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Original Paper

Assessment of seed quality and identifying sources of contaminants for maize seed across seed generations accessed through different seed source in Northwest Amhara.

Tilaye Anbes[1], Dereje Abebe[2], Melkamu Elimihun[2], Semagn Asredie[3], Wasihune Ewenetu[2] and Yematew Chanie[1]*
1). Technology Multiplication and seed research, Adet Agricultural Research Center, P.O. Box 8, Bahir Dar, Ethiopia
2). Crop research supply Directorate, Adet Agricultural Research Center, P.O. Box 8, Bahir Dar, Ethiopia
3). Plant breeding and Genetics, Amhara Agricultural Research Institute, P.O. Box. 527, Bahir Dar, Ethiopia
**) Corresponding Author: tilayean43@gmail.com*

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***Abstract*— Genetic purity is one of the quality criteria required for successful seed production of maize. In hybrid seed production, genetic purity can be contaminated by outcrossing from other varieties or events of inbreeding. The objectives of the study are to clearly put sources of contaminants at each seed class level and suggest possible recommendations to maintain seed quality and to test the physical and physiological quality parameters of each seed classes. A multistage sampling technique was applied for this survey study. Total sample size of 160 households from all districts was interviewed and both qualitative and quantitative data was generated on constraints of hybrid maize production in western Amhara region. Filed inspection of maize seed production fields was done. Moreover, seed samples were collected from, company one, company two, company three and company four. Seed quality testing was carried out at Adet agricultural research center seed laboratory in 2021 for the collected samples. Mean percentages of quality parameters were computed and used for comparing the formal seed sources. The survey study indicated that maize seed production in the districts is constrained by a variety of related factors; the most important constraints are insufficient supply, delayed delivery, unavailability of preferred variety. The field inspection showed the presence of contaminants of maize seed at parental lines (inbred lines) and hybrid seed production. Seed samples of SC-22 parental lines collected from company two and company one showed standard germination of 30.25 and 76.5%, respectively. The laboratory test indicated that majority of seed samples from different seed sources met the minimum requirements for hybrid maize seed standards.**

***Keywords*— Seed class, Seed quality, Seed contaminants, Seed source.**

I. Introduction

As far as global production volume goes, maize (Zea mays L.) is the most important staple crop. There are over 205 million hectares of maize grown worldwide, and about 1.2 billion MT of maize are produced overall [15]. It is one of the main cereal crops that most developing nations rely on for both income and food security. In terms of production and consumption, maize is the third most significant crop farmed, behind rice and wheat [34]. A robust national maize breeding program was established at Bako Research Center (BRC) from the beginning of the 1980s. The BH-140, BH-660, and BH-540 are three exceptional hybrids that this program has produced since 1988 [6]. Ethiopia's maize production has changed dramatically as a result of the adoption of hybrid maize. Currently, 77 types of maize, the majority of which are hybrids, are registered for production in Ethiopia, despite the fact that numerous varieties and hybrids have been released there throughout the years [22].

The usage of high-quality seeds is essential for productive farming. This necessitates cautious seed production, processing, and storage. Planting high-quality seeds promotes crop development and productivity. Crop production can be raised by using high-quality seeds and other agricultural inputs along with new or enhanced technology [16]. Farmers, processors, and other end users are among the groups that evaluate the quality of seeds. Farmers, for example, anticipate receiving superior seeds that will sprout and provide healthy seedlings in field settings [23]. Up to 45% of the overall crop can be directly attributed to high-quality seeds [2]. Genetic purity, physical purity, germination rate, seed vigor, and seed health are all included in the quality of seeds [14]; [21].

The Ethiopian seed systems can be categorized into three categories: informal, intermediate, and formal. The unofficial seed system, sometimes referred to as the local system or the farmers system, functions under unregulated conditions and is defined by the flow of seeds from farmer to farmer. The goal of the intermediate sector is to officially acknowledge community-based organizations that receive funding from various development partners as distinct entities from the informal and formal sectors. A number of organizations may fit into an intermediate category between formal and informal, but among them may be cooperative seed producers' unions, which are not officially recognized or licensed to manufacture certified seed as a member of the formal sector.

Several variables contribute to low yield in maize production. A major issue limiting maize's output capacity is seed quality, which is influenced by both internal and external influences. The term "formal sector" refers to the recognized organizations that are part of the seed value chain, from development to distribution. These organizations include public seed companies, registered seed cooperatives, registered private producers, and research institutions. Three main components comprise the formal sector: 1) production of seeds; 2) marketing and distribution of seeds; and 3) varietal development and release. There are a number of components in each of these elements. In the official seed production method, seed is multiplied over multiple generations in order to prevent genetic or physical contamination from gradually building up in the same lot of seed. In order to guarantee that all seeds supplied to farmers come from a reliable source (breeder seed), seed production adheres to a generation system.

All seed generations in the formal system have to be generated under close control and have to meet the specified standards for seed quality. In order to preserve and provide the public with high-quality seeds for future generations, seed certification was established. Depending on the crop's manner of reproduction, contamination danger, multiplication ratio, and amount of seed needed, the number of generations after breeder seed accepted is determined. Ethiopia employs the breeder, pre-basic, basic, and certified seed classes. the terms used by the Organization for Economic Cooperation and Development (OECD) for every generation.

Improved seed can produce remarkably abundant crops for Ethiopia's small-scale farmers when combined with contemporary technology and slight adjustments to farming methods. In addition to solving the nation's problems with food security and poverty reduction, this abundance can help increase production and productivity in the agricultural sector [11]; 2001; Dawit et al., 2004; [9] ; [10]. Many factors have been blamed for the reported low yield, including the scarcity of better seeds, the lack of knowledge and access to improved varieties, pests and diseases, drought stress, and the deterioration in soil fertility in most farming areas [24]; [28]. The productivity of maize is impacted by all of this, making it possible to produce only a few types, mostly white maize. However, concerns regarding northwest Ethiopia's decreased output have recently surfaced in the public domain. Low productivity has an unknown cause at this time. As a result, these kinds' acceptance has been steadily dwindling. Despite this criticism, there is insufficient data to guarantee quality and satisfy customer demands. The inspection system lacks the means to directly identify the true causes of such complaints, address them, or support any data that is devoid of complaints when they arise. The regional certification authority and ARARI worked together to establish this research proposal and conducted the study in west Amhara while accounting for such gaps. The study aims to elucidate the origins of contaminants at the seed class level, provide recommendations for enhancing seed quality maintenance, and assess the physical and physiological quality indicators of each seed.

