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Maize Varietal Adoption Rate in Ethiopia, the Farmer Self Identification and DNA Finger Printing Approaches

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Abstract
The study examined the rate of maize adoption using farmer self identification and DNA fingerprinting in Ethiopia. Secondary data from the household survey data collected by Central Statistical Agency and DNA fingerprinting identified for maize varieties were used in the analysis. The findings of the study indicate that rate of maize adoption estimates from the DNA fingerprinting technology is different from farmer perceptions. As indicated, according to the household survey 43.75% of the farmers used improved maize varieties during the study main cropping season, whereas, based on DNA fingerprinting analysis 97.16% of the respondents used improved maize varieties and the difference was statistically significant at ($p<0.01$) realizing the importance of DNA fingerprinting technique over farmer self identification.
Keywords: DNA Fingerprinting, Maize adoption rate, Hybrid maize and OPvs
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1. INTRODUCTION

1.1. Background of the Study

Realizing the growing importance of maize in the country's crop production and food security, significant research effort has been done to develop new varieties of this crop that can enhance the food security in the country. The collaborative research efforts of Ethiopian Institute of Agricultural Research (EIAR) and International maize and wheat improvement center (CIMMYT) have resulted in the development of widely adapted hybrid seeds; open pollinated, low-moisture stress resistant and nutritionally enhanced varieties of maize beginning from 2007 onward. Other studies have observed that maize area covered by the improved varieties in Ethiopia is about 40% (Shiferaw et al., 2014; Abate et al., 2015).

On the other hand, according to Maredia and Reyes (2015), 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 (Chilot et al., 2016; Frédéric et al., 2016) and so was used in this study in crop varietal identification to undertake maize adoption rate.

1.2. Objectives of the Study

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

1. To measure the rate of maize adoption using DNA fingerprinting approach;
2. To compare the difference between maize adoption rate as reported by farmers and what DNA fingerprint identified.

1.3. Research Questions

The research questions answered by this study are:

1. What is the maize adoption rate in Ethiopia as reported by farmer self identification?
2. What is the maize adoption rate in Ethiopia using DNA identification?

3. METHODOLOGY

3.1. Description of Genetic Fingerprinting Survey

The study is based on Genetic Fingerprint Survey conducted during the 2014/15 cropping season covering a total of 400 enumeration areas located in four regions of Amhara, Oromia, Tigray and SNNP region. These regions together account for more than 93 percent of nationwide maize production (Schneider and Anderson, 2010).

The sample enumeration areas' in each of the respective regions were also selected to have good representation of the agro-ecology, topography, crop grown and related agricultural practice. In order to easily link to the Agricultural data set and efficiently utilize scarce resources the 2014 Genetic Fingerprint Survey was designed not only to cover the 2014/15 Agricultural Sample Survey (AgSS) covered enumeration areas' (EAs') but also covered the 1673 sample households from the EAs located in the four regions mentioned above. However, the 2014 GFP survey covered a total of 400 enumeration areas where 110 EAs' were from Amhara, 136, 50 and 104 EAs' were from Oromia, Tigray and SNNP regions, respectively.

3.2. Types, Sources and Methods of Data Collection

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 (Chilot et al., 2016). 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 this GFP 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 Abate et al. (2015) 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.

3.3. Sampling technique and Sample Size

3.3.1. Farm Household Sampling Technique

The farm household sampling strategy following Chilot et al. (2016) involves several steps. The first step focused on the preparation of a household survey instrument for soliciting farmer knowledge and use of improved varieties of maize. A questionnaire was prepared and circulated for maize for comments and suggestions by the socioeconomics task team of EIAR. Based on the feedback, contents of the questionnaire were refined and determined.

The next step involved establishing and training the survey teams. The enumerators and supervisors were recruited by CSA that have previous experience in the CSA surveys. A two-day intensive training was given to the selected enumerators and supervisors in the zones of the pilot areas. The training included briefings on the study objectives, a thorough review of the questionnaires, interviewing techniques, and tips on how to fill the structured questionnaires to ensure the collection of quality data. Following the in class trainings, enumerators and supervisors were taken to maize growing areas for on the job training and administering the questionnaires to households that are not part of the sample. The questionnaires are then revised in light of the feedbacks and finally be ready for the survey.

The final step was dealt with administration of the questionnaires to sample households and collection of completed questionnaires. 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.

Finally, 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.

3.3.2. Genetic Profiling Sampling for Maize DNA Extraction and Matching

Crop cuts and associated data collection forms the basis for this study. Crop cut involves the use of appropriate sampling techniques for collecting crop samples from randomly selected maize fields (Chilot et al., 2016). The main objective of the crop cut was to collect maize grain samples from farmer fields for extraction of DNA and subsequent laboratory analysis for genetic matching with known reference materials. Crop cuts were taken from maize fields planted during 2014/15 crop season. The method involved demarcating small subplots of rectangular shape from randomly selected crop fields for each crop type and subsequent threshing, drying and weighing and recording the weight of the harvest. In each enumeration area, five maize fields were selected for conducting crop-cutting experiment.

Besides, grain samples from the crop cuts, maize seed samples from the maize breeding programs responsible for releasing and maintaining improved varieties were collected by the biotechnology task team for the development of a reference library. Grain samples and completed questionnaires were delivered to Ethiopian Institute of Agricultural Research (EIAR) in two ways. In the first case, the research team traveled to CSA branch offices and collected grain samples from the crop cuts along with completed questionnaires. In the second case, CSA experts brought the grain samples, completed questionnaires to Addis Ababa, and delivered it to EIAR. Similarly, seed samples of maize varieties from breeders and the Ethiopian Seed Enterprise (ESE) were collected for developing a reference library. Then, after collected samples were delivered to Holeta, the biotechnology task team labeled the samples properly and stored for DNA extraction at Holeta Biotechnology Research Center laboratory. Then the collected samples were processed for DNA extracts at NABRC by the EIAR biotechnology task team. In order to ensure that the DNA extractions are done properly, an expert from DArT provided hands-on training for the EIAR biotechnology researchers at Holeta. The biotechnology task team processed the DNA extracts, and shipped to Australia for DNA fingerprinting by DArT (Chilot et al., 2016 and DNA fingerprinting project).

