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Determinants of Maize (*Zea mays L.*) Varietal Turnover in Ethiopia

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Abstract: While many smallholder farmers all over the developing countries have benefited from the introduction of first-generation green revolution cultivars that replaced lower-yielding landraces, adoption of second and third-generation cultivars offering improvements in yield, output quality, and stress resistance seems now to be occurring at a much slower pace. Most varietal adoption and impact assessment studies in the past have relied on farmers' responses at household level surveys to estimate these indicators. Such method of 'farmer elicitation' to estimate varietal adoption can be fairly accurate in a setting where farmers are mostly planting seeds freshly purchased or acquired from the formal seed market as certified or truthfully labeled seed, and the seed system is well-functioning and effective in monitoring the quality and genetic identity of varieties being sold by the seed suppliers. Thus, this study focused on varietal turnover by calculating an index of the weighted average age of varieties grown by farmers in a given year (measured in years since release) and factors affecting this varietal turnover, using a recently collected DNA fingerprinting dataset. Secondary data from the household survey data collected by Central Statistical Agency were used in the analysis. The multiple linear regression models were used in identifying determinants of maize cultivars varietal turnover. Econometric results indicate that, Farmers' experience in growing maize affects WA weakly and statistically significant and positive. This implies that more experienced farmers are refusing to change their varieties as they are small holders and so risk averse. Family size being positively affecting varietal turnover also implies that if the decision to cultivate a new variety requires consensus among key family members who are involved in farming, then idea generation and making decision may become more difficult and taking time, causing households to forgo varietal turnover in order to avoid disagreement.

Keywords: DNA Fingerprinting, Varietal Turnover, Age of Varieties

1. Introduction

1.1. Background

While many smallholder farmers all over the developing countries have benefited from the introduction of first-generation green revolution cultivars that replaced lower-yielding landraces, adoption of second and third-generation cultivars offering improvements in yield, output quality, and stress resistance seems now to be occurring at a much slower pace [6] Seed has unique features as a medium for germplasm exchange among farmers and between farmers and researchers. In short, seed is a medium through which a new crop technology is transferred to farmers. It is the carrier of genetic message for different characteristics embodied in a variety. A seed of particular characteristic represents a variety.

On the other hand, according to [15], most varietal adoption and impact assessment studies in the past have relied on farmers' responses at household level surveys to estimate these indicators. Such method of 'farmer elicitation' to estimate varietal adoption can be fairly accurate in a setting where farmers are mostly planting seeds freshly purchased or acquired from the formal seed market as certified or truthfully labeled seed, and the seed system is well-functioning and effective in monitoring the quality and genetic identity of varieties being sold by the seed suppliers. However, in settings where the formal seed system is non-existent or ineffective, and farmers mostly rely on harvested grain (either from their own farms or acquired from other farmers or purchased from the market) as the main source of planting material, the reliability of estimating varietal adoption using this method is challenging. This may indicate that genetic fingerprinting appears to be an accurate method for tracking varietal diffusion [5] and so was used in this study in crop varietal identification to undertake varietal turnover analysis.

Thus, in the earlier studies, maize varietal turnover and its determinants have not been assessed using a unique data from DNA fingerprinting. Therefore, this study focused on varietal turnover by calculating an index of the weighted average age of varieties grown by farmers in a given year (measured in years since release) and factors affecting this varietal turnover, using a recently collected DNA fingerprinting dataset that has wider area coverage in terms of diversity in maize production potentials and administrative regions in Ethiopia.

1.2. Objectives

The general objective of the study was to analyze the maize varietal turnover in Ethiopia while the specific objectives of the study were:

1) To measure the rate of varietal turnover of maize using DNA fingerprint;
2) Identifying factors affecting hybrid maize and Open pollinated varietal turnover at household level.

2. Methodology

2.1. Types and Sources of Data

Following standard CSA procedures, two stage stratified sampling strategy was employed, with enumeration areas serving as the primary sampling units and the households being the secondary sampling units. The sampling enumeration areas in each region was randomly selected following probability proportional to size technique from a list of enumeration areas compiled during the 2007 population and housing census [5]. Farmers producing maize were considered from four regions; Amhara, Oromia, SNNP and Tigray, and then, zones, districts and enumeration areas (lowest administrative unit) with the highest number of maize producing farmers were selected randomly.

