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Evaluating Performance Of CIMMYT Maize Inbred lines Against Maize Streak Virus (MSV), Grey Leaf Spot (GLS), Rust (PS), Turcicum (ET) And Yield Potential In Zimbabwe

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ABSTRACT

CIMMYT maize inbred lines selected for tolerance to maize streak virus, grey leaf spot, rust and turcicum were used in this project. Yield was very important trait and was considered as a check to find the ability of different lines to tolerant various diseases. In this study several inbred lines were evaluated for per se performance against disease tolerant and yield potential under different environmental conditions of Zimbabwe. The trial was carried out at Harare CIMMYT (misting), Art Farm, Devonia and Kadoma. The trial was carried out during the 2013/2014 summer season. A total of 35 entries were planted in an alpha (0.1) lattice design with two replications and five (two row) plots per incomplete block. Data was collected on several traits that is grain yield and diseases from across sites. The data was analyzed using GenSat and Fieldbook softwares. Significant variation was noted at all the sites for grain yield ($p<0.001$). Entries (genotypes) were all affected by environment as there was a highly significant difference of $p<0.001$ for the GLS, turcicum, rust and MSV from all the sites. Same entries had different yield. However, the following lines proved to be ready for release for public and private seed companies to use them in their breeding programs. TL115986, TL123981, TL1311661, TL115989, VL0511320, TL124615, TL115974, TL117079, TL115983 and TL115993. The other lines that had produced below average yield can undergo further trials until they have proved to be stable.

Key words: Inbred lines, Significant difference, tolerance, yield.

Background

Maize (*Zea mays*) is a coarse leafed annual grass. It originated from Central America (Mexico), later spread to Africa in the 16th century by the Portuguese (Rukuni et al, 2006). In Zimbabwe, it became popular in 18th century, and up to now is the major staple food after sorghum and millets (Troyer, 2001). The crop is a warm weather plant and requires an average temperature of about 24^0C during the growing period. Low temperatures reduce growth and high temperature above 35^0C is more injurious to the plant at tasselling stage. It grows best at soil pH ranges between 5.5 and 6.5 on a calcium chloride scale (FAO, 2011).

Inbred lines are the foundation of breeding programs of all the plants. These are known as pure lines that can be used as commercial varieties but having low yield. If inbred lines are crossed, they produce single cross, double cross, three way cross or four way crossings. This is the foundation of hybrids. Their base should be of paramount important so that they are not easily affected by change in environmental conditions both biotic and abiotic (Sinha, 1996). The current varieties are reducing their tolerance to these conditions.

However the production of maize is hindered by diseases such as maize streak virus (MSV), gray leaf spot (GLS), turcicum (ET), rust (PS) and random droughts that are experienced in the southern region of Africa. The turcicum disease is caused by the fungi *Exserohilum turcicum* formerly known as *Helminthosporium turcicum* (Hooker, 1981). It is an important disease of maize in most humid regions of the world where the growing season is characterized by temperatures ranging from 17^0C to 27^0C and there are periods of extended dew or leaf wetness (Carson, 1999). Turcicum leaf blight can be very severe especially if it establishes before flowering. Maize streak virus (MSV) is spread by leafhoppers can affect the maize crop to extend of reducing yield. MSV can be controlled by controlling the vector or breeding for a tolerant variety. Gray leaf sport is caused by the fungus *Cercospora zeae-maydis*. The disease is one of the most significant yield-limiting diseases of maize worldwide. It reduces yields of maize on both small-scale farms and commercial farms. Maize rust is caused by the fungi *Puccinia sorghi* and is found in most subtropical, temperate, and highland environments with high humidity (Pataky, 1999). It is seen by small lesions that appear on leaves. They show circular to elongate in shape and are in clusters. As lesions get mature, the fungus erupts through the leaf surface (epidermis) and the yellow halo lesions are seen as more elongated (Sangoi, 1996). The above diseases had brought idea for the breeders to breed more tolerant lines. These are the lines that are going to be evaluated for yield and per se performance in different environments.

Problem statement

New CIMMYT maize inbred lines have no full information on per se performance against the diseases such as maize streak virus (MSV), grey leaf spot (GLS), Turcicum leaf blight and rust. So the research was to evaluate the given 35 inbred lines under different environmental conditions of Zimbabwe. The diseases contributed to yield output, so yield potential of each line was determined by tolerant to disease in the field of trial demonstration site.