3.4. Methods of Data Analysis

Descriptive analyses was done including; 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.

4. RESULTS AND DISCUSSION

4.1. Characteristics of Farm Households

The average age of the sample household heads was about 47 years with minimum of 18 and 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 1 show 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.

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 2: 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	
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	
House hold 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 2) 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.

4.1.1. Maize Varieties Grown by Farmers

The study results indicate farm households cultivate many maize varieties (Appendix Table 1). 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 (the Pioneer Hi-bred Seed).

4.3.2. 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 5). 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.

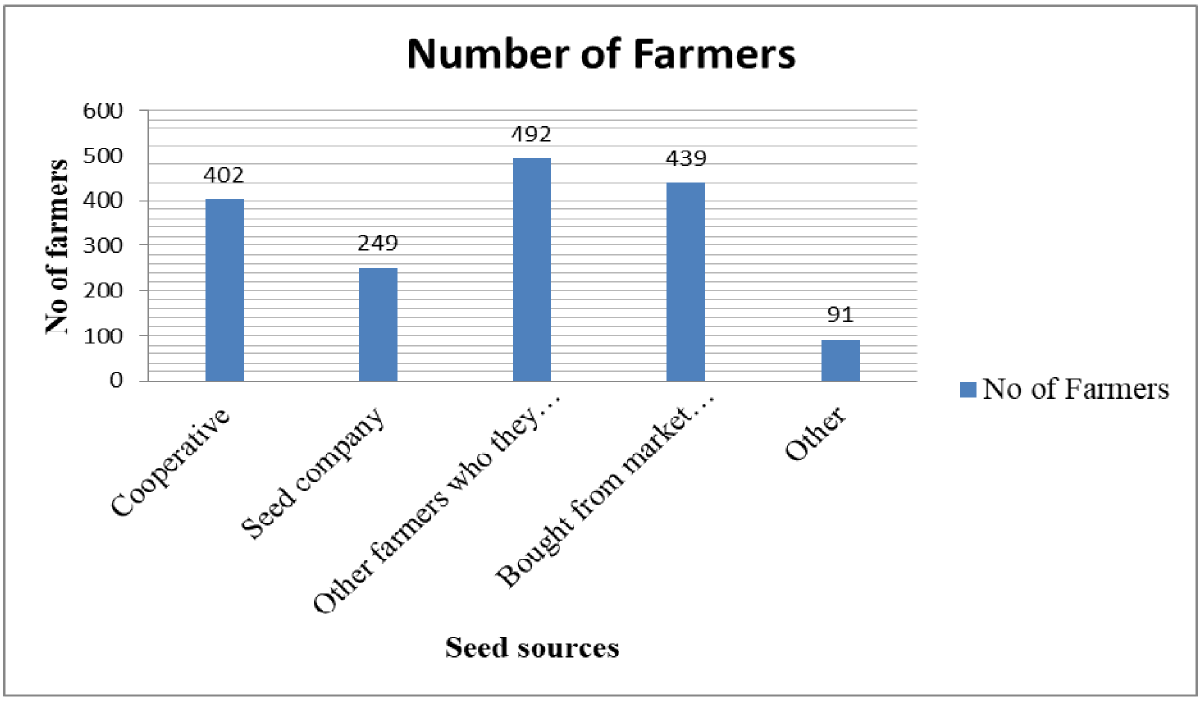

Figure 1: Sources of maize seed
Source: GFP survey, 2014/15

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 3). 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 3: 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

4.3. Maize Varietal Adoption Rate Using Farmer Estimates and DNA fingerprinting Approach

Maize varietal adoption rate and area under improved hybrid, OPVs and local maize varieties were estimated in this study for maize producers during the study crop year in Ethiopia. Accordingly, maize varietal identification estimates were done based on two different approaches namely farmer recall (farmer self identification) and DNA finger printing.

4.3.1. Maize Varietal Adoption Rate Estimates based on Farmers Perception

The household survey indicated that farmers were able to name 16 hybrids, 7 OPVs, and more than 40 local varieties. Furthermore, 43.75% claimed to have cultivated improved maize varieties that matched with names of released improved maize varieties while; 8.86% reported to have used improved maize varieties that could not be matched with any of the released or recommended improved varieties. Another 15.74% claimed to have grown local varieties but reported varietal names matched with names of released varieties. The rest, 40.5% of households claimed to have grown local maize varieties of unknown origin (Appendix Table 2). The household survey also suggested that 43.75% of the households adopted improved maize varieties (both hybrid and OPV) during the study on 47.5% of the maize area. When considering adopters of improved maize varieties, about 31.24% of the farmers used hybrid maize; about 3.65% used OPVs while the rest (8.86%) reported to have grown unknown improved varieties. The most popular maize variety was BH660 followed by Shone and BH 540 in that order (Appendix Table 2).