In the survey, names of cultivars and the proportions of plots of each cultivar mentioned by each household was taken. To determine the age of each cultivar, national as well as regional catalogues was referred to compile the release year. It was confirmed that there are large numbers of cultivars for which release years are not provided. The cultivars were then divided into their respective classes of hybrids, improved open-pollinated varieties (OPVs), and local (farmers', traditional, or obsolete) cultivars. According to the study by [1] the definitions of the different categories of maize are as follows:

Hybrid: Freshly purchased hybrid seed;

OPV: Seed that has not been recycled for more than three seasons; and

Local (farmers' or traditional) cultivars: It includes landraces, recycled hybrids, OPVs recycled more than three seasons, and or those for which no information is available on year of release.

2.2. Sampling Strategy and Sample Size

Field data collection was carried out by Central Statistical Agency (CSA) teams. Each team was supervised by the respective head of the CSA zonal branch offices. In addition to the survey teams, one supervisor from the respective enumeration areas stationed in the respective districts assisted the survey team in implementing the household questionnaire. Overall, data collection was supervised and monitored by senior CSA management personnel.

Accordingly, the required sample respondents in each enumeration areas were determined based on proportions of maize producer households of the respective enumeration areas and simple random sampling technique was applied to identify sample farm households. Accordingly, the sample size was determined based on the proportion of maize producer households to have a total of 1,673 respondent farmers.

2.3. Methods of Data Analysis

Similarly, multiple linear regression model (OLS) was estimated with on farm WA of hybrid and OPVs separately as a function of a number of farm, household and village characteristics to identify determinants of maize varietal turnover. These numbers of farm, household and village characteristics include size of ownership (in hectare), area allocated for maize varieties, age of the household head, education, sex of the household head, distance to the local market, access to credit and development agents or extension contact.

Therefore, let weighted maize cultivar age be Y_i (variate) and the independent variables listed be X_i (Covariates), (where i=1, 2, 3…n).

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i \tag{1}$$

Where,

X_i: is independent variables (where i=1, 2, 3…n),

Y: weighted maize cultivar average age (measuring maize cultivars varietal turnover);

$\beta_{0:}$ Constant

$\beta_{i:}$ Coefficient or parameters (i= 1, 2, 3…n) and

$\epsilon_{i:}$ Random term (error).

This measure was estimated at the farm level and captures features of the relative speed of diffusion at which a new cultivar is adopted by farm-households (a lower age represents a highly responding maize cultivar system with efficient dissemination) and the cultivar turnover of the system [12].

2.4. Definition of Variables and Hypothesis

The hypothetical variables that are expected to be included in the analysis of maize varietal turnover in calculating an index of weighted age are:

Weighted Average Age (WA): It is an index to be calculated and is an outcome variable to calculate maize varietal turnover.

Maize varieties: name of maize varieties include: BH-540, BH-543, BH-660, Shone, Agar and others. It is used to identify the maize varieties that are widely cultivated. Maize varieties release date is about a date of release for each and every maize variety from research institutions and universities. It is used to calculate the weighted age of a maize varieties being cultivated by farmers. Maize area indicates the area allocated for each maize varieties in a given crop year.

The Sex of the household head: is a dummy variable that takes the value of 0 if the head of the household is female, and 1 if male. The general assertion is that women are generally discriminated against in terms of access to external inputs and information. Gender of the household head has been found to influence the decision to adopt new technologies [14]. Gender is therefore hypothesized to have a positive or negative sign.

The Education variable: is measured as the number of years of schooling. The importance of education and experience in enhancing human capital through acquisition and learning of skills has been documented [8, 2]. More educated farmers are typically assumed to be better able to process information and search for appropriate technologies to alleviate their production constraints. Therefore education is expected to positively influence the decision to adopt improved maize varieties.

Farming experience: it is expected increase the probability of uptake of new technologies because experienced farmers have better knowledge and information on management practices. Farming experience is measured as the number of years one has spent in farming.

Family size: is the number of family members that are headed by a household head. Land holding (measured in hectare) is an amount or size of cultivated land owned by a household head.