The current maize cultivars are highly susceptible to major maize diseases. Yields are declining season after season due to poor planting materials. However, the number of people worldwide is increasing thereby need more maize but the land has no capacity to become larger instead it is reducing in size due to poor management by human beings hence affect yield of maize. A change in weather is the key point that favours the diseases development. Basically temperature and humidity changes are the factors necessary for the survival of the pathogens that cause fungal diseases.

Justification

CMLs performed very well in disease tolerant and managed to produce high yields will be used as parents of hybrids or improved open pollinated varieties (OPVs) by public and private sector institutions such as breeders of

Pioneer seed company, SeedCo, Pannar Seed Company and all other upcoming seed companies and CIMMYT itself in hybridization programs. The materials are given on free of charges under CIMMYT' s standard material transfer agreement (Banziger at el 2004). These seed companies are going to use the lines in breeding programs for seed production as male or female lines as they will be good in combining ability, high yielding and tolerant to diseases. Varieties produced from these lines will be ideal for the farmers as they will be end user of the certified seed. However, old varieties are getting less in disease tolerant to disease attack and are producing low yields because of weak genes that would have been developed during the time the seed was under cultivation. The farmers in marginal area cannot afford to buy chemicals to control diseases as well as irrigating crops to extend the growing period of the season to maximize yields, so are going to benefit from the newly produced varieties. The breeders themselves also get helped in realizing their effort to come up with lines that are adapted to various environmental conditions and shall use the lines successfully in their breeding programs.

Main objective

To evaluate per se performance of improved inbred lines against MSV, GLS, rust and Turcicum and yield potential under optimum and stress environmental conditions.

Specific objectives

1. To determine the performance of the improved inbred lines against the GLS, MSV, rust and Turcicum diseases in Zimbabwe.

2. To determine yield potential of the CIMMYT improved maize inbred lines.

Hypothesis

1-Improved inbred lines are tolerant to the GLS, MSV, rust and Turcicum.

2-Improved inbred lines are high yielding.

Literature review

Maize inbred lines of CIMMYT

Maize (*Zea mays* ssp. *mays* L.) is the world's third most important by acreage and is a multi-purpose crop for food, animal feed, biofuel, and raw material in the synthesis of a broad range of industrial products (Troyer 2001). Over the past 4 decades, breeders at the International Maize and Wheat Improvement Center (CIMMYT), in collaboration with the National Agricultural Research Systems (NARS) of many maize-growing countries, have developed numerous germplasm pools, populations, and open-pollinated varieties (Carson, 1999). CIMMYT maize germplasm is widely used by various public and private sector institutions worldwide for the development of open pollinated varieties, hybrid seed production, pedigree breeding, molecular breeding, doubled haploid production, and transgenic introduction of traits. The objective of this research was to evaluate the performance of CIMMYT inbred lines for their parental characteristics. The results of this research will assist in understanding the relationship between yield components, susceptibility to disease attack and the general per se performance of the 35 maize inbred lines.

Prior to their release, the CMLs are intensively evaluated for per se performance (especially under abiotic and biotic stresses) and performance in hybrid combinations (combining ability) (Sinha, 1996). Release of a CML does not guarantee high combining ability or per se performance in all environments, rather, it indicates that the line is promising or useful as a hybrid component or as a parent for pedigree breeding for one or more target mega-environments (Banziger, 2004).

Most of the inbred lines produced are early-maturing, drought tolerant, late-maturing and resistant to maize streak virus (MSV), turcicum leaf blight (TLB), common rust (PS), and gray leaf spot (GLS). Some of the lines are classified as a CIMMYT heterotic group A or B and others have high combining ability with other lines (Banziger, 2004). However, in breeding these lines, are used as male or female parents.

Maize streak virus (MSV)

It is viral disease spread by leafhoppers. The leafhoppers are small insects that live in the bush and act as reservoirs of the virus and the vectors. MSV favours the grass family plants. Outbreaks of maize streak have been associated with drought and irregular rain in West Africa (Muchena, 1987). As maize streak is vector transmitted, disease outbreaks are dependent on favorable conditions for *Cicadulina species*.

According to Pingali and Pandey (2000), the nature of damage is characterized by the following,

(i) Yield loss due to plant stunting and the termination of ear formulation, development and grain filling in infected plants.

(ii) Severe infection will result in death of plants prematurely.