These adoption figures are higher than what had been reported for Ethiopia in the past. For instance, Byerlee and Jewell, (1997) and Maredia et al. (1998) reported modern cultivars adoption of 13–29% in 1990 in Ethiopia. Similarly, Morris (2002) reported approximately about 4% of the area in Ethiopia to be under hybrid maize in 1997. Similarly, Spielman et al. (2013) reported that the area covered by improved seed was 2% in 1995 and increased to 20% in 2003. Langyintuo et al. (2008) also reported that the coverage by modern cultivars of about 18%. De Groote et al. (2013) reported modern cultivars adoption of 28% for national average and 18% for the Central Rift Valley in 2009 crop year. Moti et al. (2013) also reported modern cultivars adoption of 31% during the 2011 main crop season. Similarly, this study's result is in line with the recent study by Abate et al. (2015) which showed that the area covered by modern cultivars increased from 13 percent in 2004 to 40 percent in 2013 crop season.

4.3.2. Regional Level Maize Varietal Adoption Rate Estimates Based on Farmers' Recall

The household survey indicated that farmers in Tigray region were able to name 8 hybrids, 3 OPVs, and more than 11 local varieties. Furthermore, 26.01% reported to have cultivated improved maize varieties that matched with names of released improved maize varieties; 9.42% reported to have used improved maize varieties that could not be matched with any of the released or recommended improved varieties. Another 12.44% claimed to have grown local varieties but reported varietal names matched with names of released varieties. The rest, 45.29% of households claimed to have grown local maize varieties of unknown origin (Appendix Table 3).

With same approach applied, farmers in Amhara region were able to name 9 hybrids, 4 OPVs, and more than 15 local varieties. Furthermore, 39.46% claimed to have cultivated improved maize varieties that matched with names of released improved maize varieties; 9.73% reported to have used improved maize varieties that could not be matched with any of the released or recommended improved varieties. Another 14.19% claimed to have grown local varieties but reported varietal names matched with names of released varieties. The rest, 36.59% of households claimed to have grown local maize varieties of unknown origin (Appendix Table 4).

Similarly, farmer recall data analysis indicated that farmers in Oromia region were also able to name 14 hybrids, 7 OPVs, and 19 local varieties. Furthermore, 35.46% claimed to have cultivated improved maize varieties that matched with names of released improved maize varieties; 7.66% reported to have used improved maize varieties that could not be matched with any of the released or recommended improved varieties. Another 9.6% claimed to have grown local varieties but reported varietal names matched with names of released varieties. The rest, 42.5% of households claimed to have grown local maize varieties of unknown origin (Appendix Table 5).

During the study, it is indicated that farmers in Southern Nations Nationalities and Peoples (SNNP) region were able to identify 11 hybrids, 4 OPVs, and 20 local varieties. Furthermore, 33.9% claimed to have cultivated improved maize varieties that matched with names of released improved maize varieties; 9.8% reported to have used improved maize varieties that could not be matched with any of the released or recommended improved varieties. Another 17.09% claimed to have grown local varieties but reported varietal names matched with names of released varieties. The rest, 39.22% of households claimed to have grown local maize varieties of unknown origin (Appendix Table 6).

4.3.3. Maize Varietal Adoption Rate Estimates based on DNA Fingerprinting

Adoption estimates of maize varieties based on Data from the DNA fingerprinting technology approach depicted that 97.16% of the farmers used improved maize varieties, of which 72.06% adopted hybrids and the remaining 25.10% used improved OPV varieties. In terms of land allocation, 97.1% of the maize area was allocated for improved varieties, of which, 73.03% and 24.07% of the land were under hybrids and OPVs, respectively similar to the report by (Tura et al**.**, 2010) which indicated that adoption rate of maize seed in the study area is more than 92%. Adoption levels measured in terms of proportion of farmers and land allocated was slightly higher for BH660 maize variety. For instance, 34.6% households cultivated BH660 during the study year. In the same manner, the variety covered 39.3% of the maize area. The most popular maize variety was BH660 followed By Shone, Argane and BH540 in that order from hybrid maize varieties while Kuleni, Melkassa-1Q and Gibe1 were from OPVs (Appendix Table 7).

4.3.4. Maize Varietal Adoption Rate Estimates Based on DNA Fingerprinting in different Administrative Regions of Ethiopia

Adoption estimates of maize varieties based on Data from the DNA fingerprinting technology approach indicated that 97.20% of the farmers in Tigray region used improved maize varieties, of which 72.73% adopted hybrids and the remaining 24.48% used improved OPV varieties. In terms of land allocation, 97.46% of the maize area was allocated for improved varieties, of which, 77.49% and 19.97% of the land were under hybrids and OPVs, respectively (Appendix Table 8).

Based on Data from the DNA fingerprinting technology, it is observed that about 98% of the farmers in Amhara region used improved maize varieties, of which nearly 68% adopted hybrids and the remaining 30% used improved OPV varieties (DNA purity level of >=70%). In terms of land allocation, 98.75% of the maize area was allocated for improved varieties, of which, 62% and 36.75% of the land were under hybrids and OPVs, respectively (Appendix Table 9).

Estimation of adoption rate of maize varieties (at purity level of >=70%) based on Data from the DNA fingerprinting technology approach indicated that about 97% of the farmers in Oromia region adopted improved maize varieties, of which nearly 72% used hybrids and the remaining 25% used improved OPV varieties. In terms of land allocation, 96.57% of the maize area was allocated for improved varieties, of which, 72.56% and 24.01% of the land were under hybrids and OPVs, respectively (Appendix Table 10).

Similarly, adoption estimates of maize varieties based on Data from the DNA fingerprinting technology approach indicated that 97.25% of the farmers in SNNP region used improved maize varieties, of which 77.06% adopted hybrids and the remaining 20.18% used improved OPV varieties. In terms of land allocation, 96.72% of the maize area was allocated for improved varieties, of which, 77.69% and 19.03% of the land were under hybrids and OPVs, respectively (Appendix Table 11) (DNA identified at purity level of >=70%).