II. Materials And Methods

A. *Descriptions of The Study Area*

The maize growing zone is located in northwestern part of Amhara national regional state. The specific study areas are West Gojjam, Awi and South Gondar zones of Amhara Regional state of Ethiopia and five districts which are the major maize growing belts in terms of area coverage and production. These are Wonberma, North Achefer, Mecha, Ayhu Guagusa and Dera. The study area falls within the altitude ranging from 1300 to 2150 m.a.s.l. and geographically located between 12º 51´ 54.44´´ N to 10º 17´ 58.06´´ N latitude and 36º 18´ 28.30´´ E to 37º 40´ 31.7´´ E longitude (Figure 1).

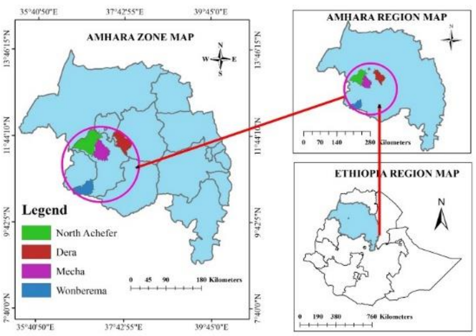

Fig. 1. Map of survey area

Sampling procedure and method of data collection

he research survey comprises of maize seed quality, varieties performance, maize seed constraints and farmers maize seed perception, field inspection and sample collection and laboratory testing. The laboratory experiment was conducted at Adet Agricultural Research Center seed quality laboratory.

In order to conduct the study in a representative way and to increase its reliability and validity multi stage sampling procedure was employed for selection of representative sites and sample respondents. First, four districts were selected purposively based on wide coverage of maize and production potential and secondly two kebeles (the lowest administrative unit) per district were selected randomly. Then, a total of 160 sample respondent household heads were selected randomly. The kebeles were first stratified as first maize potential and maize growing, and those without the potential of maize production. Identification was made through reviewing secondary data on the production potential of maize and dissemination of the improved maize technologies and area coverage of the crop.

B. *Data Source, Type and Analysis*

Data was collected from both primary and secondary sources. Primary data was collected from maize growing farmers on their demographic, Socio economic, and on maize quality indicators (presence of off types, disease, noxious weeds, germination, the presence of inert matter, weevil damage,) based on Hybrid maize seed specification, 2017. Semi- structured questionnaire was employed to obtain the above stated data from sample respondents. Secondary data was taken from the office records of production of maize in each district to consider production trends of each district. Quantitative data was collected through structured questionnaire which was encoded in to SPSS version 20. Descriptive statistics was employed to analyze percentage, mean and standard deviation. Qualitative data was used to substantiate the results obtained by quantitative analysis.

C. Field Inspection Method

Field inspection was begun by identifying sample fields across seed generations/classes (Table I). This was done by stratifying inspected seed fields on seed laboratory basis. Sample fields for evaluation of laboratory seed quality the procedure implemented were drawn randomly from the total field of each seed class based on the collected seed from different sources. Of the total inspected fields by seed labs 5% of it was re-inspected by team of researchers. Following the inspectors' field decision, the research teams were collected field data according to field inspection procedures set by MOA as adopted from OECD scheme during flowering/tasseling stage. This was done by observing morphological characters based on the description of each hybrid varieties and parental line, especially color of anther, tassel, silk and overall appearance of the plant. The number of total plants counted and off type plants from the field were recorded. Finally, the result of the field inspection was reported as the percentage of other off type plants based on the following Eq (1) [17

$$Percent\ (\%)\ of\ off\ type = \frac{Number\ of\ off-types}{Total\ number\ of\ plants\ counted}\ X\ 100 \quad \text{.......... (1)}$$

D. Sample Collection and Laboratory Testing

A sample size of 1000 gram seeds of different varieties of maize parental lines (CML395, CML202, BKL001, BKL004, BKL003) and available hybrids were collected. Samples were collected from company one, company two, company three and selected private seed growers. Sampling was done according to Ethiopian Standard Agency sampling specification number ES 471/2000. Accordingly, composite samples were taken on lot basis and submitted to AARC seed laboratory. Samples were divided in to working samples for data collection of purity test (pure seed, other crop seed and inert matter), germination test, speed of germination, seedling dry weight, seedling shoot and root length and vigor index. Purity and germination tests were considered according to Ethiopian Standard (ES) 420/2017(Table II). The seeds were incubated at a temperature of 25°C for 8th days as specified by International Seed Testing Associates [20]. Three sets of experiments were carried out in 2021, under laboratory conditions at Adet Agricultural Research Center. The first set involved the testing of certified seed; the second set involved the testing of basic seed and the third set involved the testing of pre-basic seed classes.

Set–I: Certified seed

The experiment consisted of 6 treatment combinations of seed source and hybrid maize varieties for physical and physiological tests in laboratories and they were laid out in Completely Randomized Design (CRD) with four replications. There were three seed source (company one, company two and company four) and two hybrid maize variety (BH-660 and BH-661).

Set-II Basic seed

The experiment consisted of 6 treatment combinations of seed source and basic seeds hybrid maize varieties for physical and physiological tests in laboratories and were laid in Completely Randomized Design (CRD) with four replications. There were two seed source (company one and company two) and three basic seed maize crosses and varietal lines (142-1-e, CML-395/CML-202 and A-7033/F-7215).

Set-III Pre-basic seed

The experiment consisted of 9 treatment combinations of seed source inbred line (pre-basic seed) of hybrid varieties for physical and physiological tests in laboratories were laid in Complete Randomized Design (CRD) with four replications. There were three seed source (company one, company two and company three) and three pre-basic seed of maize parental lines (CML-395, CML-202 and SC-22).

All laboratory data analyses were done using statistical analysis system (SAS) software version 9.4 program. The analysis of variances (ANOVA) was computed using proc ANOVA procedure. Mean comparison were done using least significant difference at (p<0.05).