Land holding: It is expected that the households with greater wealth or larger operational landholdings would cultivate varieties that have been released more recently when compared with poorer households or households with smaller operational landholdings [9].

Farmers contacts with extension agents: is measured as a binary variable: 1 if the farmer has been in contact with any extension, 0 if otherwise. Agricultural extension enhances the efficiency of making adoption decisions replacing obsolete varieties with newly released varieties. Contact with extension agents is expected to have a positive effect on adoption of improved maize varieties. Contacts with extension agents expose farmers to necessary information concerning agricultural technologies and are likely to stimulate adoption [17]. It is a contacting frequency of a development agent that a farmer or household faces in a given cropping year. The availability of the intensity of demonstrations and extension work influences the rate of varietal replacement [10].

Livestock holding: Livestock a proxy for wealth is expected to enable farmers to access and purchase agricultural technologies. Farmers with high livestock units are also expected to be less risk averse as they have the capacity to cope with risks associated with the use of a technology. Some crop residues are used as feeds for animals and farmers also use livestock manure for soil management, this make crop and livestock production to be complementary enterprises. Therefore, farmers who have a greater number of livestock units are more likely to adopt [18].

Access to credit (dummy): is related to credit accessibility for purchasing improved varieties of maize and related packages. Access to information and credit [7, 11] positively affects adoption.

The age of household: is variable, measured in number of years, is a continuous variable expected a priori to be positively influenced the decision to adopt new technologies [13]. It may be that older farmers are more risk-averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies. It could also be that older people have more experience and are in a better position to assess characteristics of new technology than younger farmers, and hence a higher probability of adopting the new technology.

Distance to input market: (Distance to village, main and input market) measured in kilometers is expected to negatively influence adoption of improved maize varieties. Input markets allow farmers to acquire the inputs they need such as pesticides and weedicides. The general perception is that the shorter the distance from the household to the nearest market, the higher the probability of adoption [18, 13].

The status of farmer: includes model farmer and follower farmer. If a farmer is model farmer, then it is expected that this uses recently released maize variety.

Asset owned: is a resource (either farm or nonfarm or both) that a farmer owns. Farmers' resource base affects crop varietal turnover [10]. Source of income may include farm income or nonfarm income.

Descriptive analyses done include; mean, standard deviation, minimum and maximum for continuous variables and percentages for categorical variables. Analysis of variance (ANOVA) tests were used to test whether continuous variables on farm and farmer characteristics of the study area were homogenous or varied. It was also used determine whether continuous variable on farm and socioeconomic characteristics of the households of Amhara, Oromia, SNNP and Tigray regions were homogenous or varied. Chi-square was used to test whether the percentage of categorical variables on socioeconomic characteristics of the households among the regions were homogenous or varied. It was used to determine whether categorical variable on farm and farmer characteristics among the Amhara, Oromia, SNNP and Tigray regions were homogenous or varied.

On the other hand, interpretation of OLS model outputs is possible only when the basic assumptions of classical linear regression model are satisfied. There are many post-estimation tests used to check the satisfaction of the basic assumptions of multiple linear regression model. Accordingly, tests for heteroscedasticity and multicollinearity were reported with the OLS (Ordinary Least Square) model outputs.

3. Results and Discussion

3.1. Characteristics of Farm Households

The average age of the sample household heads was about 47 years with minimum of 18and maximum of 97 years. In the same manner, average family size of the sample households was found to be 4.46, with the minimum of 1 and maximum family size of 13 (Table 1). According to Survey results, an increase in family size was directly proportional to allotted productive labor sources for maize production.

Table 1. *Household characteristics of the study area (n=1673).*

Variable	Mean	St. Deviation	Minimum	Maximum	F-test
Land owned	1.61	2.00	0.0016	50	42.38***
Experience	17.76	13.58	0	83	14.39***
Age	46.88	14.21	18	97	7.02***
Education	1.90	3.04	0	19	12.04***
Family size	4.46	2.14	1	13	4.56***
Livestock	5.15	3.97	0	36.2	10.46***
Distance nearest seed dealer	6.36	6.44	0	96	2.15*
Distance to nearest fertilizer dealer	10.89	8.48	0	90	4.37***

Source: GFP survey, 2014/15

Table 2 shows that the differences in mean age and family size among Tigray, Amhara, Oromia and SNNP households were insignificant. The overall mean number of years the household head had in formal education was 1.93 years. The mean number of years the household head had in formal education was higher for Oromia household heads (2.39 years) than for other regions and the difference was statistically significant at 1% probability level. Therefore, the likelihood of technology uptake would be higher for Oromia farmers.