4.3.5. Comparison of Maize Varietal Adoption Rate Estimates from Both Approaches

When comparing maize varietal identification from the household survey with DNA fingerprinting, it gives insights on the level of differences from using either approach. The comparison can be made in terms of the size of the estimated figure as well as whether there is match in variety identification. Table 4 compares maize adoption estimates from the DNA fingerprinting analysis with farmer perceptions. As noted, according to the household survey 43.75% of the farmers used improved maize varieties during the study cropping year, whereas, based on DNA fingerprinting technology, 97.16% of the respondents cultivated improved maize varieties which is almost more than double. On the other hand, the adoption estimates for OPV maize varieties through both methods indicate slightly lower figures when compared to hybrids. The estimate for adoption of hybrid maize varieties is 31.24% using farmers' response and 72.06% using DNA sequencing. For OPV varieties, the estimate is about 3.65% using farmers' response and 25.10% using DNA analysis. In contrary to the previous studies, this result shows that farmers underestimate their use of improved maize varieties, suggesting that the use of DNA fingerprinting corrects for underestimation in adoption estimates. A result of this study corresponds with the findings of Chilot et al. (2016) and Frederic et al. (2016) that used a similar approach.

Therefore, the discrepancy between farmer self-identification and DNA fingerprinting is statistically significant at p< 1% and this implies that better extension services are needed to properly educate farmers on the types of maize varieties they are growing. Moreover, farmer misidentification of the varieties they are cultivating may lead farmers to use on-farm practices that are not well suited for certain improved varieties or landraces. In general, farmers need to know their varieties correctly if they are to apply the correct amount of fertilizer, or to plant varieties in the best soil type to maximize yields.

Table 4: Comparison of maize varietal Adoption rate estimates from both approaches

Regions	Variety	Farmer response		DNA fingerprinting	
		Number	Adoption rate (%)	Number	Adoption rate (%)
Tigray	Hybrid	53	23.77	104	72.73
	OPVs	5	2.24	35	24.48
	Unknown improved	21	9.42	-	-
Amhara	Hybrid	159	35.25	255	67.67
	OPVs	19	4.21	114	30.24
	Unknown improved	44	9.73	-	-
Oromia	Hybrid	199	31.79	430	72.03
	OPVs	23	3.67	148	24.79
	Unknown improved	48	7.66	-	-
SNNP	Hybrid	110	30.81	252	77.03
	OPVs	11	3.08	66	20.18
	Unknown improved	35	9.8	-	-
Overall	Hybrid	522	31.24	1042	72.06
	OPVs	61	3.65	363	25.10
	Unknown improved	148	8.86	-	-

The difference between the result of adoption rate using DNA and farmer self identification is significant at p<1% (t=33.7***)

Source: GFP survey, 2014/15

5. Conclusion and Recommendation

5.1. Conclusion

The study examined the maize varietal adoption rate using farmer self identification and DNA fingerprinting in Ethiopia. Secondary data from the household survey data collected by CSA and DNA fingerprinting identified for maize varieties were used in the analysis. The findings of the study compares maize adoption estimates from the DNA fingerprinting technology with farmer perceptions. As noted, according to the household survey 43.75% of the farmers used improved maize varieties during the study main cropping season, whereas, based on DNA fingerprinting analysis 97.16% of the respondents used improved maize varieties which is more than two fold. This indicates that around half of the farmers do not know maize variety they are producing. The estimate for adoption of hybrid maize varieties is 31.24% using farmers' response and 72.06% using DNA analysis. For OPV varieties, the estimate is about 3.65% using farmers' response and 25.10% using DNA analysis.

5.2. Recommendation

1. Thus, there is a need to strengthen information delivery services. This shows that extension agents need to target not only the farmers who have not adopted the technology but also try to increase the use of recent technology by the farmers who have already adopted.
2. The farmer-extension-research linkages need to be strengthened. The study revealed that 56.2 percent of the farmers used unknown maize varieties and only 43.8 percent of the farmers could name the improved maize varieties correctly.

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7. APPENDICES

Appendix Table 1: Shows the maize varieties grown by the farmers during the study

Hybrid	No of farmers	%
Aba Raya	1	0.06
Agar	9	0.54
BH140	8	0.48
BH540	54	3.23
BH541	5	0.30
BH543	12	0.72
BH545	4	0.24
BH660	301	18.01
BH661	3	0.18
BH670	5	0.30
BHQPY545	1	0.06
Jabi	8	0.48
Limu	3	0.18
Shone	107	6.40
Welel	1	0.06
Total hybrid	**522**	31.24
OPVs		
Fetene		
Katumani	24	1.44
Kulani	2	0.12
Melkasa-1Q	9	0.54
Melkasa-3	1	0.06
Melkasa-4	1	0.06
Melkasa-5	1	0.06
Morka	3	0.18
Total OPVs	61	3.65
Unknown Improved Varieties	148	8.86
Total improved	**731**	43.75
Local varieties		
Unknown Local Varieties	677	40.51
Known local varieties	164	9.81
Amare	1	0.06
Anji	3	0.18
Areba	3	0.18
Awash	1	0.06
Awassa	1	0.06
Awo	1	0.06
Bekelo demetu	1	0.06
Berhulay	2	0.12
Berihulay	3	0.18
Beselay	1	0.06
Boshe	3	0.18
Bukuri	2	0.12