TABLE I . GENETIC MATERIALS AND THE SOURCES

No	Hybrid variety	Source	Single cross female parents	Source	Inbred line	Source
1	BH660	C3	CML395xCML202	C1	CML395	C5
2	BH660	C4	A7033xF7215	C1	BKL001	C5
3	BH661	C1			CML202	C5
4	BH661	C3			BKL003	C5
5	BH661	C4			BKL004	C5
6	BH540	C1				
7	BH540	C2				
8	BH547	C2				
9	BH546	C1				
10	Limu	C2				

NB. C = Company

TABLE II. REQUIREMENTS FOR HYBRID MAIZE SEED CERTIFICATION STANDARDS

Characteristics	Parental line (pre-basic seed) A	Basic seed (cross) B	Certified seed C_1
Field standards			
Isolation distance (min, meters)	400	400	200
Off-type at and after flowering (max %)	0.1	0.1	0.1
Pollen shading heads in seed parents at flowering	0.2	0.52	0.5
Laboratory standards			
Pure seed (min %)	99	99	98
Other crop seed (max %)	0.05	0.05	0.05
Inert matter (max %)	0.95	0.95	0.95
Germination (min %)	80	80	85
Moisture content (max %)	13	13	13

Source: Ethiopian Standards Agency, 2017

III. RESULTS AND DISCUSSION

The results and discussion described below the assessment of maize seed systems in the study area and the quality analysis of maize seed obtained from different seed sources.

A. Demographic and socio-economic characteristics of sample respondents

Maize producers' households were mainly headed by male in the study area. The survey result indicated that 89.4% of the respondents are male headed while 10.6% are female headed (Table III).

TABLE III. SEX AND EDUCATIONAL STATUS

Categories		Frequency	percent
Sex	Male	143	89.4
	Female	17	10.6
Educational status	Illiterate	62	38.8
	Read and write	46	28.8
	1 to 4 grades	28	17.5
	5 to 8 grades	17	10.6
	9 and above	7	4.4

This was attributed to various reasons including the problem of economic position of female-headed households like shortage of labor and land, limited access to information and required inputs, and other cultural conditions. Education is often considered as the best alternative to empower farm households and believed to improve access to information on improved technologies. The study revealed that 38.8% of sample respondents were found to be illiterate where as 61.3% were found to literates. This shows that the majority of maize producing farmers are literates which can be seen as opportunity to increase production and productivity of maize by introducing better technologies as educated farmers are capable of accepting and implementing the technologies which they receive. The mean age of sample respondents is 43.91 with 10.98 standard deviation and the range between 25 and 75. Most of sample respondents are classified in economically active age group (Table IV).

TABLE IV. AGE, LABOR AVAILABILITY, AND LAND ALLOCATION OF THE SAMPLE RESPONDENTS

Variable	Minimum	maximum	mean	Std. Dev.
Age	25	75	43.91	10.98
Land owned (qada)	0	3	1.19	0.80
Rented land (qada	0	4	0.64	0.795
Land allocated for maize (qada)	0.13	2	0.77	0.43
Labor in man equivalent	1	4.8	2.98	0.97

Land is one of the most important properties for farming communities for any economic and social activities. It is the determinant factor for the improvement of agricultural production since the livelihood of people is highly dependent on it. The mean land owned by sample respondents is 0.64 hectare with the range between 0 to 4 hectares (Table IV). The result also showed that there are farmers who do not own land but cultivate land for maize by renting from farmers who have ample land or from those who cannot use for themselves because of different reasons. A household with a greater working force is believed to be in the position to manage the labor-intensive agricultural activities than those who have less number of the labor force. The money which could be spent on the hiring of labor is also saved and used to purchase better crop production inputs. Thus, paves the way for farmers to look forward to the utilization of new technologies and complementary inputs such as seeds, fertilizers, and herbicides. As indicated in (Table IV), the average number of active labor force in terms of man equivalent is 2.98 with standard deviation of 0.97.

B. Improved Maize Seed Source For Maize Producers

Sample farmers used both legal and illegal seed sources of maize. The seed obtained from legal sources was distributed to the farmers through farmers cooperatives Unions and district agricultural offices while the rest seed from illegal sources.

TABLE V. FARMERS' SOURCE OF HYBRID MAIZE SEED

Source of maize seed	Frequency	Percent
Agri office or Cooperatives	118	73.8
Market or other farmers	18	11.3
Both	24	15

As indicated in (Table V) below, 73.8% of the sample respondents gets their seed from legal sources which are basic cooperatives in their villages, while 11.3% get their seed from market or farmers who have their preferred maize varieties. 15% of the respondents revealed that they get their maize seed from both sources. Focus group discussion with farmers revealed that their most preferred variety is Limu which they perceived very productive so that they tend to cover their land allotted for maize with Limu variety. If they could not get from legal sources, they buy from illegal sources such as market or from farmers.

C. Farmers' Information Access For Improved Maize Seed Varieties

According to the current survey, 86.87% of the respondents access improved maize seed information through district agricultural office, about 4% from extension service and research centers, 3.12% from neighbors and relatives, and 1.9% from radio and television (Table VI).

TABLE VI. ACCESS TO INFORMATION ABOUT IMPROVED MAIZE SEED IN STUDY AREA

Access to information to improved maize seed	Frequency	Percent
Yes	155	96.9
No	5	3.1
Source of information		
Agri. Extension	139	86.87
Research center	2	1.3
Radio and television	3	1.9
Neighbors and relatives	5	3.12
Agri. extension and research center	6	3.8

The relationship between farmers' access to extension service and improved technology has been reported as a positive and significant influencing factor for usage of technology by many authors in different studies. [5]; [29] indicated the relationship between technology adoption by the farmers and extension service provided to them. The survey study indicated that 96.5% the respondents get information about improved maize varieties from different sources.

D. *Constraints to Improved Maize Seed in The Study Area*

Farmers in northwest Amhara planted different local maize cultivars before the release of improved varieties. After the release of different improved varieties of different ecological suitability, farmers of the study areas, mainly grow the released hybrid maize varieties, particularly BH-660, BH-661, BH-540 because of their adaptability to the area, for its high yield, and food and market quality.

TABLE VII. MEAN RANK FOR PERCEIVED SEED SUPPLY CONSTRAINTS IN FORMAL SURVEY

Constraints	Mean rank*
Insufficient supply	1.65
Delayed delivery	2.55
unavailability of preferred variety	2.74
Poor seed quality	3.96
High seed price	4.10

*Constraint with the lowest mean rank is the most important

However, insufficient supply of seeds of these varieties, delayed delivery, unavailability of preferred varieties are one of the major constraints in the study area (Table VII).