The overall mean distance traveled by the household heads to get seed was 6.85 km. The mean distance traveled by the household head to seed markets was longer in Amhara (7.47 km) and Oromia (6.99 km) regions than the other two regions and the difference was significant at 1% probability level. The overall mean distance traveled by the household head to fertilizer markets was 6.36 Km. The mean distance traveled by the household heads to fertilizer market was longer in Amhara region (7.17 Km) than in Oromia, SNNP and Tigray regions which are 6.38, 6.50 and 4.32 kilometers respectively. The difference was statistically significant at 1% probability level. The mean differences for land ownership and experience in maize farming across the regions were also statistically significant at 1% significance level.

Table 2. *Descriptive statistics of socioeconomic characteristics of the farmers in the selected regions of Ethiopia for continuous variables.*

Characteristics	Tigray (N=226)	Amhara (N=454)	Oromia (N=634)	SNNP (N=359)	Overall (N=1,673)	F-test
Age	50.64 (14.54)	47.45 (14.83)	45.81 (15.04)	45.45 (15.09)	46.84 (15.02)	7.02***
Family size	4.47 (1.95)	4.33 (2.12)	4.68 (2.19)	4.17 (2.13)	4.45 (2.13)	4.56***
Education level	1.66 (2.82)	1.32 (2.53)	2.39 (3.38)	2.11 (3.14)	1.94 (3.07)	12.04***
Land owned	0.99 (0.71)	1.21 (1.17)	2.09 (2.03)	1.51 (1.36)	1.58 (1.61)	42.38***
Farmer's experience	19.86 (14.85)	18.14 (13.22)	18.9 (14.11)	13.62 (11.32)	17.7 (13.59)	14.39***
Distance to seed market	6.64 (7.18)	7.47 (11.22)	6.99 (8.35)	5.85 (7.27)	6.85 (8.94)	2.15*
Distance to fertilizer market	4.32 (4.42)	7.17 (11.2)	6.38 (7.37)	6.5 (12.02)	6.36 (9.41)	4.37***
Livestock	4.57 (2.84)	4.68 (3.4)	5.82 (4.89)	4.92 (3.14)	5.14 (3.96)	10.46***

Source: GFP survey, 2014/15

Note: *** and * Significant at 1% and 10% probability level respectively

Figures in parentheses are the standard deviation

The overall mean total number of livestock owned by the household head was 5.14 units and the majority of the farmers owned cattle, goats and sheep a picture typical of smallholder mixed farming. The mean total number of livestock units owned by the household heads was the highest in Oromia region (5.82 units) followed by (4.92 and 4.68 units) in SNNP and Amhara regions respectively and the difference was significant at 1% probability level. These results could be explained from the point of the view that, household heads of Oromia region had more land hence, more pasture that could accommodate more livestock units.

Table 3. *Descriptive statistics of socioeconomic characteristics of the farmers in the selected regions of Ethiopia for categorical variables.*

Characteristics	Tigray (N=226) %	Amhara (N=454) %	Oromia (N=634) %	SNNP (N=359) %	Overall (N=1673) %	χ2-value
Sex						
Female	2.38	4.52	6.12	4.63	17.65	5.22
Male	11.05	22.82	31.67	16.82	82.35	
Access to extension						
No	8.14	13.95	17.93	6.59	46.62	57.63***
Yes	5.34	13.36	19.83	14.85	53.38	
Household's status						
Follower	10.21	23.1	34.14	18.94	86.4	33.03***
Model	3.27	4.22	3.62	2.49	13.6	
Whether agriculture is hh head's source of income						
No	0.65	1.01	1.66	0.53	3.86	2.95
Yes	12.83	26.31	36.1	20.9	96.14	
Asset ownership						
No	8.31	20.07	23.28	13.3	64.96	20.17***
Yes	5.17	7.24	14.49	8.14	35.04	

Source: GFP survey, 2014/15
Note: *** Significant at 1% probability level

Descriptive statistics of socioeconomic characteristics of the farmers in the selected regions of Ethiopia for categorical variables in (Table 3) indicate that the difference in percentage in terms of gender of household head and whether agriculture is source of income among regions were insignificant. But the difference in percentage in terms of farm asset ownership, access to extension services, and access to credit and status of farmer among regions' households were significant.