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Bunugn	1	0.06
Cg20	1	0.06
Chindi	3	0.18
Enat bekolo	3	0.18
Faho	1	0.06
Fayinel	2	0.12
Filetema	4	0.24
Finer	1	0.06
Fisho	1	0.06
Germany	2	0.12
Germashila	2	0.12
Habesha	7	0.42
Huletegna zer	1	0.06
Jole	1	0.06
Kei bekolo	3	0.18
Kenchi	4	0.24
Kenfe asi	1	0.06
Kenkena	1	0.06
Kenya	9	0.54
Limat	1	0.06
M4 & M1	1	0.06
Maro	3	0.18
Meki	3	0.18
Merid	3	0.18
Orome	8	0.48
Pioner	1	0.06
Ponera	1	0.06
Shara	2	0.12
Sheye	1	0.06
Sheyo	1	0.06
Shoye	4	0.24
Subtotal known local	263	15.74
Total local	**940**	56.25
Over all	1671	100.00

Source: GFP survey, 2014

Appendix Table 2: Maize Adoption Estimates based on Farmers perception

Hybrid	No of farmers	%	Area in ha	%
Aba raya	1	0.06	1	0.15
Agar	9	0.54	1.6	0.24
BH140	8	0.48	1.7	0.26
BH540	54	3.23	31.3	4.70
BH541	5	0.30	0.3	0.05
BH543	12	0.72	3.9	0.59
BH545	4	0.24	1.3	0.20
BH660	301	18.01	136.1	20.44
BH661	3	0.18	3.2	0.48
BH670	5	0.30	3.5	0.53
BHQPY545	1	0.06	0.3	0.05
Jabi	8	0.48	1.1	0.17
Limu	3	0.18	12.9	1.94
Shone	107	6.40	45	6.76
Welel	1	0.06	0.3	0.05
Total hybrid	**522**	31.24	**243.5**	36.58
OPVs				
Fetene	20	1.20	5.3	0.80

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Katumani	24	1.44	1.3	0.20
Kulani	2	0.12	0.3	0.05
Melkasa-1Q	9	0.54	1.1	0.17
Melkasa-3	1	0.06	0.5	0.08
Melkasa-4	1	0.06	15.5	2.33
Melkasa-5	1	0.06	0.3	0.05
Morka	3	0.18	4.5	0.68
Total OPVs	61	3.65	28.8	4.33
Unknown Improved Varieties	148	8.86	44	6.61
Total improved	**731**	43.75	**316.1**	47.48
Local varieties				
Unknown Local Varieties	677	40.51	244.4	36.71
Known local varieties	164	9.81	57.5	8.64
Amare	1	0.06	0.2	0.03
Anji	3	0.18	0.4	0.06
Areba	3	0.18	1	0.15
Awash	1	0.06	0	0.00
Awassa	1	0.06	0.5	0.08
Awo	1	0.06	0.4	0.06
Bekelo demetu	1	0.06	0.3	0.05
Berhulay	2	0.12	0.5	0.08
Berihulay	3	0.18	0.9	0.14
Beselay	1	0.06	0.3	0.05
Boshe	3	0.18	0.8	0.12
Bukuri	2	0.12	0.1	0.02
Bunugn	1	0.06	0	0.00
Cg20	1	0.06	0.1	0.02
Chindi	3	0.18	1.5	0.23
Enat bekolo	3	0.18	0.3	0.05
Faho	1	0.06	0	0.00
Fayinel	2	0.12	0.4	0.06
Filetema	4	0.24	1.9	0.29
Finer	1	0.06	0.5	0.08
Fisho	1	0.06	0	0.00
Germany	2	0.12	0.1	0.02
Germashila	2	0.12	0	0.00
Habesha	7	0.42	1.3	0.20
Huletegna zer	1	0.06	0.2	0.03
Jole	1	0.06	0.5	0.08
Kei bekolo	3	0.18	12.9	1.94
Kenchi	4	0.24	0.7	0.11
Kenfe asi	1	0.06	0.8	0.12
Kenkena	1	0.06	0.1	0.02
Kenya	9	0.54	0.3	0.05
Limat	1	0.06	9	1.35
M4 & M1	1	0.06	0.3	0.05
Maro	3	0.18	0.3	0.05
Meki	3	0.18	1.8	0.27
Merid	3	0.18	0.7	0.11
Orome	8	0.48	1.8	0.27
Pioner	1	0.06	3.6	0.54
Ponera	1	0.06	0.6	0.09
Shara	2	0.12	0.5	0.08
Sheye	1	0.06	0.2	0.03
Sheyo	1	0.06	0.5	0.08
Shoye	4	0.24	1.4	0.21

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Subtotal known local	263	15.74	105.2	15.80
Total local	**940**	56.25	**349.6**	52.52
Over all	1671	100.00	665.7	100

Source: GFP survey, 2014

Appendix Table 3: Maize Adoption Estimates based on Farmers perception in Tigray region

Items	**Variety**	**No of farmers**	**Percent**	**Total area (ha)**	**Percent**
Hybrid	BH540	2	0.89	0.27	0.61
	BH541	1	0.44	0.01	0.02
	BH543	2	0.89	0.12	0.27
	BH545	2	0.89	0.66	1.47
	BH660	30	13.33	8.07	18.03
	BH661	2	0.89	3.13	6.98
	Chindi	1	0.44	1.00	2.23
	Shone	13	5.78	1.76	3.94
	Subtotal hybrid	**53**	**23.77**	**15.02**	**33.54**
OPVs	Katumani	1	0.44	0.25	0.56
	Fetene	2	0.89	0.10	0.22
	Melkasa-1Q	2	0.89	0.22	0.49
	Subtotal OPVs	**5**	**2.24**	**0.57**	**0.72**
	Unknown Improved Varieties	21	9.42	2.35	5.25
	Total improved	**79**	**35.43**	**17.94**	**39.51**
Local Varieties	Local Varieties	28	12.44	2.97	6.63
	Anji	3	1.33	0.40	0.89
	Berihulay	2	0.89	0.77	1.72
	Beselay	1	0.44	0.25	0.56
	Bukuri	1	0.44	0.11	0.25
	Fisho	1	0.44	0.03	0.06
	Germashila	2	0.89	0.04	0.08
	Kenchi	1	0.44	0.03	0.06
	Kenfe Asi	1	0.44	0.08	0.19
	Kenya	1	0.44	0.05	0.10
	Limat	1	0.44	0.34	0.76
	Orome	1	0.44	0.50	1.12
	Subtotal local	**43**	**19.28**	**5.56**	**12.42**
	Unknown Local Varieties	101	45.29	15.72	35.10
	Total local	**144**	**64.57**	**21.28**	**47.52**
	Total	223	100.00	44.79	100.00