E. *Farmers' Seed Quality Perception*

Farmers had different perceptions for maize seed quality supplied from different sources. Ethiopian standard agency has indicated hybrid maize seed specification which states the parameters listed in (Table II). Most sample farmers in the study area recognized the difference between grain and seed used for planting purposes. As indicated in the (Table VIII) significant number of farmers revealed that the quality of maize seed provided to them is very low except it from noxious weeds and no presence of noxious weeds. The disease occurrence was mostly associated with Limu variety in contrary to its high productivity and much liked by the farmers. They perceived seed quality in relation to physical qualities of the seed such as different tassel (36.3%), broken seed (25%) and freedom from insect damage (36.2%), no mixture of other varieties (55.5%) and those who perceived intact seed with good germination were 82.5% (Table VIII). Similar study made by [1] indicated that the criteria used by farmers to define seed quality include freedom from impurities, disease and adaptation to local conditions.

TABLE VIII. PERCEPTION OF FARMERS ON DIFFERENT PARAMETERS OF QUALITY HYBRID MAIZE SEED

Quality parameters		Frequency	Percent
Different tassel	Yes	58	36.3
	No	102	63.8
Different length	Yes	50	31.3
	No	110	68.8
Noxious weed	Yes	0	0
	No	160	100
Broken seed	Yes	120	75
	No	40	25
Good germination	Yes	132	82.5
	No	28	17.5
Free from disease	Yes	98	61.2
	No	62	38.8
Insect Damage	Yes	58	36.2
	No	102	63.8
Presence of inert matter	Yes	3	1.9
	No	157	98.1
Off Types	Yes	71	44.4
	No	89	55.6

F. *Genetic Purity From The Field Inspection*

Results of the field inspection on three-way hybrids, single cross and inbred line parents are depicted in (Table IX). Normally, seed certification for purity and variety distinctness is based on morphological evaluation of seeds and growing plants. Based on field inspection the variety's morphological description, the three-way cross hybrids showed off type levels ranging from 1 to 15.2% at C2 and C3 sources, respectively. The off-types level in hybrid varieties was high at C2 and C3 sources, which 15 and 15.2%, respectively (Table IX)

TABLE IX. THE PURITY OF SEEDS OF HYBRID, SINGLE CROSS AND THEIR INBRED LINE PARENTS AT DIFFERENT SEED COMPANIES BASED ON FIELD INSPECTION

Variety name	Company1 (C1)		Company2 (C2)		Company3(C3)		Company4(C4)		Company5 (C5)	
	No of plants	% off type	No of plants	% off type	No of plants	% off type	No of plants	% off type	No of plants	% off type
BH660	-	-	-	-	500	6	500	6.4	-	-
BH661	500	5	-	-	500	15.2	500	3		-
BH546	500	2.4	-	-	-	-	500	15	-	-
BH547	-	-	-	-	400	4	-	-	-	-
BH540	500	-	-	-	-	-	-	-	-	-
Limu	-	-	500	1	-	-	-	-	-	-
CML-395xCML202	500	5.8	-	-	-	-	-	-	-	-
A7033xF7215	500	3.8	-	-	-	-	-	-	-	-
CML202	-	-	-	-	-	-	-	-	400	7.5
CML395	-	-	-	-	-	-	-	-	400	6.25
BKL001	-	-	-	-	-	-	-	-	400	37.5
BKL003	-	-	-	-	-	-	-	-	400	4.5
BKL004	-	-	-	-	-	-	-	-	400	3.75

The single cross (CML395/CML202) female parent of BH661 and BH546 showed a high level of off type (heterogeneity) 5.8% at company1 (C1). This may indicate the contamination of single crosses through the selfing of female inbred line (CML-395) during single cross formation at the source. At company 1, (C1) A7033/F7215 single cross showed homogeneity and heterogeneity level of 96.2% and 3.8%, respectively. This may indicate the contamination of single crosses through the selfing of female inbred line (A7033) during single cross formation at company1 (C1). [44] stated that homogeneity of heterozygous genotypes is increased due to an inbreeding of a given material or parent. In the current study, three inbred lines namely CML395 and CML202 (Parents of BH661 and BH546) and BKL001 (parents of BH546) showed the off type level is unacceptable level for genetic purity of maize parental line seed production. In line this, inbred lines across the samples showed contaminants greater than 5% or the proportion of homogeneity less than 95%. This indicated that these inbred lines are present at rejectable genetic purity levels for seed production and the presence of major contamination in the genetic materials [17]. These results might be because of contamination occurred at initial time or out crossing occurred from foreign parents. Inbred lines are considered as homogenous or genetically pure when the proportion of contaminants for every inspection does not exceed 5% [19]. This result is contrary with that of [12]; [7] and [13] who reported that they had an acceptable level of genetic purity (homogeneity) among different sources of maize inbred lines.

G. Evaluations Of Hybrid And Parental Line Maize Physical And Physiological Seed Laboratory Test Results

1) SET-I: Certified seed laboratory tests

a) Physical purity

The analytical purity of hybrid maize seed samples collected from different sources were presented in (Table X). Analysis of variance showed that all main effects and interaction effects of seed source and variety did not significantly ($P > 0.05$) affect the percent of the pure seed and other crop seed in the seed samples. This implies that these seeds had minimal impurities and met the minimum requirements of hybrid maize seed certification standard for certified seed (98%) according to the Quality and Standards Authority of Ethiopia [31]. While the main effect of variety significantly ($P \leqslant 0.01$) affected the inert matter, but its interaction with seed source was not affected. Thus, seed samples from all treatment combinations had minimal impurities and met the maximum prescribed standards ($\leqslant$ 2%) described by [31] for certified seed of hybrid maize (Table X).

TABLE X. MAIN EFFECTS OF SEED SOURCE AND HYBRID MAIZE VARIETIES ON PHYSICAL AND PHYSIOLOGICAL QUALITY PARAMETERS.

Treatment	PS%	OCS%	IM%	SG%	ABS%	DS%	FS%	SPG(days)
Seed source								
C1	98.5	0.00	1.58	96.38^{a}	1.13	1^{b}	1.13	16.83
C2	98.11	0.00	1.88	91.88^{b}	4	2.75^{a}	1.75	16.63
C4	99.08	0.00	0.92	94.25^{ab}	3.5	1^{b}	1.25	16.66
LSD(0.05)	ns	ns	ns	3.32	ns	1.37	ns	ns
Variety								
BH-660	98.19	0.00	1.87^{a}	94.83	2.75	1.17	1.25	16.3
BH-661	98.93	0.00	1.06^{b}	93.5	3	2	1.5	17.11
LSD(0.05)	ns	ns	0.77	ns	ns	ns	ns	ns
CV	0.96	0	60.44	3.31	82.04	81.26	86.37	6.22

b) Standard germination

The laboratory experiment showed normal germination of seed samples obtained from each sources and variety incubated for eight days. The growth of plumule and radicle started after four to the last eight days of incubation. The proportion of normal seedlings were significantly ($P \leqslant 0.05$) affected by the main effects of seed source, but its interaction with variety was not affected. Analysis of variance showed that the main effects and interaction effects of seed source and variety did not significantly ($P \geqslant 0.05$) affect the percent of the abnormal seedling, fresh and dead seed in the seed samples, but seed source significantly ($P < 0.05$) affected percent of dead seed (Table X).