3.1.1. Farmers' Seed Sources and Seed Management

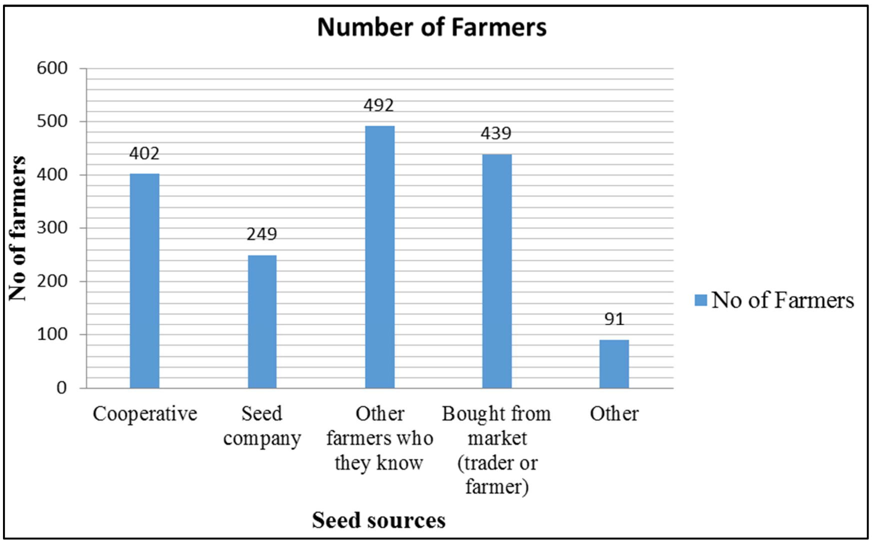
Seed source is an important variable hypothesized to have an important bearing on varietal turnover. Among the farmers who have reported the main source of seed, 24% reported cooperatives, 29.4% obtained from other farmers who they know, 26.2% bought from the market either from traders or farmers, 14.9% reported from Seed Company and the rest got from other sources (Figure 1). However, the reality of this study was that, only 249 (14.9%) of the farmers sourced their seeds from recommended sources. About 492 (29.4%) of the sample households used seeds they purchased from other farmers which were originally distributed by woreda bureau of agriculture and saved from previous harvest.

During the 2014/15 production season, 55.6% of the farmers reported using saved maize seed; from the saved seed users, 75% reported application of some sort of seed management to ensure quality seed. The most common seed management practices reported are related with selection of field, better cultivation, rouging, threshing in separate place, and storing seed separate from grains (Table 4). Seed management practices are very important for saved seed to avoid loss of crop vigor and varietal contamination in the production, threshing and storing.

Table 4. *Maize seed management by sample households.*

Seed production measures	Number of farmers (n=733) Number	%
Plant seed fields separate from grain fields	114	15.55
Keep isolation distance to reduce varietal contamination	26	3.55
Better cultivation and weeding of seed	283	38.61
Rouge off-types in seed fields	61	8.32
Thresh seed in separate place	37	5.05
Clean seed separate from grain	30	4.09
Treat seed before storage	2	0.27
Store seed separate from grain	109	14.87
Clean seed before planting	49	6.68
Other	22	3
Total	733	100

Source: GFP survey, 2014/15



Source: GFP survey, 2014/15

***Figure 1.** Sources of maize seed.*

3.1.2. Access to Credit to Purchase Agricultural Inputs

Table 5 shows households access to credit to buy improved maize seed and chemical fertilizer. Therefore, it is indicated that during the study, only 28 percent of the households used credit to buy improved seed of maize; whiles about 35 percent of the respondent farmers used credit to purchase chemical fertilizer.

