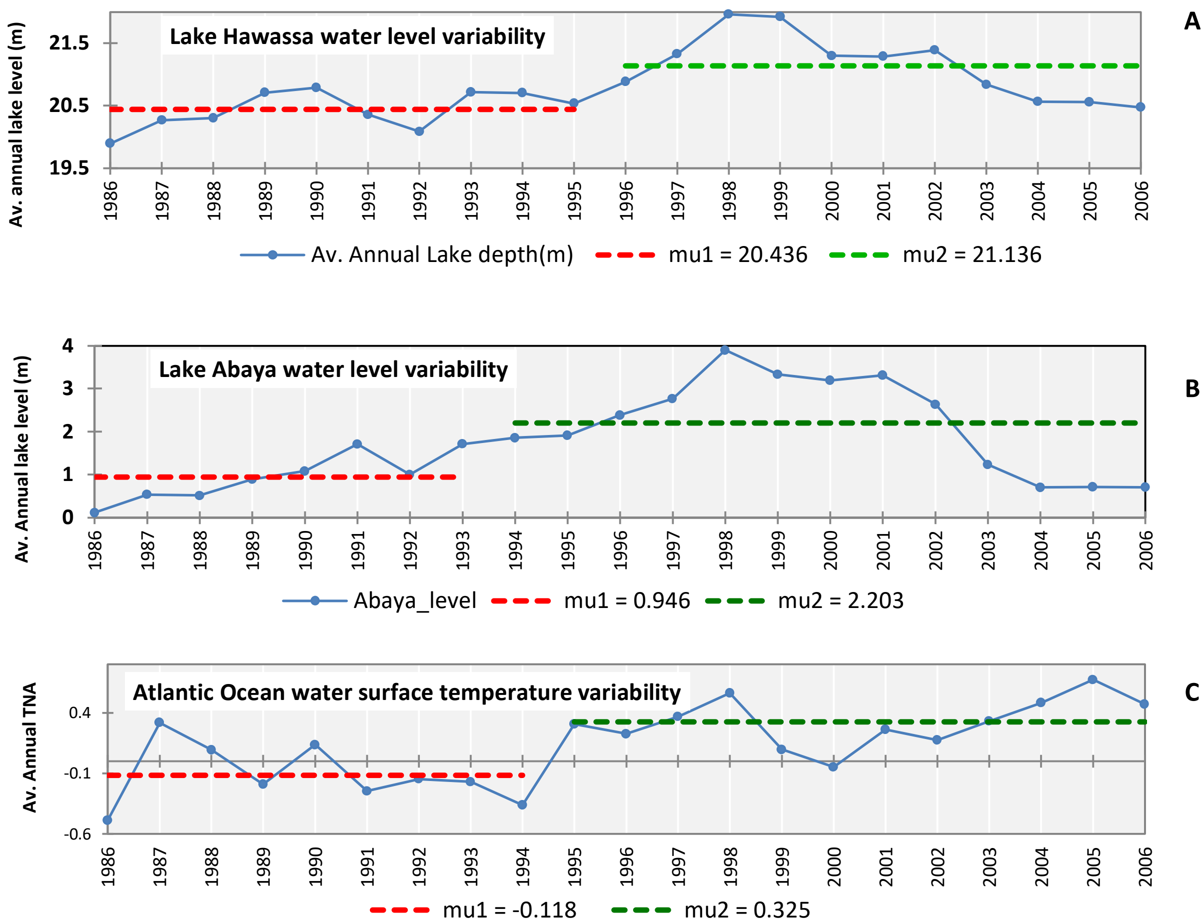

Figure 2. Dominant regime shift period of the local hydro-climate variables (NB: mu= μ=mean value)

Coherence analysis

The study indicated that the local hydrology has significant coherence with the corresponding distant signal at Atlantic Ocean as evidenced by the occurrences of significant peaks at 99%, 95% and 90% confidence limit (*represented by the three solid lines*) (Fig. 3). These high powers (significant peaks) in the same spectral frequency bands are statistical evidences for the significant interrelationship in the spectral domain at some specific frequencies where the peaks occurred.

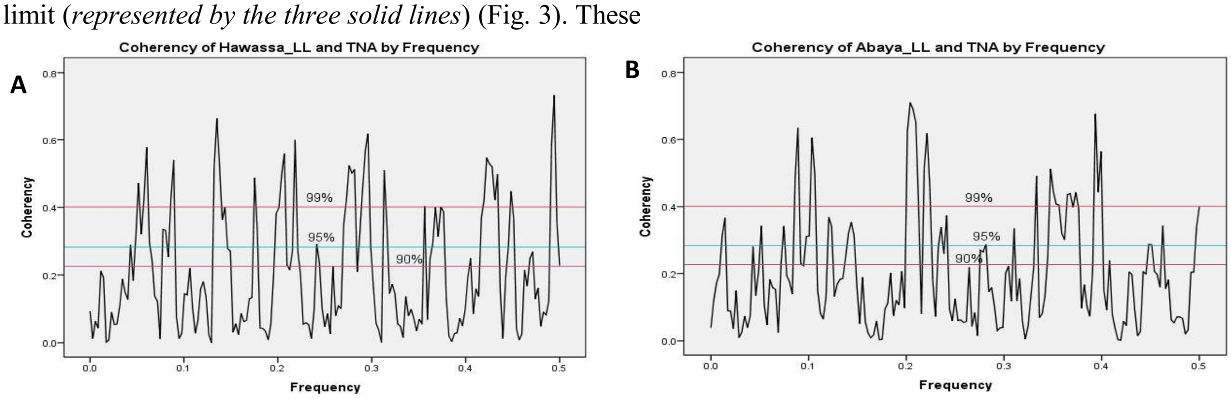

Figure 3. Relationship between SST of Atlantic Ocean and local lake level variability (A = Lake Hawassa; B = Lake Abaya)

Principal component analysis

The principal component analysis (PCA) traced out four important variabilities (Table 1). The first principal component (F1) which accounts for 26.2% of the total variation corresponds to the local rainfall and followed by the local hydrology (F2) which accounts for about 15.4%. The third component (F3) which explains the 11.5% of the vairiation is likely associated to the temperature variabilities in Indian and Atlantic Oceans. The fourth component (F4) with 9.8% of the total variation represents sea surface temperature (SST) variability at Pacific Ocean.

Table 2. Correlations between hydroclimatic variables and factors

Hydroclimate variables	F1	F2	F3	F4
Sea surface temperature variation: Indian ocean	0.1	-0.4	**0.6**	0.3
Sea surface temperature variation: Pacific ocean	-0.1	-0.5	0.1	**0.6**
Sea surface temperature variation: Atlantic ocean	0.2	0.2	**0.8**	0.1
Rainfall: Lake Hawassa	**0.7**	-0.4	0.1	0.1
Rainfall: Lake Abiyata	**0.8**	-0.2	-0.1	-0.2
Rainfall: Lake Ziway	**0.7**	-0.1	-0.3	0.0
Rainfall: Lake Abaya	0.2	-0.3	-0.1	0.3
Rainfall: Lake Chamo	**0.7**	-0.3	0.2	-0.1
Rainfall: Lake Langano	**0.8**	-0.2	-0.2	-0.3
Lake level variation: Lake Ziway	0.5	**0.7**	-0.1	0.4
Lake level variation: Lake Hawassa	0.5	**0.6**	0.3	0.3
Lake level variation: Lake Abaya	0.2	**0.6**	0.2	-0.2
Lake level variation: Lake Chamo	0.3	0.4	-0.5	0.5
Lake level variation: Lake Langano	0.0	0.2	0.3	-0.3

Though Indian Ocean has significant teleconnection, the case of Atlantic Ocean is shown to be stronger. The third principal component that shows the association between SSTs of Indian and Atlantic is in consistent with the findings of Chiang and Sobel (2002) who reported the impact of ENSO on Africa via tropical Atlantic. On the other hand Alexander et al. (2002) argued it to happen via Indian Ocean in which both oceans are likely to impact African hydroclimate.

CONCLUSION

The findings provide strong bases to consider Atlantic Ocean as a candidate predictor of local hydroclimate in East Africa in general and Ethiopia in particular. Such findings with further future researches on the modes of variabilities in Atlantic Ocean will improve the predictability of hazardous hydroclimatic events such as flood and drought. The finding also implies the importance of considering the sea surface temperature (SST) variability of Atlantic Ocean in future modeling of local hydroclimate in addition to the frequently employed Indian and Pacific SSTs. Such conditions provide opportunities to make use of better predictability of tropical sea surface temperatures up to two years ahead of time (Chen et al., 2004) that potentially be transferred to forecasting the local hydroclimate. Moreover, the argument on the primary impact of Indian Ocean on East African hydroclimate requires reconsideration due to the significant share of Atlantic Ocean to influence the local hydroclimate.

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Morphological and Molecular Identification and Categorization of *Aspergillus* Isolates Associated with Different Crops from Delhi Market, India

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Abstract

Aspergillus species infecting fruits (Apple & Brinjal) and crop seeds (Maize, wheat, beans, groundnut, paddy and black gram) collected from the market of Delhi during 2008 were identified by using morphological and molecular methods. Sixty-five diseased specimens of fruits and crops were collected from the market and isolations of the pathogens were made. Twenty isolates of *Aspergillus* were separated on the basis of genus characters. The isolates were further categorised into five different species based on their colony characters, viz. colony growth, color and texture and microscopic observations,i.e. conidial head, conidiophore, vesicle, sterigmata and conidia. Random amplified polymorphic DNA (RAPD) fingerprints using six arbitrary 10 mers primers clearly separated the species. Morphological grouping and speciation matched with the molecular grouping for most of the isolates. The random primer OPB11 gave reproducible and very stable result for strain delineation of five examined pathogenic *Aspergillus* species (*A. niger, A. flavus, A. parasiticus, A. terreus* and *A. ochraceus)* in comparison to other primers and this primer was used to develop species specific marker to identify *Aspergillus flavus* as it gave monomorphic band for all the *A. flavus* isolates studied.