Seed sample collected from C1 scored a highest standard germination (96.38%) compared to improved maize seeds collected from C2 (91.88%), while the lowest standard germination recorded from C2. The highest and lowest germination of seeds indicated that the highest and lowest potential of vigoursity of the seed. Samples were collected above the average germination percentage from C1, C2 and C4 as prescribed in the Ethiopian National Seed Standard of hybrid maize seed (Table X) were met the minimum requirements (85% for certified seed) according to the Quality and Standards Authority of Ethiopia [31]. This result was in agreement with the results reported by [3] that the bread wheat variety sown with bolder seeds resulted in significantly higher seed germination of 95.29% as compared to the wheat variety sown with small sized seeds with 91.7% germination.

c) Speed of germination

Analysis of variance indicated that the main effect of seed source, variety and their interaction effect not significantly ($P > 0.05$) affected the speed of germination (Table X).

Means in the column with the same letter are not significantly different at 5% level based on Least significant Difference (LSD) at 0.05 C1, company one , C2 company two, C3, company four, PS, pure seed, OCS, other crop seed, IM, inert matter, SG, standard germination, ABS, abnormal seedling, DS, dead seed, FS, fresh seed and SPG, speed of germination.

d) Seedling length

Seedling shoot length was significantly (P ⩽ 0.01) affected by main effects of variety, while variety interaction with seed source not significantly (P > 0.05) affected seedling shoot length (Table XI). The highest mean value of shoot length (11.13 cm) was obtained from the seed samples of hybrid maize variety of BH-661, while the minimum value was obtained from the seed sample variety of BH-660 (10.25 cm) (Table XI). [41] found that seedlings with robust shoot and root systems would be more resilient to unfavorable circumstances and would result in improved seedling emergence and establishment in the field. While seed source and its interaction with variety did not significantly (P>0.05) alter seedling root length, the main effects of variety had a significant (P<0.01) effect on seedling root length (Table XI). The seed samples of the hybrid maize variety BH-660 had the largest mean root length value (12.28 cm), whereas the seed sample variety BH-661 had the smallest value (Table XI). Usually, the seedlings that were created. Similarly, [41] reported that seedlings with well-developed shoot and root systems would withstand any adverse conditions and provide better seedling emergence and seedling establishment in the field. It was assumed that seedlings with well-developed shoot and root systems provide better seedling emergence and seedling establishment in the field [43]. Seedling root growth was affected by the weight of the seed of a variety. Seeds that have greater grain weight affect the length of the primary root because they provided greater energy to help the root growth.

e) Seedling vigor index and seedling dry weight

Analysis of variance indicated that the main effect of seed source, variety and their interaction did not significantly (p > 0.05) affect the formation of seedling dry weight, seedling vigor index-I and vigor index-II (Table XI).Vigor test is very important parameter because it ranks the potential field performance of seed lots, high and rapid germination, estimate good stand establishment which resulted in high yields [35].

TABLE XI. MAIN EFFECTS OF SEED SOURCE AND CERTIFIED SEED OF HYBRID MAIZE ON SEEDLING VIGOR QUALITY PARAMETERS.

Treatment	SL(cm)	RL(cm)	SDW(g)	SVI	SVII
Seed source					
C1	11.03	12.29	0.17	2229.08	16.66
C2	10.53	12.08	0.16	2093.94	15.59
C4	10.52	11.69	0.19	2093.2	16.25
LSD(0.05)	ns	ns	Ns	ns	ns
Hybrid variety					
BH-660	10.25^{b}	12.8^{a}	0.17	2187.19	16.56
BH-661	11.13^{a}	11.24^{b}	0.17	2090.3	15.79
LSD(0.05)	0.42	1.07	Ns	ns	ns
CV	4.49	10.27	19.46	6.71	14.07

Means in the column with the same letter are not significantly different at 5% level based on Least significant Difference (LSD) at 0.05 C1, company one , C2 company two, C3, company four,, SL, shoot length (cm), RL, root length (cm), SDW, seedling dry weight (g), SVI, seedling vigor index 1, SVII, seedling vigor index 2.

2) SET-II: Parental line (basic seed) laboratory tests

a) Physical purity

The analytical purity of single cross of hybrid maize seed samples collected from different public seed enterprise sources were presented in (Tables XII). The analysis of variance showed that means of pure seed, inert matter were significantly (P < 0.05) affected by single cross varieties and its interaction with seed source. While, pure seed and inert matter were not significantly (P>0.05) influenced by the main effects of seed source. The highest purity percentage (99.93%) was recorded under the single cross of CML-395/CML-202 combined with seed sample collected from C2 this was statistically at par with A-7033/F-7215. while the lowest value (97.94%) was recorded from 142-1-e with the seed sample collected from C2 (Table XII). Except basic seed of 142-1-e sample collected from C2 were met the minimum requirements (99%) according to the Quality and Standards Authority of Ethiopia [32] (Table II). [41] also found significant differences among seed samples of wheat collected from different sources (formal and informal seed systems) in Ethiopia for physical purity and other crop seed contamination.

b) Standard germination

The percentage of normal seedlings, abnormal seedlings, fresh and dead seeds of different seed samples collected from seed sources under laboratory test were recorded. The main effect of seed source as well as that of single cross parents and their interactions significantly (P < 0.001) influenced the standard germination, dead seed of maize. However, basic seed of hybrid maize and interaction with seed source was not significantly (P> 0.05) affected abnormal seedling and fresh seed. Moreover, the main effect of seed source significantly (P < 0.01) affected by abnormal seedling and fresh seed (Table XII). The highest standard germination (90.5 %) was recorded under the parental line of CML-395/202 and A-7033/F-7215 combined with seed sample collected from C1, while the lowest value (57 %) was obtained from 142-1-e with the seed sample collected from C2 (Table IV). The lowest value implies that these seeds maximum impurities and did not meet the minimum prescribed standard (80%) according to the Quality and Standards Authority of Ethiopia [32] for basic seed of maize (Table XII). Moreover, the samples were collected from C1 and C2 gave above the average germination percentage as prescribed in the Ethiopian National Seed Standard of parental line basic seed (80%) of hybrid maize (Table II) and met the minimum requirements according to the Quality and Standards Authority of Ethiopia [31]. This result was in agreement with the results reported by [3] that the bread wheat variety sown with bolder seeds resulted in significantly higher seed germination of 95.29% as compared to the wheat variety sown with small sized seeds with 91.7% germination.