Signs of MSV

Figure 1 showing MSV infected plant; source Setimela et al, (2004)

The symptoms of the maize plant are exhibited as follows as described by (Setimela et al, 2004),

(i)Early disease symptoms are seen in a week time after infection and consist of very small, round, scattered spots in the youngest leaves.

(ii)The spots increase in numbers as the plants grow. They enlarge parallel to the leaf veins.

(iii)Fully elongated leaves develop a chlorosis with broken yellow streaks along the veins, contrasting with the dark green color of normal foliage.

Geographic distribution

Maize streak is predominantly a disease of maize in Africa although it has also been reported from south and south-east Asia (Poehlman and Sleper, 1995).

Turcicum leaf blight

Turcicum leaf blight (also known as northern corn leaf blight) is fungal disease. *Exserohilum turcicum* is a problem in maize production areas worldwide especially where there is high humidity and moderate temperatures (17 to 27°C) that is according to (Singh et al, 2004). Yield losses of up to 70% have been attributed to Turcicum leaf blight (Carson, 1999). Turcicum leaf blight is more prevalent where increased levels of nitrogen fertiliser are applied. *E. turcicum* is also known to infect sorghum, Johnson grass, Gama grass, teosinthe and Sudan grass (Singh, 2004).

Symptoms

Early symptoms are oval, water-soaked spots on leaves. Mature symptoms of Turcicum leaf blight are characteristic cigar shaped lesions that are 3 to 15cm long, (Hooker, 19810). Lesions are elliptical and tan in color, developing distinct dark areas as they mature that are associated with fungal sporulation (Lipps and Mills, 2002). Lesions typically first appear on lower leaves, spreading to upper leaves and the ear sheaths as the crop matures. Under severe infection, lesions may coalesce, blighting the entire leaf (Oerke and Dehne 2004).

The picture below shows the signs of the turcicum.

Figure 2 Picture showing symptoms of turcicum leaf blight on a maize plant, source: CIMMYT Zimbabwe library picture collection.

Lesions may vary slightly depending on the resistance status of the host. Lesion development on some hybrids with resistance genes may include long, chlorotic streaks that can be confused with other diseases such as Stewart' s Wilt (Carson, 1999).

2.4 Grey leaf spot (GLS) of maize

It is a fungal disease caused by *Cercospora zeae-maydis*. The disease is one of the most significant yield-limiting diseases of maize worldwide (Muchena, 1987). It reduces yields of maize on both small-scale farms and commercial farms.

2.4.1 Symptoms

Symptoms firstly appear on the lower leaves of the maize plant. The immature lesions are similar to lesions caused by other foliar maize pathogens, and first appear as small tan spots about 1 to 3 mm in size and are irregular in shape (Oerke and Dehne, 2004). The tan spots usually have yellow or chlorotic borders and, are more easily observed when the leaf is held to light (Muchena, 1987).

The pictures below show the signs that one has to take note when identifying the GLS and not get confusing with other diseases. The most ideal time of identifying the symptoms is when the crop leaves are drying. The signs are easily seen and differentiated from other diseases.