Key words: *Aspergillus*; Genetic diversity; RAPD; Speciation

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INTRODUCTION

Aspergillus is an important genus containing some toxigenic fungi that cause postharvest spoilage. Ayalew (2010) reported that *Aspergillus* is found in association with barley, maize, teff, wheat and sorghum and produced mycotoxins which are harmful to consumer health. Mohammed et al. (2016) isolated fungi from groundnut seeds and reported that *Aspergillus flavus* was the dominant species followed by *Aspergillus parasiticus* in infecting groundnut in eastern Ethiopia. *Aspergillus niger* causes black mold disease on grapes, onions and peanuts and it is a common contaminant of food (Sharma, 2012). It decreases percent seed germination during storage by invasion of the embryos and increases fatty acids by deteriorating seeds (Agrios, 2005). *A. flavus* and *A. niger* showed the highest rate of occurrence in the marketed papaya fruits in Southwest Nigeria (Baiyewu et al., 2007). Aflatoxin producing *Aspergillus* species, viz, *A. flavus* and *A. parasiticus* can infect grains from pre-harvest stage in the field to postharvest in the store (Bandyopadhyay et al., 2005). They occur in and upon a great variety of substrata, being considered as common food spoilage fungi (Pitt and Hocking, 1997).

Aspergillus taxonomy is complex and ever evolving. The genus is easily identified by its characteristic conidiophore but species identification and differentiation is complex, for it is traditionally based on a range of morphological features (Rodrigues et al., 2007). Although molecular methods continue to improve and become more rapidly available, microscopic and cultural (macroscopic) techniques remain commonly used and essential tools for identification of *Aspergillus* species (McCleny, 2005).

Diba et al. (2007) reported that the macroscopic characteristics including colony diameter, color, exudates, colony texture and the microscopic characteristics (conidial heads, stipes, color, length, vesicles shape and seriation, phialide, metula covering, conidial size, shape and roughness) are the remarkable features for species identification. The sporangium or conidial heads are used to distinguish the different groups of *Aspergillus* species. These heads are formed by conidiophores, vesicle, and a series of primary sterigmata, followed by a second series of secondary sterigmata of which the conidia or spores sprout (Soledad et al., 2005).

Mitchel et al. (1994) developed polymerase chain reaction (PCR) primers to identify *Aspergillus fumigatus* at low stringency**.** Peter et al**.** **(**2002**)** studied SDS-PAGE and RAPD to identify *A. fumigatus*, *A. niger, A. terreus* and *Aspergillus ustus*, and reported that RAPD analysis showed a high degree of discriminatory power.

Aspergillus tubingensis and *A. niger* have a high morphological similarity, and *A. tubingensis* was considered as a subspecies of *A. niger* but the utilization of molecular methods allowed a better distinction among the species (Accensi et al., 2001). RAPD using the RI08 primer was successful in species differentiation of *A. flavus*, *A. fumigatus* and *A. niger* (Novak et al*.,* 2004; Raclavskya*,* 2006). Identification of the most common toxigenic *Aspergillus* species associated with fruit and other important crop species remained problematic due to the variability in the phenotypic and genotypic characters. The new taxonomies are based on a poly-phasic approach using phenotypical characters, like macro-and micro-morphology together with multi-gene DNA sequence (Robert et al*.,* 2006).

Therefore, the objectives of this study were to investigate the diversity and distribution of *Aspergillus* species associated with different crops and identify the *Aspergillus* species involved based on morphological and molecular diagnostic methods.

MATERIALS AND METHODS

The study on *Aspergillus* species existing in the diseased fruits and seeds collected from the market of Delhi was undertaken during 2008 (Table 1). Sixty-five diseased specimens were collected in polythene bags and incubated on moist cotton in petriplates (28 ± 2 °C) for 3-7 days and fruiting structure of the fungi were collected and isolated on potato dextrose agar (PDA) medium. Based on genus characters, twenty *Aspergillus* species isolates were separated and further identified to species level

Macroscopic studies

Spores from individual colonies of *Aspergillus* species grown on PDA were transferred to fresh PDA plates using a sterile needle, and then streak isolated using a sterile loop to obtain separate individual colonies. Plates were incubated at 30 °C for 72 h, and then small pieces of agar containing hyphal tips were transferred to Czapek dox medium prepared according to Horn et al. (1996).

The major and outstanding macroscopic features like colony growth, color and texture were studied for species identification (Diba et al., 2007). Fungal growth was measured at the reverse side of the colonies with the scale in centimeters at intervals of 24 hours starting from the third day of incubation. Further, all isolated *Aspergillus* species were identified to the species level using taxonomic systems by Klich (2002). Data collected on radial growth of the *Aspergillus* isolates were analyzed by SAS statistical package (SAS 9.1.3, 2009).

Table 1. Plant sources for isolation and identification of different *Aspergillus* species/isolates

Sample number	Source	
	Common name	Scientific name
1	Groundnut seed	*Arachis hypogaea*
2	Maize seed	*Zea mays*
3	Maize seed	*Zea mays*
4	Groundnut seed	*Arachis hypogaea*
5	Wheat seed	*Triticum aestivum*
6	Soyabean seed	*Glycine max*
7	Groundnut seed	*Arachis hypogaea*
8	Apple fruit	*Malus pumila*
9	Mushroom pileus	*Agaricus bitorquis*
10	Apple fruit	*Malus pumila*
11	Wheat seed	*Triticum aestivum*
12	Soyabean seed	*Glycine max*
13	Bean pod	*Dolichos lablab*
14	Soyabean seed	*Glycine max*
15	Black gram seed	*Vigna mungo*
16	Bean pod	*Phaseolus vulgaris*
17	Paddy seed (rice)	*Oryza sativa*
18	Wheat seed	*Triticum aestivum*
19	Wheat seed	*Triticum aestivum*
20	Brinjal fruit	*Solanum melangena*

Microscopic studies

Microscopic features of isolates, *viz.* conidial head, vesicle size, sterigmata, conidiophore wall, size and wall of conidia were taken as parameters for differentiation of species. The conidial head shape was observed directly from the tube under microscope and pictures were taken under X100 magnification. Microscopic slides were prepared and the shape, fertile area and size of the vesicle, bi/uni series of sterigmata, conidiophore roughness, size and wall of conidia were recorded. The photomicrographs of the above characters were taken using Olympus digital camera (Olympus cx41 model, Japan). Conidia of the fungal species were drawn using camera lucida and measured in µm (Model: E.LEITZ, Wetzlar, Germany).

Genetic analysis

Fungal cultures were sub-cultured onto 100 ml Erlenmeyer-flasks containing 25 ml. (per litter: 1 g K_2HPO_4; Czapek concentrate, 10 ml; yeast extract, 5 g and sucrose, 200 g) for ten days using a rotator shaker (27°C at 150 rpm). Genomic DNA for RAPD analysis was extracted from 200-300 mg frozen mycelium of *Aspergillus* species based on Cetyltrimethyl ammonium bromide (CTAB) extraction method of Raeder and Broda (1985) with partial modification. The DNA concentration and purity of the samples was determined with Nano Drop Spectrophotometer. PCR conditions and separation of RAPD-PCR fragments were carried out according to Messner et al. (1994). The PCR protocol was standardized by changing the variables like template DNA, Taq DNA polymerase and $MgCl_2$. The optimum amplification was obtained by using a reaction mix having 50 ng template DNA, 5 unit Taq polymerase, 50 mM $MgCl_2$, 10 µM primer and 10 µM dNTPs in reaction volume of 25 µl. Eight random 10 mer Operon primers from set of OPA, OPB, OPZ and another primer R108 were screened. Of these, six primers were selected for RAPD analysis based on their reproducibility and score able polymorphic bands obtained (Table 2).

Table 2**.** Primers used for RAPD analysis of different isolates of *Aspergillus* species

Number	**Primer**	**Sequence 5' to 3'**
1	OPB2	TGATCCCTGG
2	OPB5	TGCGCCCTTC
3	OPB7	GGTGACGCAG
4	OPB11	GTAGACCCGT
5	OPB17	AGGGAACGAG
6	OPB18	CCACAGCAGT
7	RI08	GTATTGCCCT
8	OPZ19	GTGCGAGCAA
9	OPA20	GTTGCGATCC

RAPD profiles were scored visually by comparing RAPD amplification profiles and scoring the presence or absence of each band in each profile according to Halmschlager et al. (1994). The bands on agarose gel electrophoresis were visualized and manually scored by hand to a two - discrete - character - matrix (0 and 1 for absence and presence of RAPD - markers). All amplifications were repeated at least twice and only reproducible bands were considered for analysis. The data obtained from RAPD analysis were subjected to un-weighed pair – group method for arithmetic average analysis (UPGMA) to generate a dendrogram using average linkage procedure.

RESULTS AND DISCUSSION

Twenty *Aspergillus* species isolates were obtained from the diseased fruits and crop seeds collected from the market randomly (Table 1).

Macroscopic studies

On the basis of growth on PDA, the isolates were categorized in to three groups. Group I consisted of eight isolates (isolates: 4, 5, 9, 10, 12, 14, 15, and 16) that were slow growing (less than 4.0 cm in diameter/ seven days). Group II had seven isolates (isolates 1, 2, 3, 6, 8, 11 and 18), which were moderately growing (4.0 – 5.0 cm in diameter/seven days). Group III had five isolates (isolates 7, 13, 17, 19 and 20) that were rapidly growing (more than 5.0 cm in diameter/seven days) (Table 3; Fig. 1).

According to colony color and texture, all the 20 isolates were classified into five different groups (Fig. 2). In the first group of isolates, the mycelium was surface and plane in most of the isolates (nos. 6, 7 and 17) but in one isolate it was radially furrowed (no. 1). The color of the colony of all the isolates within this group was yellow green when young and turned to jade green with age. The second group consists of isolates, the mycelium of which was commonly surface and plane (nos. 5, 11, and 19), slightly raised at the center (no. 5) and slightly furrowed (no. 20). Colony color was yellowish green when young and turned to brownish green with age. Colony texture of group three isolates was surface, plane and slightly raised at the center (no. 12) and occasionally radially furrowed (no. 16) with yellow brown when young later turned to dull brown color. Isolates in group four had mycelium, which is submerged and wrinkled, yellow when young and turned to orange brown with age. Isolates within the fifth group had velvety mycelium, which is plane and radially furrowed with darkest brown to carbonaceous black in color.