Means in the column with the same letter are not significantly different at 5% level based on Least significant Difference (LSD) at 0.05 C1, company one, C2, company two, PS, pure seed, IM, inert matter, SG, standard germination, DS, dead seed, SPG, speed of germination, SL, shoot length (cm), RL, root length (cm) and VII, vigor index 2

TABLE XII: INTERACTION EFFECTS OF SEED SOURCE AND PARENTAL LINE OF HYBRID MAIZE ON PHYSICAL, PHYSIOLOGICAL AND SEEDLING VIGOR QUALITY PARAMETERS

Seed source	Parental line (basic)	SG	DS	SPG	PS (%)	IM (%)	SL(cm)	RL(cm)	SVI
C1	142-1-e	87.75^{b}	5.5^{bcd}	15.8^{a}	99.06^{ab}	0.94^{b}	9.55^{a}	11.83^{a}	1875.95^{a}
	CML-395/CML-202	90.5^{a}	1.5^{d}	15.58^{a}	99.03^{abc}	0.97^{b}	9.61^{a}	10.95^{ab}	1863.88^{a}
	A-7033/F-7215	90.5^{a}	8^{bc}	14.82^{ab}	99.65^{ab}	0.35^{c}	7.67^{b}	11.77^{a}	1761.22^{bc}
C2	142-1-e	57^{d}	31^{a}	9.52^{c}	97.94^{c}	2.06^{a}	6.69^{c}	7.74^{d}	819.75^{de}
	CML-395/CML-202	79.5^{c}	10.75^{b}	13.41^{b}	99.93^{a}	0.07^{d}	7.19^{bc}	8.63^{cd}	1258.13^{d}
	A-7033/F-7215	88.25^{b}	2.5^{cd}	14.12^{ab}	99.33^{a}	0.67^{bc}	7.68^{b}	11.44^{ab}	1684.73^{c}
LSD(0.05)		5.34	7.94	0.93	0.88	0.88	0.72	1.74	207.66
CV (%)		4.31	53.34	4.46	0.59	69.08	5.99	11.14	8.92

c) Speed of germination, seedling length and vigor index-i

The speed of germination, seedling root and shoot length and seedling vigor index-I were the important seedling vigor tests showing highly significant ($P \leqslant 0.001$) differences between different seed sources and hybrid maize of basic seed samples. Additionally, the seed source and basic seed of hybrid maize interaction significantly ($P \leqslant 0.001$) affected the speed of germination, seedling length and seedling vigor index-I (Table XII).

The highest seed germination rate was recorded from C1 (15.8% and 15.58%) the basic seed of 142-1-e and CML-395/CML-202, respectively while the lowest germination rate was obtained from samples collected from C2 (9.52%) basic seed of 142-1-e. Our present finding is in agreement with [25] who revealed that early types can be chosen thanks to seeds with a high germination rate, which can withstand dry conditions. In a similar vein, the rate of seed germination determines which seedlings will emerge and germinate fastest, allowing them to escape unfavorable field circumstances. The seedlings with the highest index or first count are predicted to do so [41]. The rate at which the seeds are germinated and seedlings can emerge under very adverse field conditions is indicated by the speed of germination [26]. High-germination-speed seeds were discovered to be robust in the field and able to withstand severe conditions. The basic seed of CML-395XCML-202 and 142-1-e, C1 had the longest shoot and root lengths (9.61cm and 11.83cm, respectively), and these were statistically comparable to those of 142-1-e and A-7033/F-7215. In contrast, samples taken from ESE had the lowest shoot and root lengths (6.69cm and 7.74cm, respectively) of 142-1-e. When tested, high-quality seed generates greater roots and shoots earlier than low-quality seed, according to [8]. According to another study [27], seedlings with longer roots and shoots are more resilient to moisture stress than seedlings with shorter roots. The highest vigor index-I was obtained sample seed from C1(1875.95%) the basic seed of 142-1-e this was statistically at par with CML-395/CML-202 at the same seed source and the lowest vigor index-I was attained sample collected from C2 (819.75%) basic seed of 142-1-e. According to [37], the significance of this index was predicated on the idea that robust seeds yield robust, healthy, and uniform seedlings that are better suited for field establishment and have comparatively longer lifespans. Low-vigor spring wheat seed resulted in lower crop stand and poorer grain yields, according to research by [33]. This could be as a result of less competition between individual plants for light, space, and nutrients during crop growth and development, which results in plants sown at a reduced seed rate bearing nutritionally well-developed seeds.

d) Seedling vigour index-II and seedling dry weight

The vigor of the seedlings is an important factor to indicate the power of seedlings to grow and establish further. The higher vigor index indicates higher vigor of the seedling, guarantying they can survive under a variable range of environments. The seedling dry weight was not significantly ($P \leqslant 0.05$) influenced by different seed sources and hybrid maize of basic seed samples. While, the main effect of basic seed of hybrid maize significantly ($P \leqslant 0.01$) affected the seedling vigour index-II. Additionally, the interaction of seed source and basic seed of hybrid maize didn't significantly ($P > 0.05$) affected the seedling vigour index-II and seedling dry weight (Table XIII). The highest seedling vigour index-II seed (8.62%) was recorded from basic seed of A-7033/F-7215 and the lowest vigour index-II was achieved basic sample seed of (4.43%) 142-1-e (Table XIII).

TABLE XIII: MAIN EFFECTS OF SEED SOURCE AND BASIC SEED OF HYBRID MAIZE ON PHYSICAL, PHYSIOLOGICAL AND SEEDLING VIGOUR QUALITY PARAMETERS.