The picture below is showing GLS infected maize leaf

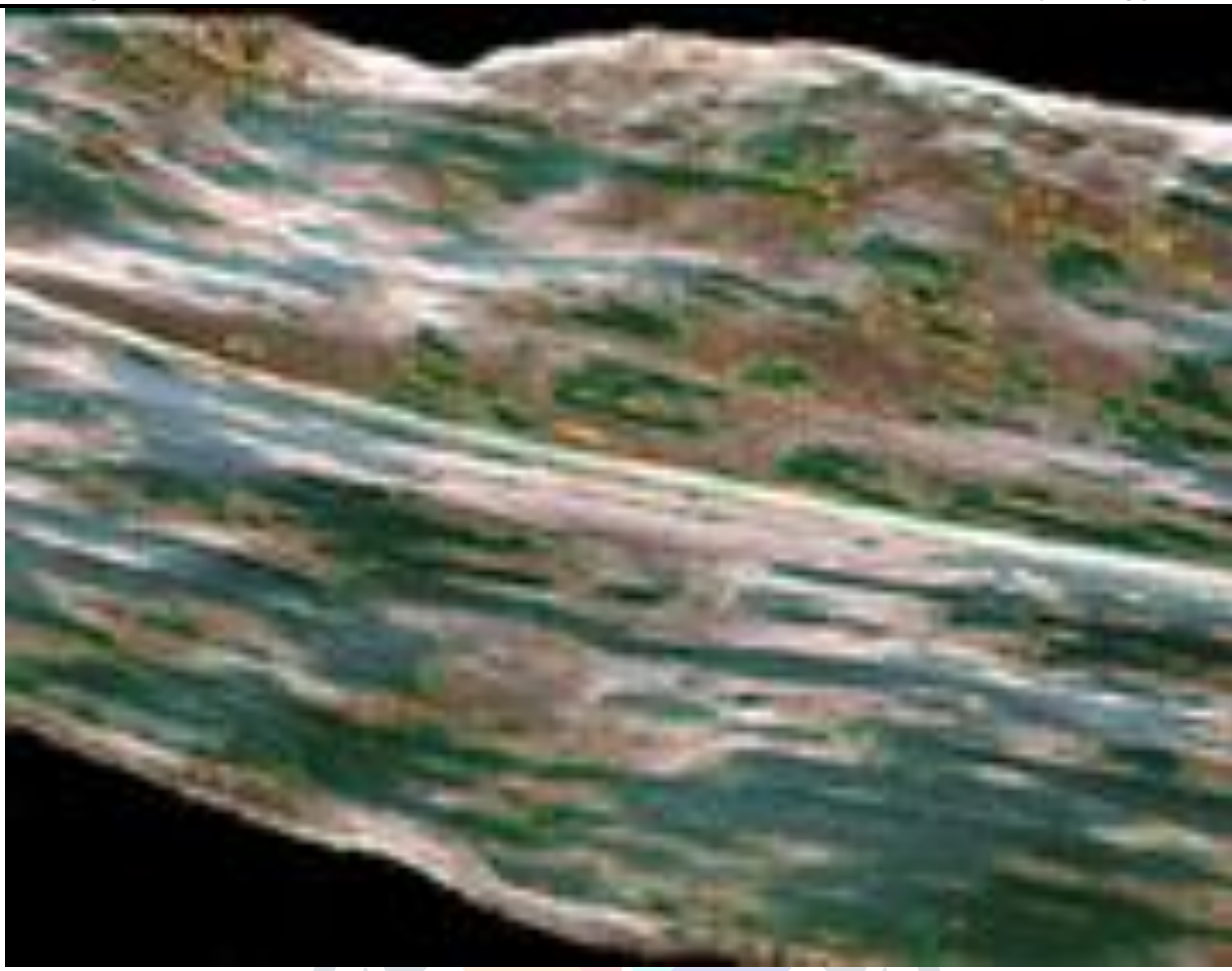


Figure 3 showing GLS on plant leaf, source Oerke and Dehne (2004).

Mature lesions are readily distinguished from other pathogen symptoms and are distinctly rectangular in shape (5 to 70 mm long and 2 to 4 mm wide) (Muchena, 1987) and run parallel with leaf-veins. Lesions, tan in colour, assume a grey sheen or caste when sporulating. As disease progresses, lesions coalesce and blighting of the whole leaf may result.

Under favourable conditions, blighting progresses upwards on the plant. The whole plant may die before the crop reaches maturity, and serious yield losses may result. Under these conditions, the maize plant may be pre-disposed to stalk-rotting fungal attack and lodging adding further to the yield losses, (Friesen et al 2002).