Table 3. Colony characteristics of the 20 isolates of *Aspergillus* species

Isolate number	Growth (cm)	Texture	Color
1	4.5	Surface, furrowed	Yellow-brown-green
2	4.0	Velvety, furrowed	Darkest brown
3	4.0	Velvety, furrowed	Carbonaceous. Black
4	3.0	Floccose	Light yellow
5	4.0	Raised, Plane	
6	5.5	Surface, furrowed	Yellow-brown-green
7	6.0	Surface, Plane	Yellowish brown
8	4.2	Velvety, furrowed	Darkest brown
9	2.8	Surface, submerged & furrowed	Brown - woody brown
10	2.6	Surface, submerged & furrowed	Yellow brown
11	4.0	Surface, plane	Yellow - dark green
12	3.0	Raised, Plane	Yellow brown
13	5.0	Velvety, furrowed	Darkest brown
14	3.0	Surface, & submerged, slightly	Brown
15	3.2	Raised, furrowed	Dirty brown
16	3.5	Raised, furrowed	Dull yellow brown
17	5.8	Slightly raised, plane	Yellowish green – brown green
18	2.8	Surface, submerged & furrowed	Brown
19	5.2	Raised, Plane	Bright yellow.-dark brown green
20	5.2	Surface & furrowed	Yellow Green – dark brown green

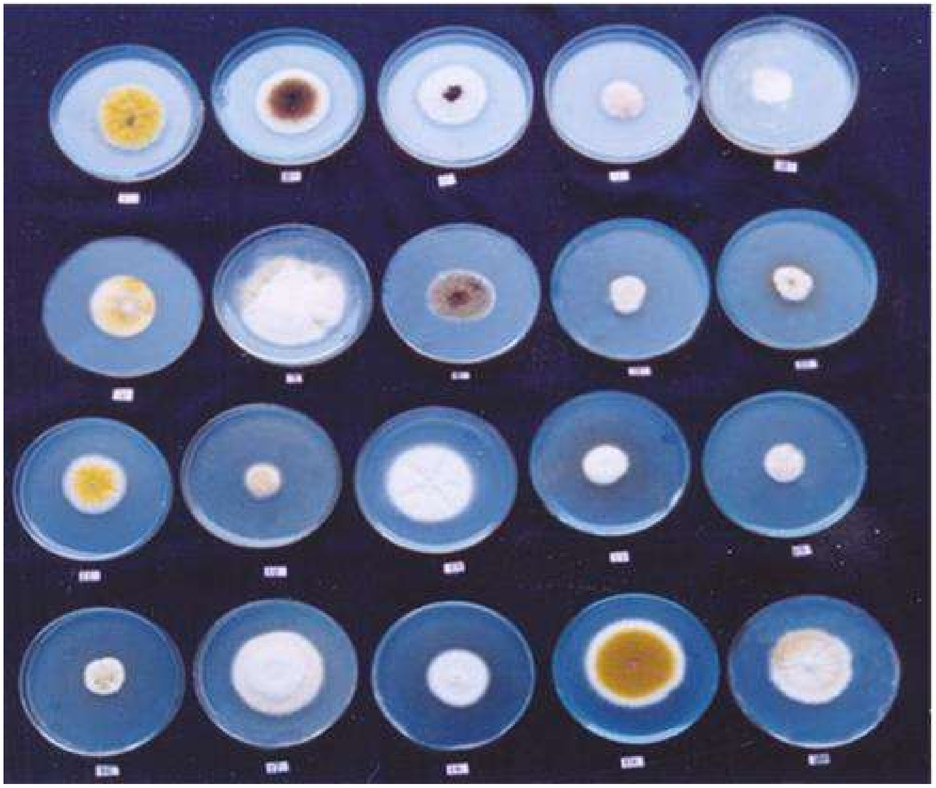
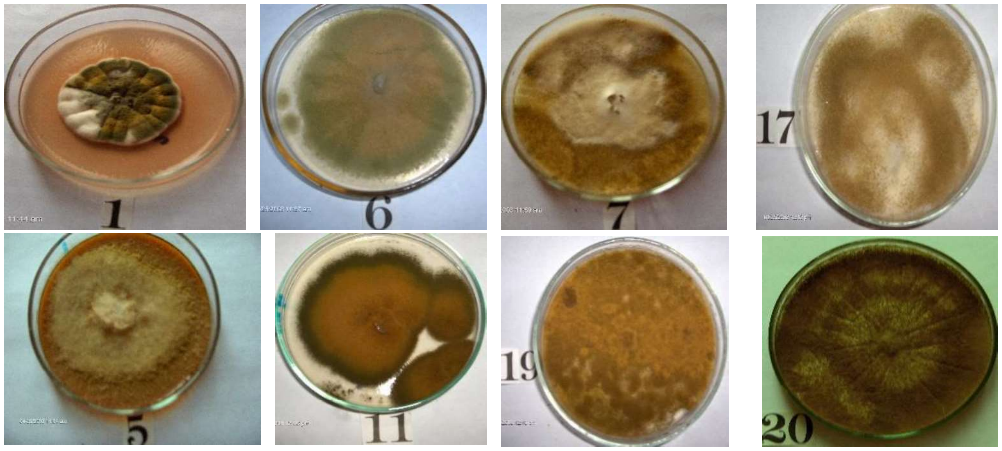


Figure 1. Colony growth of 20 different isolates of *Asperigillus* species in 7days old cultures.

Microscopic studies

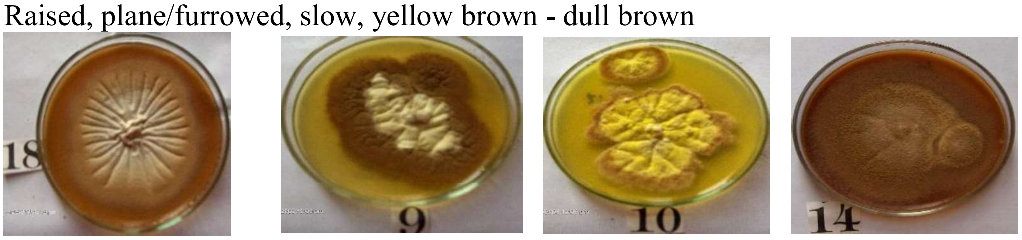
In most of the isolates, the shape of conidial head was radiate usually splitting in to many but in group three isolates (nos. 4, 12, 15, and 16), the conidial heads were globose and in group four isolates (nos. 9, 10, 14 and 18) the conidial heads were long columnar (Fig. 3).

The conidiophore wall was rough only in isolates 1, 6, 7 and 17, whereas the remaining isolates of all *Aspergillus* species had smooth wall. The vesicle shape of all the isolates was more or less globose (Fig, 4). The size of the vesicle ranged from 10 - 15 to 51 – 75μm in diameter in different groups. In the isolates 1, 9, 10, 14, 17 and 18, the vesicle was not entirely fertile (Table 4; Fig. 4).



Surface / raised, plane/ furrowed, moderate, yellow green – brownish green

Raised, plane/furrowed, slow, yellow brown - dull brown



Submerged and wrinkled, slow, yellow brown – orange brown,

Velvety, furrowed, moderate, dark brown- black

Figure 2. Colony color and texture of the 20 isolates of *Aspergillus* species (3 weeks old)

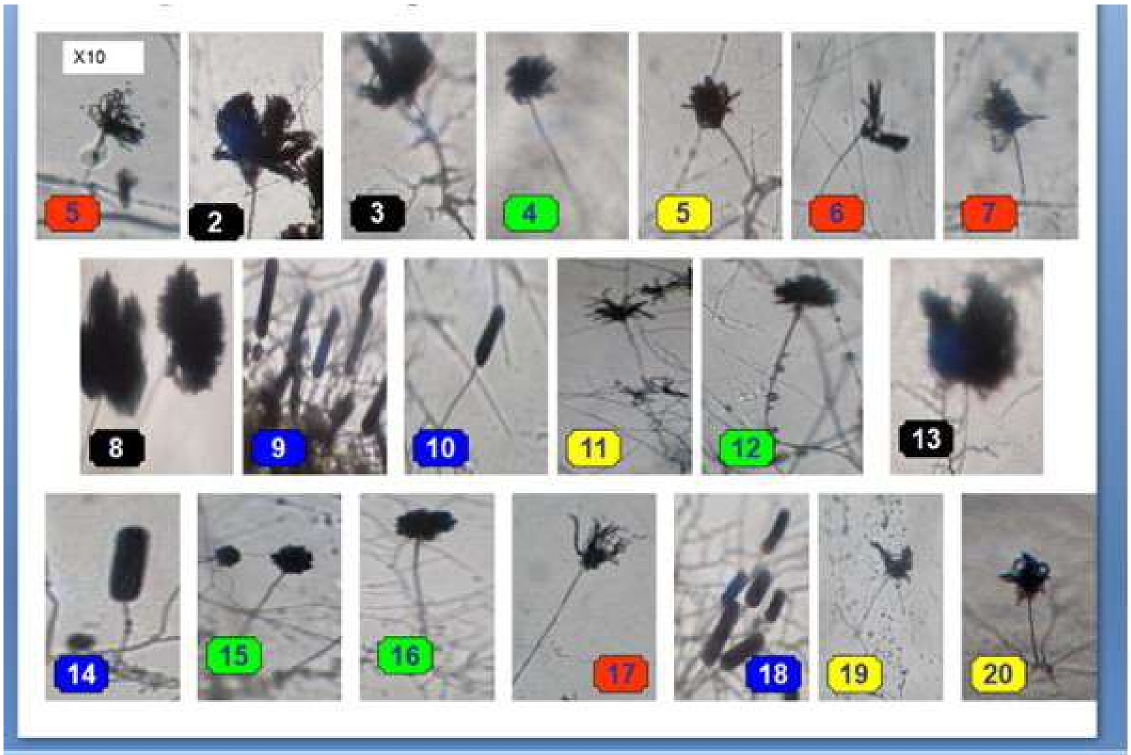


Figure 3. Size and shape of the conidial heads of 20 isolates

The arrangement of sterigmata was in two series in most of the isolates (nos. 1, 2, 3, 4, 6, 8, 9, 10, 12, 13, 14, 15, 16 and 18) but it was single series in some isolates (nos. 5, 7, 11, 17, 19 and 20). In group one isolates, sterigmata was uniserate for isolates 7 and 17, whereas isolates 1 and 6 showed biseriate sterigmata. Sterigmata in group two isolates (5, 11, 19, and 20) were in one series only measuring 10 – 13µm in length. All the isolates of group three (nos. 4, 12, 15 and 16) and four (nos. 9, 10, 14 and 18) showed biseriate sterigmata. In group five isolates (nos 2, 3, 8 and 13), the primary sterigmata was double to the secondary sterigmata in size (Table 4).