Source: GFP survey, 2014

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Appendix Table 4: Maize Adoption Estimates based on Farmers perception in Amhara region

Variety		**No of farmer**	**Percent**	**Total area (ha)**	**Percent**
Hybrid	Agar	2	0.44	0.35	0.27
	BH140	2	0.44	0.62	0.48
	BH540	24	5.31	5.02	3.86
	BH541	2	0.44	0.18	0.13
	BH543	7	1.55	1.83	1.41
	BH660	91	20.13	36.31	27.93
	BH670	1	0.22	0.10	0.08
	Jabi	3	0.66	0.23	0.18
	Shone	27	5.97	9.82	7.55
	Subtotal hybrid	**159**	**35.25**	**54.46**	**41.88**
OPVs	Katumani	8	1.77	2.03	1.56
	Kuleni	1	0.22	0.05	0.04
	Fetene	5	1.11	1.54	1.18
	Melkasa-1Q	5	1.11	0.36	0.28
	Subtotal OPVs	**19**	**4.21**	**1.90**	**1.46**
	Unknown Improved	44	9.73	11.97	9.20
	Total improved	**222**	**49.22**	**68.32**	**52.55**
Local varieties	Local Varieties	44	9.73	11.49	8.84
	Amare	1	0.22	0.18	0.14
	Areba	1	0.22	0.03	0.02
	Awo	1	0.22	0.38	0.29
	Berihulay	1	0.22	0.11	0.08
	Boshe	1	0.22	0.06	0.04
	Bunugn	1	0.22	0.04	0.03
	Enat Bekolo	1	0.22	0.06	0.05
	Filetema	1	0.22	1.00	0.77
	Kei Bekolo	1	0.22	0.37	0.28
	Kenchi	1	0.22	0.15	0.12
	Kenya	2	0.44	2.59	1.99
	M4 & M1	1	0.22	0.25	0.19
	Maro	3	0.66	1.75	1.35
	Merid	1	0.22	1.00	0.77
	Shoye	3	0.66	0.41	0.32
	Subtotal local	64	14.19	19.86	15.28
	Unknown Local	165	36.59	41.84	32.18
	Total local	229	50.78	61.70	47.45
	Total	451	100	130.02	100.00

Source: GFP survey, 2014

Appendix Table 5: Maize Adoption Estimates based on Farmers perception in Oromia region

	Variety	**No of farmer**	**Percent**	**Total area (ha)**	**Percent**
Hybrid	Abaraya	1	0.16	1.00	0.32
	Agar	7	1.12	1.25	0.40
	BH140	3	0.48	0.45	0.14
	BH540	20	3.19	9.87	3.17
	BH541	1	0.16	0.06	0.02
	BH543	2	0.32	0.98	0.31
	BH660	114	18.18	63.15	20.26
	BH670	3	0.48	2.37	0.76
	BHQPY545	1	0.16	0.25	0.08
	Chindi	2	0.32	0.54	0.17
	Jabi	3	0.48	0.77	0.25
	Limu	1	0.16	0.29	0.09
	Shone	40	6.38	20.45	6.56
	Welel	1	0.16	0.25	0.08
	Subtotal hybrid	**199**	**31.79**	**101.67**	**32.62**
OPVs	Katumani	11	1.75	9.02	2.89
	Kulani	1	0.16	0.25	0.08
	Fetene	6	0.96	1.13	0.36
	Melkasa-3	1	0.16	0.50	0.16
	Melkasa-4	1	0.16	0.39	0.13
	Melkasa-5	1	0.16	0.25	0.08
	Morka	2	0.32	4.25	1.36
	Subtotal OPVs	**23**	**3.67**	**15.79**	**5.07**
	Unknown Improved Varieties	48	7.66	16.39	5.26
	Total improved	**270**	**43.13**	**133.84**	**42.94**
Local varieties	**Local varieties**				
	Local Varieties	60	9.57	32.39	10.39
	Areba	2	0.32	1.00	0.32
	Awash	1	0.16	0.02	0.01
	Bekelo Demetu	1	0.16	0.25	0.08
	Boshe	1	0.16	0.25	0.08
	Enat Bekolo	2	0.32	0.28	0.09
	Faho	0	0	0.00	0.00
	Fayinel	1	0.16	0.12	0.04
	Filetema	2	0.32	0.64	0.20
	Finer	1	0.16	0.50	0.16
	Germany	1	0.16	0.05	0.02
	Habesha	5	0.8	0.97	0.31
	Huletegna Zer	1	0.16	0.21	0.07
	Kenchi	1	0.16	0.13	0.04
	Kenya	2	0.32	4.50	1.44
	Merid	1	0.16	0.50	0.16
	Orome	5	0.8	2.60	0.83
	Ponera	1	0.16	0.50	0.16
	Sheye	1	0.16	0.50	0.16
	Sheyo	1	0.16	1.19	0.38
	Subtotal local	**90**	**14.38**	**46.59**	**14.95**
	Unknown Local Varieties	266	42.49	131.28	42.12
	Total local	**356**	**56.87**	**177.87**	**57.06**
	Total	626	100	311.70	100.00