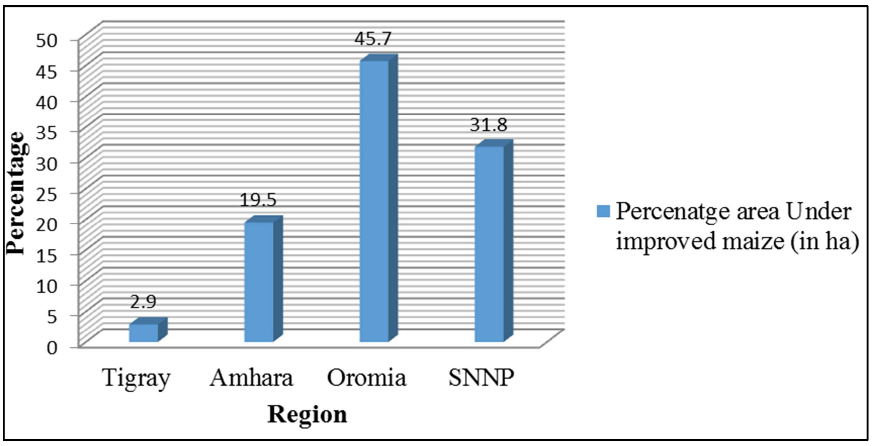
***Table 5.** Access to credit to buy improved maize seed and chemical fertilizer.*

Access to credit for		No of farmers	Percent
Improved maize seed	No	1,203	71.95
	Yes	469	28.05
	Total	1,672	100
Chemical fertilizer	No	1,075	64.29
	Yes	597	35.71
	Total	1,672	100

Source: GFP survey, 2014/15

3.1.3. Maize Varieties Grown by Farmers

About 52.0 percent of the respondents claimed to have grown local and unknown local maize varieties. Unknown local and local variety was not a particular maize variety since any maize variety whose name the farmers did not know was classified as unknown local or unknown. Improved maize germplasm has played a key part in catalyzing change in production practices by replacing traditional varieties with input-responsive, stable and high yielding improved varieties. The Ethiopian NARS has released a total of 61 maize varieties between 1973 and 2013. The first locally developed hybrid (BH140, in the early to intermediate-maturity group) was released in 1988, followed by a late- maturing hybrid (BH660) in 1993, and BH540 and the Ethiopian hybrid marketed as Jabi.



Source: GFP survey, 2014/15

***Figure 2.** Area under MVs in hectare in 2014/15 in selected regions of Ethiopia.*

Figure 2 depicts the area coverage by improved varieties by administrative regions in Ethiopia in 2014/15 cropping season. The Oromia Region with 45.7% of the maize area under improved varieties comes first followed by SNNP and Amhara with 31.8% and 19.5%, respectively.

3.2. Maize Varietal Turnover Analysis

The availability of recommended varieties of maize alone would not imply varietal diversity, if they were not available at the farm level and grown by farmers. The weighted average age (WA) of varieties is used to estimate the rate of varietal replacement, based on the age of varieties grown by farmers in a given year since release, weighted by the area planted to each variety in that year [3]. The total number of maize cultivars grown in Ethiopia during the study main crop season was more than 60. These consisted of sixteen hybrids, eight OPVs, with more than 40 cultivars including known and unknown local varieties. The intermediate maturity group hybrid BH660 occupied the largest area (more than 20%). This cultivar was released in 1993 and currently due for replacement, with recently released more robust and higher-yielding cultivars such as BH661 and BH546. In addition, nearly 32% of the total cultivars reported covered less than 1% of the total area each.

In Ethiopia, the WA calculated for modern maize varieties (both hybrid and OPVs) showed a low level of varietal turnover of about 11 and 14years respectively, according to the farmer responses (Table 6). This figure also indicates that although Ethiopian farmers are growing modern varieties of maize, it is slow in changing to new varieties released in recent years or having difficulty to get quick access to improved seeds.