The conidial walls were smooth for isolates 4, 9, 10, 12, 14, 15, 16 and 18, whereas the remaining isolates were rough walled (Fig. 5). The diameter of conidia of group 1, 2, 3, 4 and 5 were 6 - 8, 8 - 10, 3 - 4, 2 - 3, and 4 - 6µm, respectively (Table 4; Figs. 5 and 6).

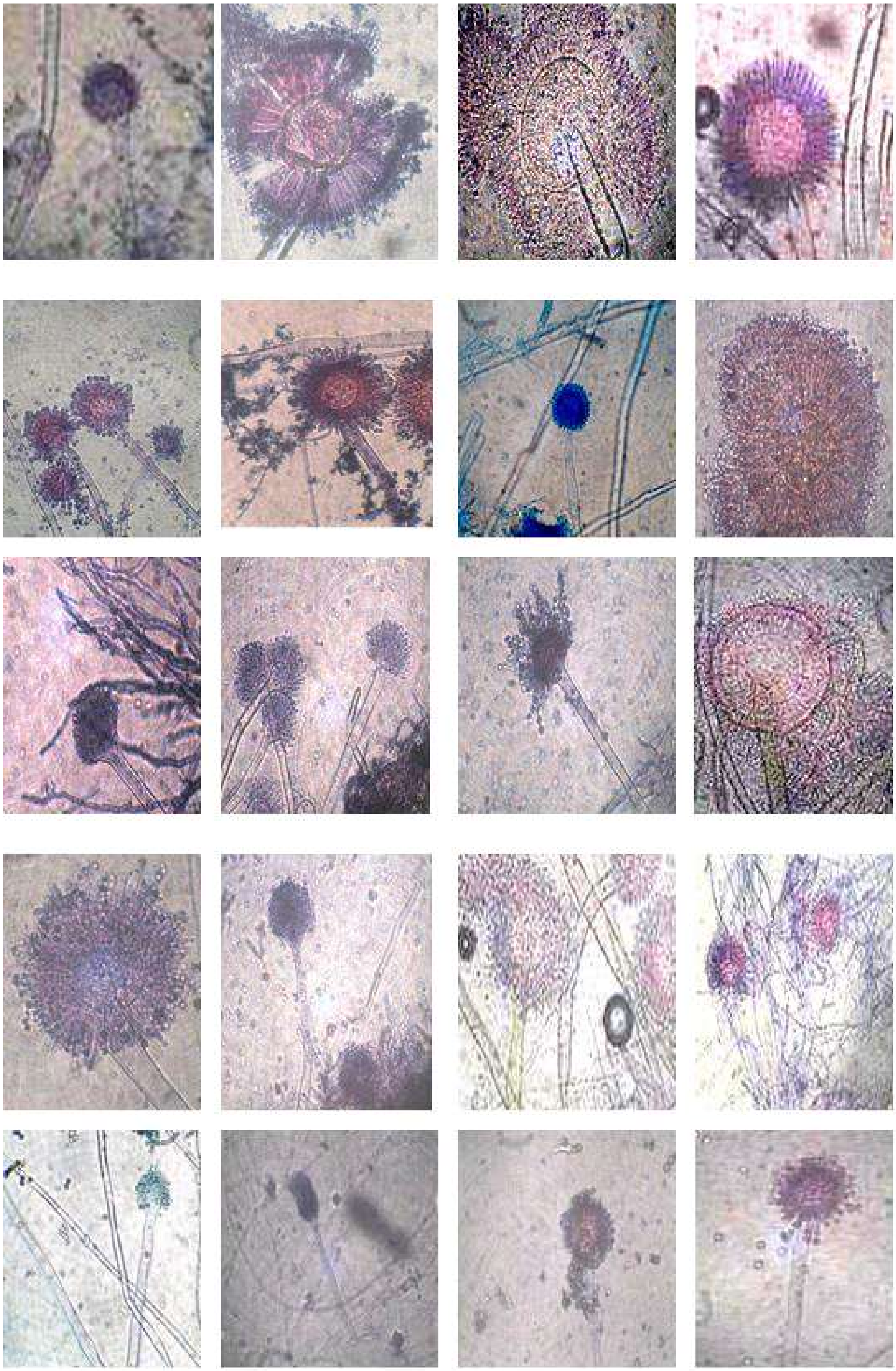


Figure. 4. Vesicle, Sterigmata and Conidiophore characters of 20 isolates *Aspergillus* species (X400)

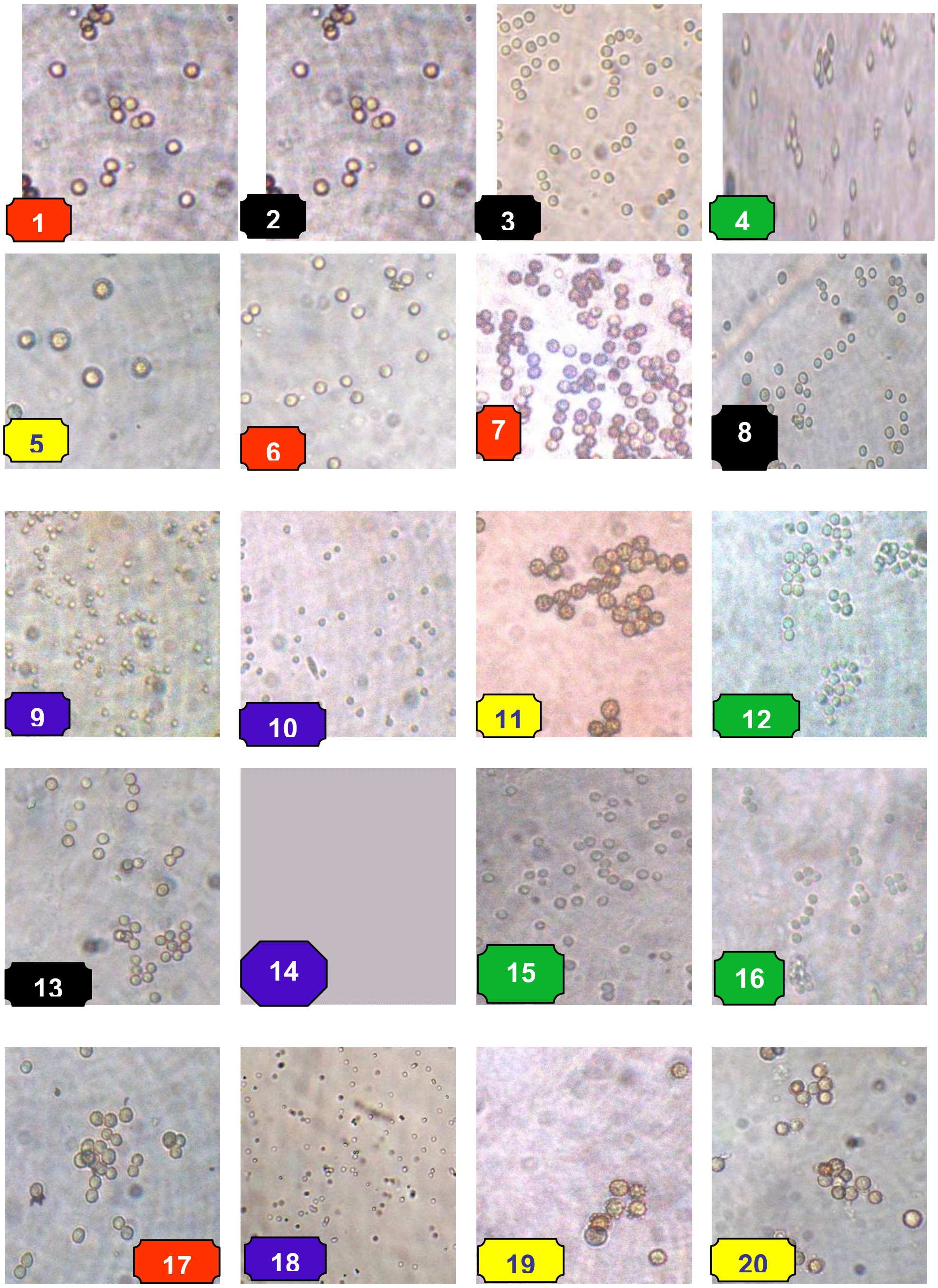


Figure 5. Size and texture of the conidia of 20 different isolates of *Aspergillus* species (X400)