Treatment	ABS%	FS%	OCS%	SDW	SVII
Seed source					
C1	4.83^{b}	2^{a}	0.00	0.09	7.99
C2	10^{a}	0.42^{b}	0.00	0.07	5.35
LSD(0.05)	3.27	1.08	ns	ns	2.51
Basic seed					
142-1-e	7.63	1.75	0.00	0.059	4.43^{b}
CML-395xCML-202	7.13	1.25	0.00	0.083	6.96^{ab}
A-7033xF-7215	7.5	0.63	0.00	0.095	8.62^{a}
LSD(0.05)	ns	ns	ns	ns	3.07
CV	50.66	51.47	0	41.27	43.21

Means in the column with the same letter are not significantly different at 5% level based on Least significant Difference (LSD) at 0.05. C1, company one, C2, company two, ABS, abnormal seedling, FS, fresh seed, OCS, other crop seed, SDW, seedling dry weight (g) and VII, seedling vigor index 2

3) SET-III: Inbred line (pre-basic) seed laboratory tests

a) Physical purity

The physical quality of inbred line of maize seed samples collected from different sources was presented in (Table XIV). The analysis of variance showed that means of pure seed, inert matter were significantly (P<0.001) affected by inbred lines and its interaction with seed source. While, other crop seed was not significantly (P > 0.05) influenced by the main effects of seed source, inbred line as well as interaction of both factors. The highest analytical purity was found in C2 (99.85%) of CML-395 inbred line parents. The lowest (97.4%) physical purity was observed in C2 in SC-22 inbred line of maize, followed by C1 of the same parental line (98.9%). Similar to this, [42] found that there were highly significant variances (p<0.001) in the analytical purity and inert matter seed contamination of maize seed batches obtained from various suppliers. Additionally, [39] discovered that barley seed samples taken from several regions of Ethiopia differed significantly in terms of physical purity, contamination from weed seeds, and other crop seed.

b) Standard germination

The main effect of seed source as well as that of hybrid maize inbred line seed significantly (P < 0.001) influenced the standard germination and dead seed. Additionally, the interaction effect of seed source and inbred line seed significantly (P < 0.001) influenced the standard germination, abnormal seedling and dead seed, but seed source and its interaction with inbred line didn't significantly (P > 0.05) affected abnormal seedling, moreover the main effect of seed source, inbred line and the interaction of both didn't significantly (P ≤ 0.05) affected by fresh seed (Table XIV).

The highest standard germination (94.5%) was recorded under the inbred line of CML-395 combined with seed sample collected from C1, while the lowest value (30.25%) was obtained from SC-22 with the seed sample collected from C2 (Table XIV). Comparison of germination potential of seed from formal sources showed there was significant difference in the quality of inbred line of hybrid maize seed lots obtained from different sources. Moreover, the majority of samples were above the average germination percentage except two samples were collected from C1 and C2 of SC-22 (76.75% and 30.25%), respectively as prescribed in the Ethiopian National Seed Standard of inbred line of hybrid maize seed (Table XIV) were met the minimum requirements for pre-basic seed (80%) according to the Quality and Standards Authority of Ethiopia [32]. [39] also found a very significant variation in the germination of barley seed collected from different Regions and sources. [38] also found similar results where a substantial number of samples from their formal sector (36%) were with low germination than the standard for certified seed. The normal seedling growth in the laboratory obtained from mature endosperm of food storage, because after germination seedlings use the endosperm food for growth and development. The higher food reserve in the endosperm results higher kernel weight and leads to vigorous crop in the field.

TABLE XIV: INTERACTION EFFECTS OF SEED SOURCE AND INBRED LINE OF HYBRID MAIZE ON PHYSICAL, AND PHYSIOLOGICAL SEED QUALITY PARAMETERS.

Seed source	inbred line	SG(%)	ABS(%)	DS(%)	SPG(%)	PS(%)	IM(%)
C1	CML-395	94.5^{a}	2^{d}	2.25^{c}	16.19^{a}	99.47^{ab}	0.53^{bc}
	CML-202	92.25^{ab}	2.5^{cd}	1.75^{cd}	16.19^{a}	99^{ab}	1.1^{b}
	SC-22	76.75^{c}	13^{b}	9^{b}	11.62^{bc}	98.9^{b}	0.94^{b}
C2	CML-395	89.25^{b}	4.75^{bc}	4.75^{bc}	13.04^{b}	99.85^{a}	0.15^{d}
	CML-202	91.25^{ab}	3.25^{c}	$4.5b^{c}$	13.99^{b}	99.28^{ab}	0.72^{bc}
	SC-22	30.25^{d}	22.75^{a}	43.5^{a}	5.91^{d}	97.4^{c}	2.59^{a}
C3	CML-395	91.25^{ab}	4^{bc}	2.75^{c}	14.95^{ab}	99.67^{ab}	0.32^{c}
	CML-202	90.25^{b}	4.75^{bc}	2.25^{c}	6.49^{cd}	99.85^{a}	0.15^{d}
	SC-22	90.75^{ab}	5.75^{bc}	1.25^{d}	15.36^{ab}	99.69^{ab}	0.29^{c}
LSD(0.05)		15.65	8.71	9.29	1.61	0.84	0.87
CV (%)		13.19	77.21	70.89	8.72	0.58	79.5

c) Speed of Germination

Analysis of variance showed that seed source and inbred line of hybrid maize were significantly (p<0.001) affected by the speed of germinations, additionally, the interaction effect of seed source and inbred line significantly (p<0.001) affected the speed of germinations. Speed of germination is one of the indicators used for assessing the vigor of seeds and seeds that have high germination speed were found vigorous in the field and could be escaped harsh conditions. The highest speed of germination (16.19%) was obtained under seed sample collected from C1 and the inbred line of CML-395 this was statistically at par with CML-202 at the same seed source, while the lowest value (5.91%) was obtained from inbred line of SC-22 with the seed sample collected from C2 (Table XIV). The rate at which seeds sprout quickly and seedlings can appear is known as the speed of germination [36]. Similar to this, [41] stated that quick germination and seedling emergence are anticipated, as well as the ability to elude unfavorable field conditions, for seedlings with a higher index or highest on first count. According to [30], low germination rate seed can have a devastating impact on a farmer's income because it might be too late to plant again in that season by the time it becomes clear that the seed won't germinate. According to [26], the respiration rate was raised by the moisture content of the seeds. High moisture content and temperature will hasten the seeds.