Source: GFP survey, 2014

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Appendix Table 6 : Maize Adoption Estimates based on Farmers perception in SNNP region

	Variety	No of farmer	Percent	Total area (ha)	Percent
Hybrid	BH140	3	0.84	0.59	0.38
	BH540	8	2.24	16.12	10.35
	BH541	1	0.28	0.02	0.01
	BH543	1	0.28	1.00	0.64
	BH545	2	0.56	0.62	0.40
	BH660	62	17.37	28.60	18.36
	BH661	1	0.28	0.10	0.06
	BH670	1	0.28	1.00	0.64
	Jabi	2	0.56	0.15	0.09
	Limu	2	0.56	1.04	0.67
	Shone	27	7.56	12.96	8.32
	Subtotal hybrid	**110**	**30.81**	**62.19**	39.93
OPVs	Katumani	3	0.84	1.60	1.03
	Fetene	5	1.4	2.54	1.63
	Melkasa-1Q	2	0.56	0.47	0.30
	Morka	1	0.28	0.20	0.13
	Subtotal OPVs	**11**	**3.08**	**4.81**	**3.09**
	Unknown Improved Varieties	35	9.8	13.31	8.55
	Total improved	**156**	**43.70**	**80.31**	**51.57**
Local varieties	**Local varieties**	32	8.96	10.61	6.81
	Awassa	1	0.28	0.50	0.32
	Berhulay	2	0.56	0.53	0.34
	Boshe	1	0.28	0.50	0.32
	Bukuri	1	0.28	0.02	0.01
	CG20	1	0.28	0.05	0.03
	Fayinel	1	0.28	0.30	0.19
	Filetema	1	0.28	0.25	0.16
	Germany	1	0.28	0.06	0.04
	Habesha	2	0.56	0.36	0.23
	Jole	1	0.28	0.50	0.32
	Kei Bekolo	2	0.56	0.32	0.21
	Kenchi	1	0.28	0.50	0.32
	Kenkena	1	0.28	0.25	0.16
	Kenya	4	1.12	1.86	1.19
	Meki	3	0.84	0.67	0.43
	Merid	1	0.28	0.35	0.22
	Orome	2	0.56	0.50	0.32
	Pioner	1	0.28	0.60	0.39
	Shara	1	0.28	0.06	0.04
	Shoye	1	0.28	1.00	0.64
	Subtotal local	61	17.09	19.79	12.71
	Unknown Local Varieties	140	39.22	55.63	35.72
	Total local	**201**	**56.30**	**75.42**	**48.43**
	Total	357	100	155.73	100.00

Source: GFP survey, 2014

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Appendix Table 7 : Maize Adoption Estimates based on DNA Fingerprinting

Hybrid	**No of farmers**	**%**	**Area in hectare**	**%**
AMH-760	20	1.38	5.9	1.01
Argane	136	9.41	47.4	8.09
BH-140	37	2.56	19.7	3.36
BH-540	106	7.33	42.8	7.31
BH-660	500	34.58	230.1	39.27
BH-661	25	1.73	13.3	2.27
BH-670	14	0.97	3.9	0.67
Javi	15	1.04	6.9	1.18
Jibat	19	1.31	4.8	0.82
Limu	13	0.90	6.1	1.04
MH-130	2	0.14	0.6	0.10
Shala	3	0.21	1.2	0.20
Shone	140	9.68	42.2	7.20
Wenchi	12	0.83	3	0.51
Hybrid total	**1042**	72.06	**427.9**	73.03
OPVs				
Abo bako	6	0.41	1.6	0.27
Hora	1	0.07	4	0.68
Gambela	16	1.11	5.1	0.87
Gibe1	63	4.36	19.3	3.29
Kulani	142	9.82	52.6	8.98
Melkassa-1Q	81	5.60	34.4	5.87
Melkassa-2	20	1.38	7.2	1.23
Melkassa-3	14	0.97	6.7	1.14
Melkassa-4	11	0.76	3.3	0.56
Melkassa-5	4	0.28	4.2	0.72
Melkassa-6Q	1	0.07	1.9	0.32
Melkassa-7	4	0.28	0.7	0.12
OPVs total	**363**	25.10	**141**	24.07
Total improved	**1405**	97.16	**568.9**	97.10
Not classified varieties	41	2.84	17	2.90
Total	**1446**	100.00	**585.9**	100.00

Source: GFP survey, 2014

Appendix Table 8 : Maize Adoption Estimates based on DNA Fingerprinting in Tigray region

Variety	No of farmer	%	Total area (ha)	%
Hybrid				
Argane	13	9.09	1.84	6.55
BH-140	3	2.10	3.14	11.18
BH-540	11	7.69	0.46	1.63
BH-660	54	37.76	12.26	43.61
BH-661	4	2.80	0.53	1.88
BH-670	1	0.70	0.01	0.03
Jibat	1	0.70	0.06	0.21
Limu	1	0.70	0.02	0.07
Shone	12	8.39	2.83	10.08
Wenchi	4	2.80	0.63	2.25
Subtotal hybrid	**104**	**72.73**	**21.79**	**77.49**
OPVs				
Abo Bako	2	14.70	0.25	0.89
Kulani	15	10.49	2.50	8.89
Gibe1	12	8.39	2.28	8.11
Melkassa-1Q	5	3.50	0.46	1.62
Melkassa-7	1	0.70	0.13	0.46
Subtotal OPVs	**35**	**24.48**	**5.62**	**19.97**
Total Improved	**139**	**97.20**	**27.40**	**97.46**
Not classified	4	2.80	0.72	2.54
Total	**143**	**100.00**	**28.12**	**100.00**