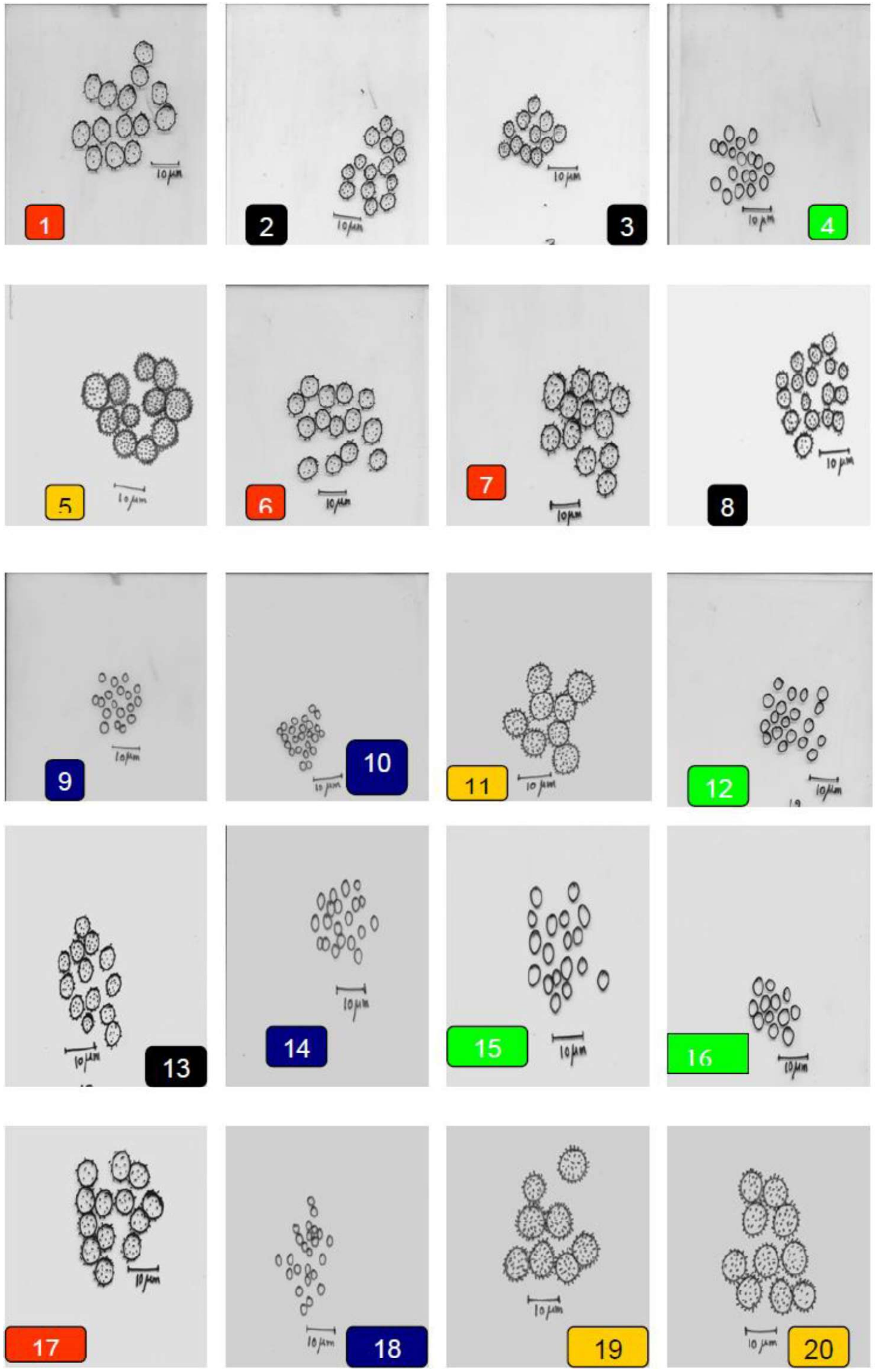


Figure 6. Camera lucida drawings of conidia of the 20 isolates of *Aspergillus* species

Table 4. Conidial stage characteristics of the 20 isolates of *Aspergillus* species

Isolate number	Conidial Head	Vesicle		Sterigmata (µm)		CP Wall	Conidia	
		Size (µm)	Fertile area	Uniserate	Biserate		Size (µm)	wall
1	Radiate	28-30	NFC	10-18	11.0	Rough	6.0-7.5	rough
2	Radiate	55-75	FC	35.0	15.0	Smooth	4.0-6.0	"
3	Radiate	58-70	"	15.0	7.0	"	4.0-6.0	"
4	Globose	40-50	"	10.0	14.0	"	3.5-4.0	smooth
5	Radiate	18-25	"	12.0	---	"	6.0-8.5	rough
6	Radiate	27-35	"	13-15	15-20	Rough	6.5-8.0	"
7	Radiate	29-33	"	13-15	---	"	6.0-8.0	"
8	Radiate	51-75	"	40-45	20.0	smooth	4.0-6.0	"
9	LC	11-14	NFC	5.0	10.0	"	2.5-3.0	smooth
10	LC	10-15	" "	7.0	7.0	"	2.5-3.0	"
11	Radiate	20-25	FC	13.0	---	"	8.0-9.0	rough
12	Globose	38-45	"	10.0	20.0	"	3.5-4.0	smooth
13	Radiate	52-65	"	16.0	7.0	"	4.0-6.0	rough
14	LC	12-15	NFC	8.0	6.0	"	2.0-3.0	smooth
15	Globose	38-50	FC	5.0	13.0	"	3.5-4.0	"
16	Globose	40-45	"	7.0	14.0	"	3.0-4.0	"
17	Radiate	30-33	NFC	8-10	---	rough	7.5-8.0	rough
18	LC	13-14	"	7.0	7.0	smooth	2.5-3.0	smooth
19	Radiate	22-25	FC	10.0	---	"	9.0-10	rough
20	Radiate	20-25	"	10.0	---	"	9.0-10	rough

Considering all the above morphological characters, the isolates were categorized into five different groups based on the key below:

***Aspergillus* species identification key made based on morphology** (Raper and Fennell, 1965)

1. Rapid - moderately growing, yellow green when young, conidia definitely echinulate.

A. Colony turned to jade green with age, sterigmata uni / biseriate, big vesicle size (27-35µm) and fertile area entire or not. Conidiophore (CP) wall rough and conidia 6-8µm**……………………………..Group 1**

AA . Colony turned to dark brownish green with age, sterigmata uniseriate, smaller vesicle size (18-25µm), fertile are entire. Conidiophore wall smooth, conidia 8–10µm……………………………………**Group 2**

2. Slow growing, yellow brown when young, conidial wall smooth

A. Colony turned to dull brown with age, head globose, bigger vesicle size (38-50 µm), conidia 3-4µm……………………………………..**Group 3**

AA. Colony turned to orange brown with age, head columnar, smaller vesicle size (10 – 15µm), conidia 2-3µm……………………………………**Group 4**

3. Moderately growing, Colony darkest brown to carbonaceous black, head radiate, very big vesicle (51 – 75 µm), biseriate (primary sterigmata is double in length to secondary sterigmata), conidia 4-6µm. ……………………………………………...**Group 5**

The morphological characters of all five groups observed in the study were compared with previous literatures (Raper & Fennel, 1965: Collier et al., 1998; Larone, 2002; Diba et al., 2007; Rodrigues et al., 2007). Accordingly, Group I was placed under *Aspergillus flvaus* (isolates 1, 6, 7 and 17), Group II as *A. parasiticus* (isolates 5, 11, 19 and 20), Group III as *A. ochraceus* (isolates 4, 12, 15 and 16), Group IV as *A. terreus* (isolates 9, 10, 14 and 18) and Group V as *A. niger* (isolates 2, 3, 8 and 13) (Table 5).

All the 20 isolates were deposited at the Indian Type Culture Collection (ITCC) and the accession numbers are given (Table 6).

Table 5. Speciation of groups of the 20 isolates of *Aspergillus* species

Group number	Species	Isolate number
1	*Aspergillus flavus*	1, 6, 7 and 17
2	*Aspergillus parasiticus*	5, 11, 19 and 20
3	*Aspergillus ochraceus*	4, 12, 15 and 16
4	*Aspergillus terreus*	9, 10, 14 and 18
5	*Aspergillus niger*	2, 3, 8 and 13

Table 6. Deposition of 20 isolates of *Aspergillus* species at Indian Type Culture Collection

Isolate	Species	ITCC
1	*A. flavus*	6347
2	*A. niger*	6348
3	*A. niger*	6349
4	*A. ochraceus*	6350
5	*A. parasiticus*	6351
6	*A. flavus*	6352
7	*A. flavus*	6353
8	*A. niger*	6354
9	*A. terreus*	6355
10	*A. terreus*	6356
11	*A. parasiticus*	6357
12	*A. ochraceus*	6358
13	*A. niger*	6359
14	*A. terreus*	6360
15	*A. ochraceus*	6361
16	*A. ochraceus*	6362
17	*A. flavus*	6363
18	*A. terreus*	6364
19	*A. parasiticus*	6365
20	*A. parasiticus*	6366

Molecular analysis

A total number of 329 bands were produced for the *Aspergillus* isolates and all of them were polymorphic. The maximum number of bands (86) was obtained with primer OPB11. The size of fragments obtained ranged from 0.5 to 4kb (Fig. 7). The dendrogram showed that the isolates representing various *Aspergillus* species are different.

Isolates formed two main clusters with all the six primers tested (Fig. 8). The cluster analysis separated one of the isolates (Isolate no. 5) of *A. parasiticus* from all other isolates. The dendrogram obtained separated *A. niger* isolates (Isolates no. 2, 3, 8 and 13) from all the other isolates and revealed more than 75% similarity among themselves. Isolate 1 was separated from other isolates (Isolates 6, 7 and 17), which were in same group under *A. flavus* according to morphological identification. These *Aspergillus flavus* isolates formed one cluster at 40% similarity. Isolates 9, 10, and 14 formed another cluster at 48% similarity, whereas isolate 18 was separated from same group of *Aspergillus terreus* according to morphological identification. *Aspergillus ochraceus* isolate 15 was separated from the rest of *Aspergillus ochraceus* isolates, i.e. 4, 12, and 16. Isolate 15 was clustered with *A. parasiticus* isolate 11 at 25% similarity but isolates 4 and 12 formed a separate cluster at 47% similarity. *Asperigillus parasiticus* isolates 19 and 20 formed one cluster at 50% similarity.

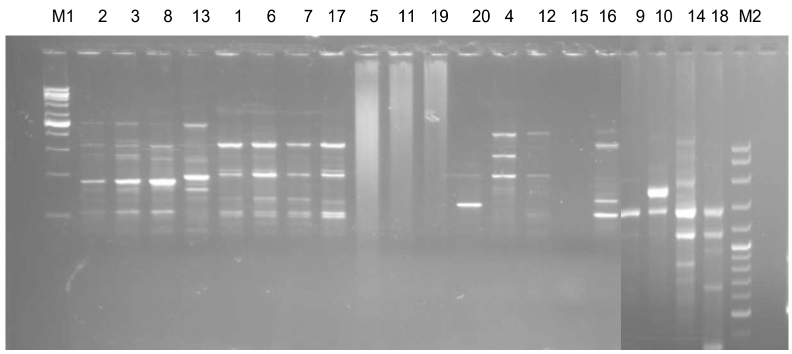


Figure 7. RAPD profile of 20 isolates of *Aspergillus* species with OPB 11 primer (M1=1 Kb ladder, M2=100 bp ladder).