Table 6. *Maize varietal turnover analysis using farmer perception.*

Hybrid	Mean area (ha)	Release year	Years since release	WA
Aba Raya	1.00	2006	9	1.4
Agar	0.18	2006	9	0.2
Shone	0.43	2006	9	0.6
Welel	0.25	2006	9	0.3
BH140	0.21	1988	27	0.8
BH540	0.58	1995	20	1.7
BH541	0.05	2002	13	0.1
BH543	0.33	2005	10	0.5
BH545	0.32	2008	7	0.3
BH660	0.45	1993	22	1.5
BH661	1.08	2011	4	0.6
BH670	0.69	2002	13	1.4
Chindi	0.51	2001	14	1.1
Jabi	0.14	1995	20	0.4
Limu	0.44	2012	3	0.2
Total Hybrid	6.66			11.2
OPVS				
Katumani	0.54	1974	41	6.0
Fetene	0.27	1996	19	1.4
Kuleni	0.15	1995	20	0.8
Melkasa-1Q	0.12	2001	14	0.4
Melkasa-3	0.50	2004	11	1.5
Melkasa-4	0.39	2006	9	0.9
Melkasa-5	0.25	2008	7	0.5
Morka	1.48	2008	7	2.8
Total	3.70			14.3

Source: GFP survey, 2014/15

In the same manner, the combined WA calculated for modern maize (both hybrid and OPV) varieties showed a low level of varietal turnover of 12 years (Table 7). This figure again indicates that although Ethiopian farmers are growing modern varieties of maize, they are slow in changing to new varieties released in recent years or they are having difficulty to get quick access to improved seeds.

Table 7. *Combined Weighted Average Age (WA) of maize varieties grown by farmers in Ethiopia.*

Hybrid	Mean area (ha)	Release year	Years since release	WA
Aba Raya	1.00	2006	9	0.9
Agar	0.18	2006	9	0.2
Shone	0.43	2006	9	0.4
Welel	0.25	2006	9	0.2
BH140	0.21	1988	27	0.5
BH540	0.58	1995	20	1.1
BH541	0.05	2002	13	0.1
BH543	0.33	2005	10	0.3
BH545	0.32	2008	7	0.2

Hybrid	Mean area (ha)	Release year	Years since release	WA
BH660	0.45	1993	22	1.0
BH661	1.08	2011	4	0.4
BH670	0.69	2002	13	0.9
Chindi	0.51	2001	14	0.7
Jabi	0.14	1995	20	0.3
Katumani	0.54	1974	41	2.1
Limu	0.44	2012	3	0.1
Fetene	0.27	1996	19	0.5
Kuleni	0.15	1995	20	0.3
Melkasa-1Q	0.12	2001	14	0.2
Melkasa-3	0.50	2004	11	0.5
Melkasa-4	0.39	2006	9	0.3
Melkasa-5	0.25	2008	7	0.2
Morka	1.48	2008	7	1.0
Total	10.36			12.3

Source: GFP survey, 2014/15

3.3. Factors Affecting Varietal Turnover of Maize (Both Hybrid and OPVs) at Farm Level

The econometric analysis depicts that the test for multicollinearity (VIF) reported suggests that there is no serious problem of multicollinearity among explanatory variables because the mean VIF is about 1.3. The coefficient of determination (R^2) also indicates that 88%and 60 % of the variation in the dependent variable were explained by the explanatory variable for hybrid and OPV weighted age respectively. But, one problem with the R^2 is that as more explanatory variables are added, the R^2rises regardless of the value these explanatory variables add to the equation. The adjusted R^2 adjusts for the number of explanatory variables in the model and includes a penalty for increasing numbers of independent variables.

The test for heteroskedasticity indicated that there is no constant variance. The reason for this test is that in many cases homoskedasticity greatly simplifies the theoretical calculations, and it is therefore quite advantageous for teaching and learning. It should always be remembered, however, that homoskedasticity is never imposed because it is believed to be a correct feature of an empirical model, but rather because of its simplicity [4]. Therefore, as a remedial of this heteroskedasticity, variable coefficient robust standard error was used.

Factors affecting turnover of hybrid maize varieties included family size, farmers' experience in growing maize and age of maize varieties from release date. In the same manner, education level and age of varieties affects WA of OPVs. Farmers' experience in growing maize affects WA weakly but statistically significant and positive. This implies that more experienced farmers are refusing to change their varieties as they are small holders and so risk averse.