Source: GFP survey, 2014

Appendix Table 9: Maize Adoption Estimates based on DNA Fingerprinting in Amhara region

Varieties		No of farmers	%	Total area (ha)	%
Hybrid	AMH-760	4	1.06	0.68	0.70
	Argane	31	8.22	4.32	4.43
	BH-140	6	1.59	0.93	0.96
	BH-540	24	6.37	13.61	13.97
	BH-660	123	32.63	27.26	28.00
	BH-661	5	1.33	2.00	2.05
	BH-670	5	1.33	1.30	1.34
	Jabi	5	1.33	2.87	2.95
	Jibat	6	1.59	1.74	1.79
	Limu	3	0.80	0.41	0.42
	Shala	1	0.27	0.27	0.28
	Shone	39	10.34	4.55	4.68
	Wenchi	3	0.80	0.42	0.43
	Subtotal hybrid	**255**	**67.64**	**60.36**	**62.00**
OPVs	Abo Bako	3	0.80	1.05	1.08
	Kulani	46	12.20	12.73	13.08
	Gambela	7	1.86	1.27	1.31
	Gibe1	14	3.71	4.35	4.47
	Melkassa-1Q	24	6.37	7.51	7.71
	Melkassa-2	6	1.59	0.90	0.92
	Melkassa-3	4	1.06	2.85	2.93
	Melkassa-4	5	1.33	1.71	1.75
	Melkassa-5	3	0.80	1.46	1.50
	Melkassa-6Q	1	0.27	1.90	1.95
	Melkassa-7	1	0.27	0.05	0.05
	Subtotal OPVs	**114**	**30.24**	**36**	**36.75**
	Total Improved	**369**	**97.88**	**96.14**	**98.75**
	Not classified	8	2.12	1.22	1.25
	Total	**377**	**100.00**	**97.36**	**100.00**

Source: GFP survey, 2014

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Appendix Table 10: Maize Adoption Estimates based on DNA Fingerprinting in Oromia region

Variety	No of farmers	%	Total area (ha)	%
Hybrid				
AMH-760	11	1.84	4.02	1.36
Argane	66	11.06	26.72	9.03
BH-140	18	3.02	11.09	3.75
BH-540	41	6.87	17.21	5.82
BH-660	194	32.50	111.81	37.78
BH-661	12	2.01	8.41	2.84
BH-670	6	1.01	1.93	0.65
Jabi	7	1.17	2.47	0.83
Jibat	7	1.17	1.44	0.49
Limu	5	0.84	2.78	0.94
Mh-130	2	0.34	0.56	0.19
Shone	57	9.55	25.31	8.55
Wenchi	4	0.67	1.00	0.34
Subtotal hybrid	**430**	**72.03**	**214.73**	**72.56**
OPVs				
Abo Bako	1	0.17	0.30	0.10
Hora	1	0.17	4.00	1.35
Gambela	6	1.01	1.59	0.54
Kulani	55	9.21	28.05	9.48
Gibe1	21	3.52	5.98	2.02
Melkassa-1Q	38	6.37	19.94	6.74
Melkassa-2	11	1.84	4.09	1.38
Melkassa-3	7	1.17	2.78	0.94
Melkassa-4	6	1.01	1.58	0.53
Melkassa-5	1	0.17	2.75	0.93
Melkassa-7	1	0.17	0.01	0.00
Subtotal OPVs	**148**	**24.79**	**71.06**	**24.01**
Total Improved	**578**	**96.82**	**285.79**	**96.57**
Not classified	19	3.18	10.16	3.43
Total	**597**	**100.00**	**295.95**	**100.00**

Source: GFP survey, 2014

Appendix Table 11: Maize Adoption Estimates based on DNA Fingerprinting in SNNP region

Variety		No of farmers	%	Total area (ha)	%
Hybrid	AMH-760	5	1.53	1.21	0.81
	Argane	26	7.95	14.52	9.70
	BH-140	10	3.06	4.50	3.00
	BH-540	30	9.17	11.53	7.70
	BH-660	128	39.14	63.94	42.72
	BH-661	4	1.22	2.40	1.61
	BH-670	2	0.61	0.69	0.46
	Jabi	3	0.92	1.58	1.06
	Jibat	5	1.53	1.56	1.04
	Limu	4	1.22	2.86	1.91
	Shala	2	0.61	0.96	0.64
	Shone	32	9.79	9.54	6.38
	Wenchi	1	0.31	1.00	0.67
	Subtotal hybrid	**252**	**77.06**	**116.28**	**77.69**
OPVs	Gambela	3	0.92	2.20	1.47
	Kulani	26	7.95	9.34	6.24
	Gibe1	16	4.89	6.64	4.44
	Melkassa-1Q	14	4.28	6.45	4.31
	Melkassa-2	3	0.92	2.24	1.50
	Melkassa-3	3	0.92	1.11	0.74
	Melkassa-7	1	0.31	0.50	0.33
	Subtotal OPVs	**66**	**20.18**	**28.48**	**19.03**
	Total Improved	**318**	**97.25**	**144.76**	**96.72**
	Not classified	9	2.75	4.91	3.28
	Total	327	100.00	149.67	100.00

Source: GFP survey, 2014

Appendix Table 12: Conversion factors used to calculate tropical livestock unit

Animal category	**TLU**
Calf	0.25
Weaned Calf	0.34
Donkey (young)	0.35
Donkey (adult)	0.70
Camel	1.25
Heifer	0.75
Sheep and Goat (adult)	0.13
Caw and Ox	1.00
Sheep and Goat young	0.06
Horse/mule	1.10
Chicken	0.013

Source: Ramakrishna and Demeke, (2002)