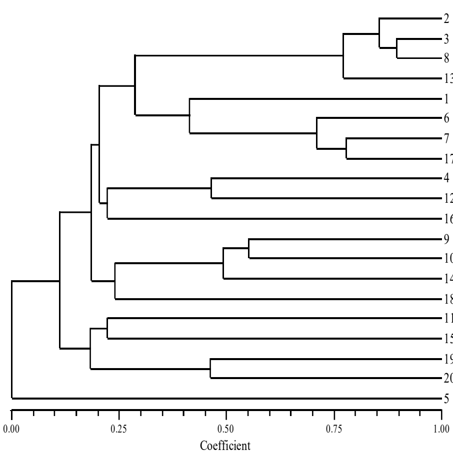


Figure 8. Dendrogram from RAPD analysis of *Aspergillus* isolates with combined primers.

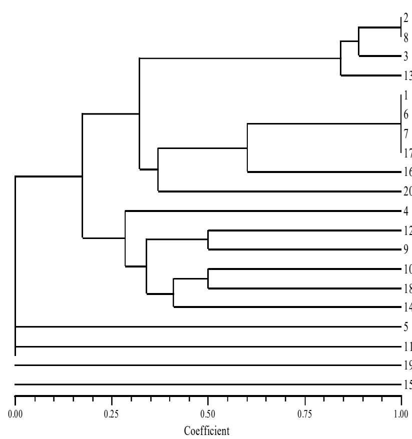


Figure 9. Dendrogram from RAPD analysis of *Aspergillus* species with primer OPB 11.

UPGMA cluster analysis with primers OPB11 and OPZ19 was also undertaken as the two primers showed a very distinct pattern differentiating clearly *Aspergillus* isolates. The obtained dendrogram (Fig. 9) revealed the lack of DNA amplification using OPB11 arbitrary 10 mer primer in some of *A. parasiticus* isolates (nos. 5, 11 and 19) and *A. ochraceus* isolates (no. 15). The analysis revealed two main clusters. In the first cluster, there are two sub clusters in which *Aspergillus flavus* isolates (nos. 1, 6, 7 and 17) showed 100% similarity. *Aspergillus niger* isolates 2 and 8 were identical, whereas isolates 3 and 13 formed one cluster at 80% similarity. *Aspergillus ochraceus* isolate 16 formed one cluster with *A. flavus* isolates at 60% similarity and isolate 20 of *A. parasiticus* also formed cluster with same species at 35% similarity. In the second sub cluster isolate 4 formed a separate cluster with 24% similarity to other isolates within sub cluster. *Aspergillus terreus* isolate 9 shared 50% similarity with *Aspergillus ochraceus* isolate 12. *Aspergillus terreus* isolate 10, 14 and 18 clustered together at 42% similarity.

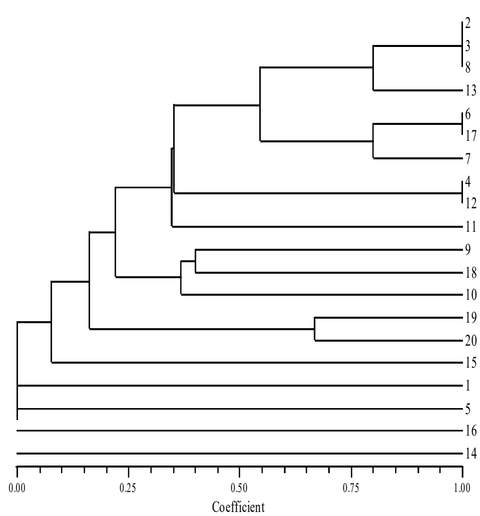


Figure 10. Dendrogram from RAPD analysis of *Aspergillus* species with primer OPZ19.

The RAPD analysis revealed that DNA was not amplified with primer OPZ19 in some *Aspergillus* species isolates (nos. 1, 5, 14 and 16) (Fig. 10). Isolates 2, 3, and 8 were identical but isolate 13 formed a distinct cluster with these isolates of same group at 80% similarity. Isolate 7 was distantly related and shared 80% similarity with isolates 6 and 17 but isolate 6 shared 100% similarity with isolate 17. There was 35% relatedness between isolates 11 and isolates 4 and 12, which shared 100% similarity among themselves. Isolate 9, 10 and 18 formed one cluster at 36.7% similarity. Isolates 19 and 20 were found related and shared 67.6% similarity.

CONCLUSION

The morphological and molecular studies revealed that various *Aspergillus* species are found in association with fruit and cereal crop species in the Delhi market. Randomly amplified polymorphic DNA (RAPD) fingerprints were used to analyze the genetic relationships among the isolates of *A. niger, A. flavus, A. parasiticus, A. terreus* and *A. ochraceus* which were identified into separate groups with the help of morphological characteristics. The study gave preliminary informative DNA-based markers for five species of *Aspergillus* identification

A good agreement was obtained between morphological and molecular characteristics. The investigation showed and proved that OPB11can be used as a specific primer for the molecular identification of the species *A. flavus.* as it gave monomorphic band for all the *A. flavus* isolates studied (Devi et al., 2013).

The phylogenetic analysis revealed that the *Aspergillus* species isolates collected from Delhi market are genetically diverse. These isolates of *Aspergillus* species are known to produce mycotoxins that are harmful to animal including human being. Therefore, attention should be given for designing management strategies to reduce the risk from mycotoxins.

Acknowledgements

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Late Initiation of Antenatal Care Service and its Associated Factors in Southern Ethiopia: A Cross-sectional Study

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Abstract

The study assessed the prevalence of late initiation of antenatal care service and the influencing factors among pregnant women in the Wonago woreda (district) of Gedio Zone, Southern Ethiopia during June - July, 2017. The institution-based cross-sectional study design was used. Data originated from a total of 407 pregnant women who attended antenatal care in three health centers. Data were collected using- semi-structured questionnaire and analyzed with descriptive statistics and logistic regression. About 68% of the respondents commenced ANC service late (after 16 weeks of pregnancy). Multivariate analysis revealed that women with husbands who had primary, secondary and tertiary education were less likely to initiate late ANC by 58%, 69%, and 85%, respectively, compared to those who had no formal education. Women who had got a planned pregnancy also were 58% less likely to initiate late compared to unplanned pregnancy [AOR= 0.42, 95% CI (0.19, 0.94)]. It was found that mothers who had 1-2, and 3-4 times history of a pregnancy were 72% [AOR= 0. 28, 95% CI (0.14, 0.56)] and 50% [AOR= 0.50, 95% CI (0.24, 0.98)] less likely to initiate late compared to women with ≥5times of pregnancy, respectively. The majority of the respondents started their ANC later than the recommended time. Husband's education, planned pregnancy and the number of pregnancy significantly influenced late booking. Therefore it is recommended to improve the level of education of women, promote husband's involvement in pregnancy care, and strengthen family planning services.

Key words: Late antenatal care initiation; Public health centers; Wonago district; Gedio, Ethiopia

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INTRODUCTION

Antenatal care is the care given to pregnant women so that they have a safe pregnancy and a healthy baby. This care also promotes healthy lifestyles that benefit both mother and child. During follow-ups, pregnant women receive health information over maternal physiologic changes in pregnancy, biological changes, prenatal and postnatal nutrition (Wesse, 1999). World Health Organization (WHO) has recommended a minimum level of care to be four visits throughout the pregnancy. The first visit is expected to screen and treat anemia, syphilis, risk factors and medical conditions and initiate prophylaxis if required (e.g. for anemia and malaria) and this care is recommended to be held early before the end of fourth months of pregnancy. The second, third and fourth visits are scheduled at 24–28, 32 and 36 weeks, respectively (UNFPA, 2004).

Late initiation of ANC deters pregnant mothers to get enough time for essential diagnosis and treatment regimens of different disease conditions such as treatment of Sexually Transmitted Infection (STI). There is a need to change this condition due to the high risk related with late initiation of the ANC, i.e., complications such as premature rupture of membrane, hypertensive disease of pregnancy, anemia, Chorio-amnionitis, placental abruption, post-term pregnancy, premature births and intrauterine growth retardation (Ejigu, et al., 2013). In general, late initiation of Antenatal Care (ANC) may lead to undetected or late detection of maternal health problems and subsequently may lead to unmanageable complications in pregnant women and contributes to maternal morbidity and mortality (UNFPA, 2004).

Maternal Mortality Rate (MMR) is very high in Ethiopia and according to Ethiopian Demographic Health Survey (EDHS) was 412/100, 0000 live birth in 2016 (CSA and ICF, 2016). In Ethiopia, ANC services are given free of charge in all government health institutions. However, the EDHS report in 2016 indicated that 38% of the pregnant women did not receive any ANC for their last birth in the five years before the survey. Only 17% of pregnant women made their first prenatal care visit before the fourth month of pregnancy (CSA and ICF, 2014). The Ethiopian Ministry of Health developed a plan to reduce maternal and newborn morbidity and mortality by 69% by improving access to and reinforcement of facility-based maternal and newborn services, and health sector development program (FDREMOH, 2014). However, the utilization of ANC in the recommended time is unacceptably low (CSA and ICF, 2016) and there is no sufficient information regarding ANC initiation time. Therefore determining the time of initiation and factors affecting it was the purpose of this study.

MATERIALS AND METHODS

Study setting, design, and population

The study was conducted in Wonago Woreda (district) Gedio Zone of Southern Ethiopia. It is located 375 km away from Addis Ababa, and 118 km away from the regional capital, Hawassa. At the time of the study, the district had a total population of 145,635 people out of which 71,361 were male and 74,274 female making a 1:1 sex ratio. The district had six health centers and 20 health posts in the district with 100% potential health service coverage (Wonago Woreda Health Office, 2010). Woreda is the third-level administrative division of Ethiopia which is further subdivided into a number of kebeles, the smallest unit of local government.

An institution based cross-sectional study design was used to compare the time of initiation and contributing factors. Data were collected from June 25-July 13, 2017 from all pregnant women attending the ANC service in public health facilities and resided in the study area at least for six months.

Sample size determination and sampling procedure

A sample size of 370 was computed using single population proportion formula (n = (Z α/2)2 P (1 − P)/d2) with the inputs of 95% confidence level (z=1.96), 5% margin of error (d), 59.8% expected prevalence of late initiation of the ANC (Alemayehu, 2008; Gulema and Berhane, 2017) and 10% non-response rate.

Three health centers were selected among the six in the district using a simple random sampling technique. The monthly client flow was determined by taking ANC attendants from the last quarter prior to the study period. From the three selected health facilities, the average number of pregnant mothers in the ANC follow up clinic was taken to estimate the proportion of pregnant mothers to be recruited in the study from each health center. Then all the pregnant women who came in the health centers for antenatal care during the study period were enrolled continuously until the required sample size was achieved.