Means in the column with the same letter are not significantly different at 5% level based on Least significant Difference (LSD) at 0.05 C1, company one , C2 company two, C3, company three, PS, pure seed, IM, inert matter, SG, standard germination, ABS, abnormal seedling, DS, dead seed, SPG, speed of germination

d) Seedling length and dry weight

The analysis of variance indicated that seed source and its interaction with inbred line of hybrid maize significantly (p<0.001) affected seedling shoot and root length. Additionally, the main effect of seed source significantly (P < 0.05) influenced the seedling dry weight of maize, but parental line and its interaction with seed source didn't significantly (P >0.05) affected seedling dry weight, moreover the main effect of inbred line of hybrid maize didn't significantly (P >0.05) affected by seedling shoot length (Table XV).

TABLE XV: INTERACTION EFFECTS OF SEED SOURCE AND PARENTAL LINE OF HYBRID MAIZE ON SEEDLING VIGOR QUALITY PARAMETERS.

Seed source	Inbred line	SL(cm)	RL(cm)	SVI	SVII
C1	CML-395	8.89[b]	11.19[a]	1898.43[ab]	7.68[ab]
	CML-202	10.25[a]	7.85[b]	1672.28[b]	9.28[a]
	SC-22	8[bc]	8.93[ab]	1306.85[bc]	3.58[c]
C2	CML-395	6.49[c]	6.84[bc]	1189.67[cd]	4.02[c]
	CML-202	6.99[c]	6.89[bc]	1262.56[bc]	4.92[c]
	SC-22	4.57[d]	5.34[d]	300.24[e]	0.91[e]
C3	CML-395	8.61[b]	9.05[ab]	1609.53[b]	6.23[cd]
	CML-202	4.82[d]	5.76[d]	794.41[d]	2.43[de]
	SC-22	10.4[a]	10.83[a]	1929.47[a]	6.19[cd]
LSD(0.05)		0.98	1.66	273.94	3.56
CV (%)		8.79	14.1	14.15	48.74

The SC-22 inbred line seed sample from C2 had the lowest seedling shoot length (4.57 cm), whereas the SC-22 seed sample from C3 had the longest seedling shoot length (10.4 cm), which was statistically comparable to the CML-202 seed sample from C1. The seed sample of CML-395 acquired from C1 had the longest recorded seedling root length (11.19 cm), which was statistically comparable to the SC-22 seed obtained from C3. The seed sample of SC-22 inbred line seed obtained from C2 had the shortest recorded seedling root length (5.34 cm) (Table XV). In the laboratory test, the inbred line of SC-22 seed sample taken from C3 exhibited superior seedling emergence and establishment due to its well-developed shoot and root systems that can tolerate any unfavorable circumstances. Those seedlings typically developed longer shoots, and the roots came from strong seeds. This conclusion was consistent with the research conducted by to [18], who suggested that the huge food stores of the heavy seeds may be the reason for the higher seedling length and dry weight of the heavy seeds. Seeds from C1 had the highest recorded seedling dry weight (0.075 g), while seeds from C2 had the lowest recorded seedling dry weight (0.043 g) (Table XVI). According to [40], larger seeds result in greater seedling dry weights. It was also observed that larger seedling dry weights were associated with increased endosperm food storage.

Means in the column with the same letter are not significantly different at 5% level based on Least significant Difference (LSD) at 0.05 C1, company one , C2 company two, C3, company three, SL, shoot length (cm), RL, root length (cm), SVI, seedling vigor index 1 and SVII, seedling vigor index 2

e) Seedling vigour index

The analysis of variance showed that the main effect of seed source and parental line of hybrid maize significantly ($p<0.001$) affected seedling vigour-I and II. Additionally the interaction effect of both factors significantly ($p<0.001$) affected seedling vigour-I and II. The highest seedling vigour index-I (1929.47) was recorded for SC-22 parental line and seeds obtained from C3 and the lowest seedling vigor index-I (300.24) was recorded for the same inbred line of hybrid maize and seeds obtained from C2 (Table XV) mainly because of the low shoot and root length. The highest seedling vigour index-II (9.28) was recorded for CML-202 inbred line and a seed obtained from C1 and the lowest seedling vigor index-II (0.91) was recorded for SC-22 inbred line of hybrid maize and seeds obtained fromC2 (Table XV). [37] reported that the vigor index of any seed is the sum of those properties of seed which determine the potential level of activity which help to withstand under a wide range of field condition. Similarly, [4] reported that practical seed vigor test should give a good indication of field performance potential of the seed lot and the test results should be reproducible.

TABLE XVI: MAIN EFFECTS OF SEED SOURCE AND PARENTAL LINE OF HYBRID MAIZE ON PHYSICAL, PHYSIOLOGICAL AND SEEDLING VIGOR QUALITY PARAMETERS.

Treatment	OCS	FS	SDW(g)
Seed source			
C1	0.004	1.75	0.075[a]
C2	0.005	1.92	0.043[b]
C3	0.04	2.08	0.058[ab]
LSD(0.05)	ns	ns	0.024
inbred line			
CML-395	0.0041	1.58	0.067
CML-202	0.0041	1.75	0.063
SC-22	0.044	2.41	0.048
LSD(0.05)	ns	ns	ns
CV	0	40.8	49.06

Means in the column with the same letter are not significantly different at 5% level based on Least significant Difference (LSD) at 0.05 C1, company one , C2, company two, C3, company three, OCS, other crop seed, FS, fresh seed, SDW, seedling dry weight(gm)

IV. CONCLUSIONS AND RECOMMENDATION

The majority of farmers in study area are educated that can create conducive environment for improvement of maize seed production because it easy to convince educated farmers than illiterates. Almost all farmers get information about the maize seed form extension service in their kebele agricultural development center. 11% of farmers get their maize seed from market or from unknown source which is a problem to be addressed as the quality is not guaranteed. Maize seed production in the districts is constrained by a variety of related factors; the most important constraints are insufficient supply, delayed delivery, unavailability of preferred variety. Farmers buy improved maize seed from market and /or from other farmers when it not timely delivered to them or when they need their preferred variety.

Genetic purity analysis through field inspection method (morphological observation) showed variation of purity level of different hybrid varieties and their parents across different seed sources. Generally, the current study showed the presence of contaminants of maize seed at parental lines (inbred lines) and hybrid seed production. Seed sources collected from company two the variety of 142-1-e didn't met the minimum requirements of purity percentage and standard germination for basic seed of 99% and 80% certification standards, respectively. Additionally, samples collected from company two and company one of SC-22 inbred line didn't met the minimum seed germination percentage requirements for pre-basic seed of 80% certification standards. Seed producer companies and research organization also could give adequate attention to hybrid maize seed's and parental line genetic purity during their production process and further studies could be conducted every season to ensure quality assurance and/ or quality control in the hybrid maize seed system.

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