Family size being positively affecting hybrid maize varietal turnover also implies that if the decision to cultivate a new variety requires consensus among key family members who are involved in farming, then idea generation and making decision may become more difficult and taking time, causing households to ignore varietal turnover in order to avoid disagreement and this result is similar to [12]. Similarly, varietal age is a factor that affects the turnover of maize cultivars significantly. The age of varieties affects WA of both hybrid and OPVs significantly and positively (at 1%) implying that a year increase in varietal age increases WA and so slows down the varietal turnover. On the other hand, significant impact of the constant at 1% probability level on weighted varietal age implies that, there are other variables rather than those specified in the model that are important in determining the varietal turnover (Table 8).

Education level is another factor that affects improved maize of OPVs turnover significantly. The Education level of households affects WA of OPVs significantly and positively (at 10%) implying that a year increase in varietal age increases WA and so slows down the varietal turnover. Contrary to this however, Household head's sex, age, total number of livestock units, Distance to the nearest main market, Distance to the source of seed, Distance to village market, Land owned, Extension contact and Source of income were insignificant (Variable Coefficient robust standard error). Gender of household head influenced varietal turnover (WA) insignificantly. The results were consistent with findings reported by [19, 16, 12].

Table 8. *Determinants of WA of maize for hybrid maize and improved OPV cultivars at farm level.*

Variable	Weighted Age (hybrid maize)		Weighted Age (OPVs)	
	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
Sex	0.0047	0.01	0.009	0.01
Age	0.0000	0.00	0.0002	0.00
Education	-0.0005	0.00	-0.002**	0.00
Credit for maize seed	-0.0035	0.01	0.001	0.01
Livestock	-0.0008	0.00	-0.001	0.00
Experience in growing maize	0.0002*	0.00	-0.00004	0.00

Variable	Weighted Age (hybrid maize)		Weighted Age (OPVs)	
	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
Distance to the nearest main market	-0.0004	0.00	-0.0003	0.00
Distance to source of seed	0.0072	0.01	0.016	0.01
Distance to village market	0.0000	0.00	0.0001	0.00
Land owned	-0.0005	0.00	0.001	0.00
Total maize area	-0.0010	0.00	-0.007	0.01
Status of farmer	0.0139	0.02	0.007	0.01
Farm asset	0.0055	0.01	0.002	0.01
Source of income	0.0030	0.01	0.014	0.02
Extension contact	0.0020	0.01	0.006	0.01
Family size	0.002***	0.00	0.002	0.00
Adoption	0.0043	0.01	-0.007	0.01
Yield obtained	-0.0004	0.00	-0.001	0.00
Varietal age	0.04***	0.00	0.02***	0.00
Family members	0.01	0.00	-0.006	0.00
Constant	-0.11***	0.02	0.07**	0.03
R^2		0.88		0.60
N		874		312

Source: GFP survey, 2014/15

Notes: Dependent variable is weighted age of maize (both hybrid and OPVs) cultivars cultivated on-farm (in year). Varietal age is calculated as the difference between year of cultivation and year of official varietal release. *, ** and *** denotes estimates are significant at the 10, 5 and 1 percent probability level, respectively.

4. Conclusion and Recommendation

The study examined the varietal turnover using farmer self-identification and DNA fingerprinting and determinants of maize cultivars turnover in Ethiopia. To analyze the maize cultivars varietal turnover, a weighted average age Index (WA) was used. The multiple linear regression (OLS) was used in modeling determinants of both hybrid and OPV maize cultivars varietal turnover.

Factors affecting turnover of hybrid maize varieties included family size, farmers' experience in growing maize and age of maize varieties from release date. Farmers' experience in growing maize affects hybrid maize WA weakly and statistically significant and positive. This implies that more experienced farmers are refusing to change their varieties as they are small holders and so risk averse. Family size being positively affecting varietal turnover also implies that if the decision to cultivate a new variety requires consensus among key family members who are involved in farming, then idea generation and making decision may become more difficult and taking time, causing households to forgo varietal turnover in order to avoid disagreement and this result is similar to [12].

Eventually, varietal age in years was explored. It is a factor that affects the turnover of maize cultivars (of both hybrid and OPVs) significantly. The varietal age affects WA significantly and positively (at 1%) which implies that a year increase in varietal age increases WA of improved hybrid maize and OPVs by 4% and 2% respectively revealing that in both cases it slows down the varietal turnover. On the other hand, however, significant impact of the constant at 1% probability level on weighted varietal age implies that, there are other variables rather than those specified in the model that are important in determining the varietal turnover.

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