Data collection tool and procedure

Three qualified midwiferies who speak the local language and understand the local culture collected the data. A supervisor from each health center was selected. Both data collectors and supervisors were trained by the investigators for a day, before and one day after the pretest. The training included discussions on the objectives of the study and contents of the questionnaire, the methodology of the study and ethical issues of data collection. The trainees handled the whole process of data collection, checked and addressed to questions raised by the respondents. The investigators developed the close-ended data collection tools after reviewing related literature. The final version of the English language questionnaire was translated into Amharic language in which the data collectors were proficient. To ensure the validity of the instrument, a pretest was carried out in Gedio zone of Wonago woreda health center, which is not selected for this study, however, the client has similar socio-demographic characteristics and compared to the selected health centers for the study. The health workers interviewed the selected pregnant women in separate rooms to secure confidentiality.

Quality assurance

The collected data in each day were checked for completeness, accuracy and consistency. Supervision was carried out by the investigators throughout the data collection period.

Study variables

Time of antenatal care initiation was the dependent variable. Early ANC initiation refers to pregnancy related care received from a skilled health care professional within the first 16 weeks of pregnancy and late if it is initiated after 16 weeks of gestation (WHO, 2016).

The Independent variables were reproductive health information and socio-demographic variables including age, marital status, monthly income, family size, religion, educational status and ethnicity. Reproductive health information is about gravidity (number of pregnancy), parity (number of births), previous obstetric/ medical problems, knowledge of ANC, the advantage of ANC, knowledge of services in ANC, attitude towards ANC service, and past history of service utilization.

Knowledge about late initiation of the ANC was measured with answers to questions about the importance of ANC, time of initiation and the risk inherent during pregnancy and childbirth. The study used twenty-six multiple-choice questions, each of which scored one point for a correct response and zero for the incorrect. An overall knowledge score was calculated by adding up the scores for each respondent across all twenty-six questions. Study subjects who scored 13 (50%) and above were categorized as knowledgeable and those with lower scores as with poor knowledge.

Attitude towards ANC was measured using a 5-point Likert's scale ranging from strongly disagree (score 1) to strongly agree (score 5). When both positive and negative statements are scored, the positive answer will score 4 -5 points, neutral 3 and the negative answer 1-2 point. Following the Likert scale, an overall attitude score was determined for each respondent by adding up the scores across the nine attitude questions with maximum positive attitude score of 45 and a minimum negative score of nine. The scores 36-45 were taken as positive, 9-18 negative and 19-35 as neutral attitudes.

The data were entered using Epi info version 7 into a computer and data exported into SPSS version 20.0 for analysis. Data were summarized with descriptive statistics.

The association between the dependent and independent variables were assessed using logistic regression. The outputs were presented using crude and adjusted odds ratios.

For this study, the bivariate logistic regression model was fitted as a primary method of analysis. Odds ratios (OR) were computed with the 95% confidence interval (CI) to see the ANC time of initiation in relation to the considered associated factors in this research. Independent factors, with a P-value <0.25 in the bivariate logistic regression were entered into the multivariate logistic regression models. Consequently, the most important associated factors were identified using the multivariate logistic regression analysis. Then adjusted odds ratios (AOR) with 95% confidence interval were calculated for the significant predictive variables, and statistical significance was accepted at P< 0.05.

Ethical Considerations

Ethical clearance was obtained from Hawassa University, College of Medicine and Health Science Review Board and the concerned officials in the district at each level were formally communicated. Consent was asked from the study participants by ensuring anonymity and confidentiality and explaining the objective of the study. The pregnant women were informed that they have a full right to participate or discontinue at any time during the study.

RESULTS

A total of 407 pregnant mothers participated in the study among which about 5% of the participants were young, 15 to 19 years old, while the majority (82.5%) were between 20 and 34 years of age (Table 1). The majority of pregnant women under the study (81.3%) resided in rural areas. About 35% of the pregnant women had no formal education while 37% had primary level education, and 40% of them had husbands with primary level education (Table 1).

Reproductive health profile

Out the study subjects, 37.3% were pregnant 3-4 times in their lifetime, 45.2% had 1-2 live births in the past, and 9.3% had stillbirth for 1-2 times (Table2).

The timing of the first ANC visit

Only 31.7% of pregnant mothers started their first ANC visit early (16 weeks and less) while the majority of pregnant mothers (68.3%) started the ANC late in either second or third trimester (Fig. 1). About half of the pregnant women (51.8%) got health information for ANC follows up from health institutes followed by family/ friends (27.7%), and 16.3% from television/radio and books/newspaper/posters and the rest (4.2%) from religious leaders.

Knowledge and attitudes towards ANC

About half of the respondents (48.9%) had high knowledge about the ANC, while the remaining (51.1%) low knowledge. Positive attitude to ANC was shown by 13.7% of respondents and negative by 25.8% of the respondents. Most of the respondents (60.4%) had a neutral attitude towards the ANC. The mean attitude score for all respondents was 25.47 out of a possible 36 points (SD =4.52).

Table 1: Socio-demographic profile of pregnant women respondents in Wonago district, Southern Ethiopia July 2017.

Variables (N=407)	Frequency	Percentage
Age		
15-19	20	4.9
20-24	94	23.1
25-29	147	36.1
30-34	95	23.3
35 and above	51	12.5
Women's level of education		
No formal education	143	35.1
Primary education (1-8)	151	37.1
Secondary education (9-12)	78	19.2
Tertiary education (diploma and above)	35	8.6
Religion		
Orthodox	110	27
Muslim	62	15.2
Protestant	202	49.6
Catholic	25	6.1
Others	8	2
Ethnicity		
Gedeo	205	50.4
Oromo	73	17.9
Tigre	12	2.9
Guragie	41	10.1
Amhara	45	11.1
Others	31	7.6
Monthly income (Ethiopian birr)		
<1000	206	50.6
1001-2000	139	34.2
2001-3000	38	9.3
3001-4000	11	2.7
4001-5000	12	2.9
>5000	1	0.2

Variables (N=407)	Frequency	Percentage
Woman's occupation		
Housewife	219	53.8
Self employed	83	20.4
Government employee	49	12
Daily worker	28	6.9
NGO/private sector employee	6	1.5
Other	22	6.1
Marital status		
Single (never married)	15	3.7
Married/live together currently	314	77.1
Separated/divorced/ widowed	78	19.2
Husband's level of education		
No formal education	83	20.4
Primary education (1-	163	40
Secondary education (9-12)	76	18.7
Tertiary education (diploma and above)	85	20.9
Husband's occupation		
Self employed	185	45.5
Government employee	92	22.6
Daily worker	81	19.9
NGO/private sector employee	24	5.9
Other	25	6.1
Residence		
Urban	76	18.7
Rural	331	81.3

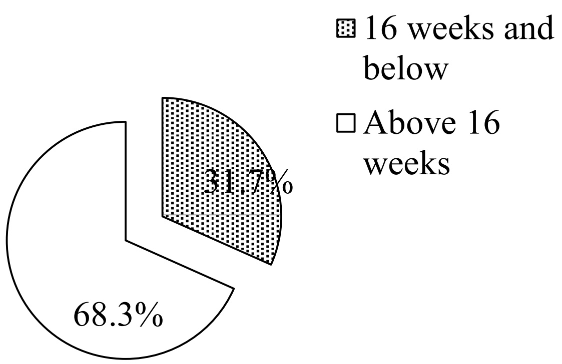

Figure 1: Proportion of late initiation of ANC among pregnant women in Wonago woreda, Gedio Zone public health centers, July, 2017.

Main reasons for late initiation of the first ANC

Out of the total number of women who did not use ANC service on time an attempt was made to know the possible reasons for the late use of the service. Most frequently responded reason was lack of appropriate information about ANC (34.2%), followed by negligence (22.6%) and distance from health facility (14.5%) (Fig. 2).

Inquiry in the past history of ANC service utilization indicated that 71.5% of the respondents had attended ANC services. However, only 17.2% of these respondents started ANC service within the first three months of pregnancy while the remaining 64.3% after 12 weeks of gestation.

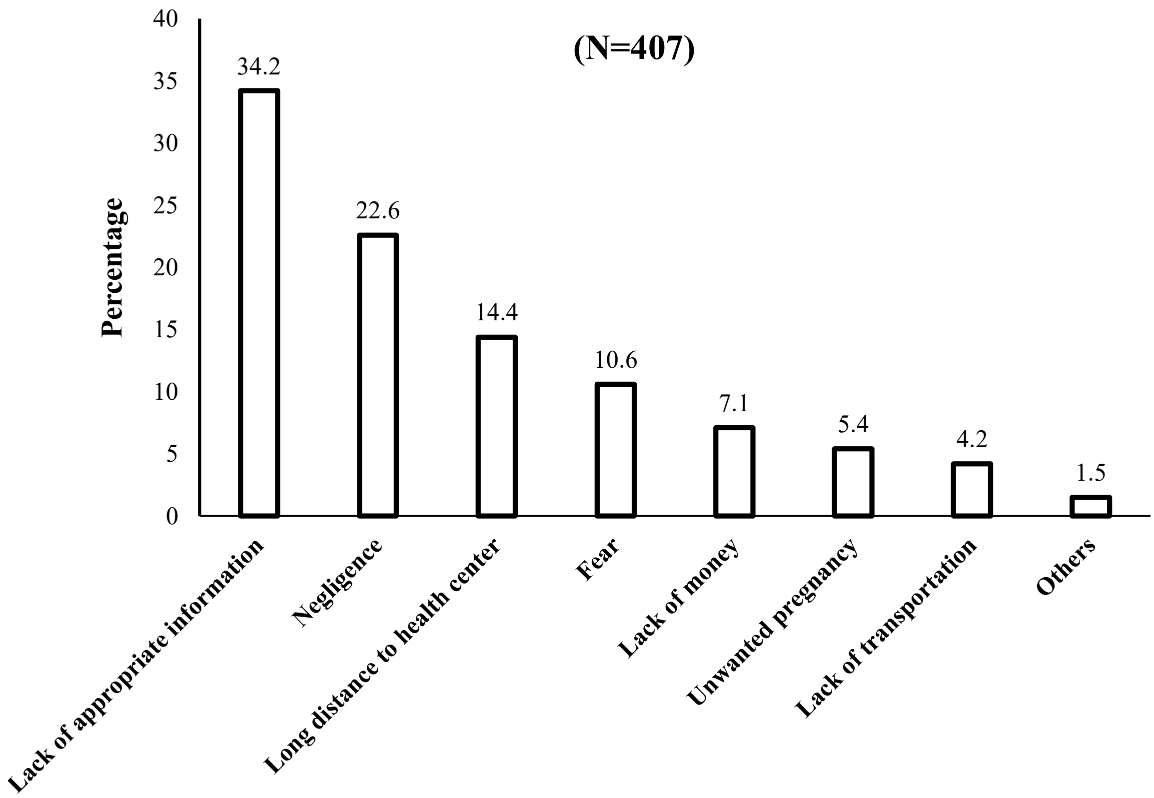

Figure 2. Reasons for late initiation of ANC among pregnant mothers in Wonago Woreda, Gedio Zone, July 2017.

Determinants of late initiation of ANC visit

In this study, husband education, planned pregnancy and number of pregnancies were significantly associated with the time of initiation of the first ANC during pregnancy (Table 3). A husband with primary education was by 58% [AOR= 0.42, 95% CI (0.19, 0.95)], secondary education by 69% [AOR= 0.31, 95% CI (0.12, 0.79)] and tertiary education by 85% [AOR= 0.15, 95% CI (0.06, 0.39)] was less likely to initiate late ANC compared to those who had no formal education. Women who had got a planned pregnancy also 58% less likely to initiate late ANC compared to those who had unplanned pregnancy [AOR= 0.42, 95% CI (0.19, 0.94)]. Those mothers who had a history of 1-2 times pregnancy were 72% [AOR= 0. 28, 95% CI (0.14, 0.56)] and 3-4 pregnancy 50% [AOR= 0.50, 95% CI (0.24, 0.98)] less likely to initiate ANC late compared to women with the number of pregnancy ≥5 times (Table 3).

Table 2. Reproductive health profile of the pregnant women respondents in Wonago district, Southern Ethiopia July, 2017

Variable (N=407)	Frequency	Percentage
Gravidity		
1-2	151	37.1
3-4	152	37.3
5 and above	104	25.6
Parity (N=329)		
1-2	184	55.9
3-4	106	32.2
5 and above	39	11.9
History of Stillbirth		
Yes	38	11.5
No	369	88.5
Inter pregnancy interval (N=344)		
Up to twelve months	40	11.6
One to three years	208	60.5
Three to six years	76	22.1
More than six years	20	5.8
Time of initiation of ANC		
≤16 weeks of gestation	129	31.7
17-20 weeks of gestation	57	14
21-24 weeks of gestation	48	11.8
25-27 weeks of gestation	35	8.6
28-42 weeks of gestation	138	33.9
Husband supports for the ANC		
Yes	325	79.9
No	82	20.1
Negative influence of others in the household not to use ANC		
Yes	60	14.7
NO	347	85.3
Current pregnancy Planned		
Yes	346	85. 0
No	61	15.0

Table 3. Factors affecting late initiation of ANC visits among pregnant women in Wonago woreda, Gedio Zone, 2017.

Variable	Late initiation of ANC		COR (95%CI)	AOR (95% CI)
	Yes	No		
Maternal Education				
No formal education	115(80.4%)	28(19.6%)	1	1
Primary education	94(62.3%)	57(37.7%)	0.402(0.23,0.68)	0.69(0.38,1.27)
Secondary education,	48(61.5%)	30(38.5%)	0.39(0.21,0.72)	1 (0.5,2.19)
Tertiary education	21(60%)	14(40%)	0.36(0.16,0.8)	1.45(0.54,3.8)
Husband's education:				
No formal education	74(89.2%)	9(10.8%)	1	1
Primary education	115(70.6%)	48(29.4%)	0.291(0.13,0.62)	0.421(0.19,0.95)*
Secondary education	48(63.2%)	28(36.8%)	0.2(0.09,0.48)	0.31(0.12,0.79)*
Tertiary education (Diploma and above)	41(48.2%)	44(51.8%)	0.113(0.05,0.25)	0.15(0.06,0.39)*
Number of pregnancy				
1-2	84(55.6%)	67(44.4%)	0,18(0.09,0.35)*	0,28(0.14,0.56)*
3-4	104(68%)	49(32%)	.31(0.15,0.6)*	.50(0.24,0.98)*
>=5	90(87.4%)	13(12.6%)	1	1
Planned pregnancy				
Yes	226(65.3%)	120(34.7%)	0.32(0.15,0.68)*	0.42(0.19,0.94)*
No	52(85.2%)	9(14.8%)	1	1

COR: Crude Odds Ratio, AOR: Adjusted Odds Ratio CI: Confidence Interval, * significant at $p < 0.05$

DISCUSSION

In this study, nearly two-thirds of the respondents started ANC visit late after16 weeks of gestation, which is not in line with the WHO recommended time for developing countries (WHO, 2016). The finding is higher compared to the 2014 EDHS when one-fourth of the women made a late first ANC visit and this is not aligned either with a study done in Kembata Zone found in the same region or with the current study (Tekelab and Berhanu 2012). The result is, however, similar to a study done in Hadiya Zone (Zeine, et al., 2010). The discrepancy in ANC initiation might be because of differences in the setting and the majority of the mothers were not exposed to formal education that could have helped them improve their use of the available health services.

The current finding is comparable to a study in Debre Berhan where majority of the pregnant women started ANC visit late and reported that lack of appropriate information about ANC and the benefits of ANC services, negligence, distance to the health facility, and fear of public exposure were among the different reasons for ANC services late attendance mentioned by the majority of women (Zegeye, et al., 2013).

Women with a husband who attended formal education were less likely to delay their first antenatal visit as compared to those women whose husband had never attended formal education. This finding agrees with EDHS 2011 report in which education was a strong predictor in the use of antenatal care services. Studies done in Addis Ababa and Hadiya also are in line with the current finding and state that education has a positive effect for maternal health service utilization (Zeine, et al., 2010; EDHS, 2014; Achia and Mageto, 2015; Gebrekidan and Worku, 2017). Educated husbands are better informed and are likely to support their wives to make the decision to start ANC service earlier.

Further analysis showed that women with less than five times pregnancies are likely to initiate ANC earlier than women with five or more pregnancies. This might be because those women with less number of children are eager to have more and therefore give more attention to their pregnancy for better outcome. The finding is also in line with studies done in Wolaita Soddo town (Hussen, et al., 2016) and the central zone of Tigray (Gebreamlak. et al., 2017).

The current study showed that women with a planned pregnancy less likely initiated ANC late compared to those who had an unplanned pregnancy. Because the pregnancy is desired, the women give due attention and care for the fetus as well as own health. These women most likely detect their pregnancy earlier. This finding is in line with studies done in Addis Ababa (Gulema and Berhane, 2017), Adigerat (Lerebo, et al., 2015), Kembata Tembaro (Tekelab and Berhanu, 2012), Arbaminch (Feleke, et al., 2015) and Dilla (Girum, 2016).

This study has some limitation since it considered only pregnant women attending ANC at the government health institutions. However, according to the 2010 Woreda Health Office report, more than 90% of eligible pregnant women have used governmental health facilities.

CONCLUSIONS AND RECOMMENDATIONS

The majority of pregnant women in the study area did not use ANC services timely as recommended by the World Health Organization (WHO). Education is an important factor for the timely utilization of ANC services. The number of pregnancy and planned pregnancy encouraged pregnant mothers to attend ANC services timely. Hence, actions should be taken to improve education, promote husband's involvement in pregnancy care, strengthen family planning services for planned pregnancy and desired family size.

Acknowledgments

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Acknowledgements: (if required). These should be brief, *e.g.* five lines of text.

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Short communications should essentially follow the structure given for research articles.

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The structure of these articles will largely be determined by their subject-matter. However, they should be clearly divided into sections by an appropriate choice of headings.

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The order of headings and sub-headings should be indicated as shown in the style sheet JSD_stylesheet.doc. Keep all levels of heading as short as possible.

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(Hartman and Kester, 1975; Anderson et al., 1993; Darwin and Morgan, 1994) chronologically.

References in the list should be in alphabetical order, in the following formats:

Journal article
Kalb J.E. 1978. Miocene to Pleistocene deposits in the Afar depression, Ethiopia. *SINET: Ethiop. J. Sci*. 1: 87-98.
Books
Whitmore T.C. 1996. *An introduction to tropical rain forests*. Clarendon Press, Oxford, 226pp.

Steel R.G.D. and Torrie J.H. 1980. *Principles and procedures of statistics*. 2nd ed. McGraw-Hill Book Co., New York. 633 pp.

Contribution as a chapter in books (Book chapter)
Dubin H.J. and Grinkel M. 1991.The status of wheat disease and disease research in warmer areas. In: Lange L.O., Nose1 P.S. and Zeigler H. (eds.) *Encyclopedia of plant physiology. Vol. 2A Physiological plant ecology*. Springer-Verlag, Berlin. pp. 57-107.

Conference/workshop/seminar proceedings
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Daniel L.E. and Stubbs R.W. 1992.Virulenceof yellow rust races and types of resistance in wheat cultivars in Kenya. In: Tanner D.G. and Mwangi W. (eds.). Seventh regional wheat workshop for eastern, central and southern Africa. September 16-19, 1991. Nakuru, Kenya: CIMMYT. pp. 165-175.

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WHO (World Health Organization) 2005. Make every mother and child count: The 2005 World Health Report. WHO, Geneva, Switzerland.
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Thesis
Roumen E.C.1991. *Partial resistance to blast and how to select for it*. PhD Thesis. Agricultural University, Wageningen, The Netherlands. 108 pp.
Gatluak Gatkuoth 2008. *Agroforestry potentials of under-exploited multipurpose trees and shrubs (MPTS) in Lare district of Gambella region.* MSc. Thesis, College of Agriculture, Hawassa University, Hawassa. 92 pp.

Publications from websites (URLs)
FAO 2000. Crop and Food Supply Assessment Mission to Ethiopia. FAOIWFP. Rome. (http://www. fao.or~/GIE WS). (Accessed on 21 July 2000).

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