Maize rust

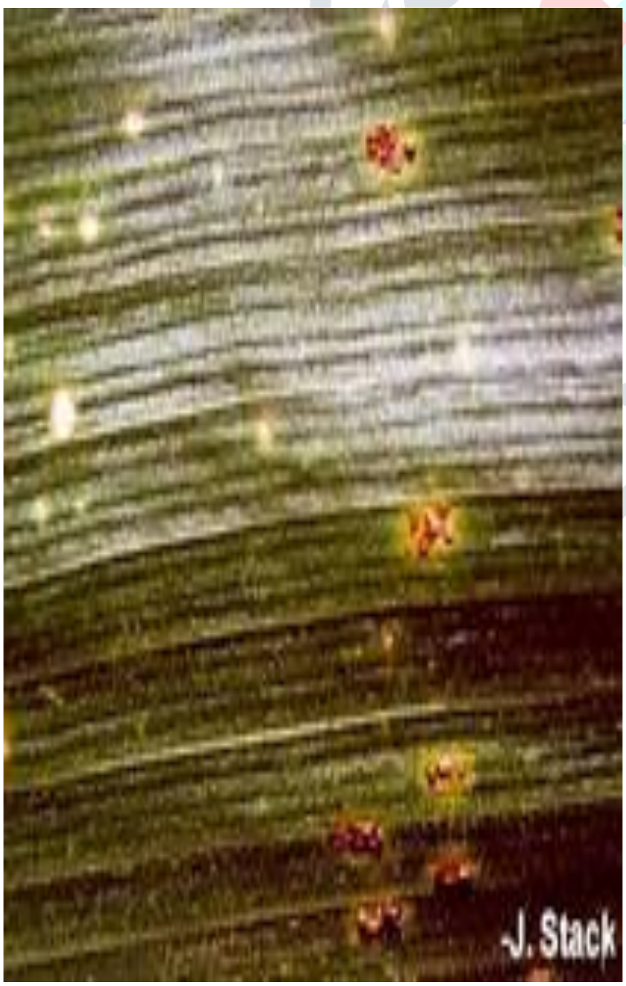
Common rust is caused by the fungi *Puccinia sorghi* and is found in most subtropical, temperate, and highland environments with high humidity. Epidemics of common rust can cause substantial yield loss. Yield losses in excess of 50% have been recorded under severe disease pressure (Doleza et al, 2007).

Disease Symptoms

Initial small lesions appear on leaves. They show circular to elongate in shape and are in clusters. As lesions get mature, the fungus erupts through the leaf surface (epidermis) and the yellow halo lesions are seen as more elongated (Sangoi, 1996). Brownish-red oblong pustules are the characteristic symptom on leaves; urediniospores that rub off on fingers are what impart the color to the lesion. Spores are wind-blown with new infections occurring every 7 to 14 days (Oerke and Dehne, 2004). As the season progresses, black teliospores are produced within the lesions. During this process, a single lesion may produce both brownish-red urediniospores and black teliospores. Finally, only black teliospores will be observed within the lesions. Cool temperatures and high humidity favor disease development (Muchena, 1987).

Signs of maize rust

Early lesions mature lesions



Brownish-red Single Lesion

Black Teliospores

Figure 4 showing signs of rust on maize plant leaf, Source; Oerke and Dehne, (2004).

Rust is a cool weather disease and occurs worldwide in subtropical and temperate environments where the growing season is characterized by mild temperatures, high relative humidity, and high moisture (Muchena, 1987). Optimum temperatures for urediospore germination and formation of infection structures are between 15 and 17°C. Common rust outbreaks are common during the ear filling period and can spread rapidly in favorable environmental conditions (Dolezal, 2007).

Leaves in the whorl are particularly vulnerable to rust due to high moisture content and relative humidity. Young leaves appear more susceptible than older leaves. Continuous cultivation of susceptible maize ensures that the pathogen has a continuous host and results in buildup of disease inoculum (Boyer, 1982).

Materials and methods

Site description

The experiment was carried out on areas that experience optimum conditions for maize growth and area of low rainfall but not extremely low in Zimbabwe. The areas were, Kadoma Research Station, Agriculture Research Trust Farm, Pannar Research Site and CIMMYT Harare.

Table .1 Trial site description

Site	Devonia	Art Farm	Kadoma Research Station	CIMMYT Harare misting
Agro-ecological region	IIb	IIa	III	IIa

Rainfall (mm)	803	820	727	891
Soil type	black clay soil	red clay soil	sandy loam	red clay soil

Devonia was chosen as a farm owned by individual thereby trying to utilize his knowledge on maize production. The knowledge was to help when analyzing the results. ART far was chosen as an independent research site for their experience in monitoring the crop growth and having high standards of farming. Kadoma was chosen as a site that experience low rainfall and cannot promote fungal diseases and soil type is sandy loam. CIMMYT Harare misting site was chosen as an artificially modified environment by misting it throughout the growing season so as to promote the fungal spore germination. This site turcicum was inoculated to make sure that the pathogen was available. Evaluating inbred lines on different environmental conditions of various natural regions helps to come up with the best lines that tolerate disease attack depending on area specific. Every area has got its natural pests that cause disease development. However the inbred lines were tested in various soil types as indicated by area and its characteristics on above table.

Experimental Design and Treatments

The trials were planted in an alpha lattice design (0, 1) 5 plots per incomplete block. The trial may be analyzed as a randomized complete randomized block design (RCBD) without violating any of the assumptions for the statistical model .Two border lines were planted both in front and back of the trial. The materials used as guard rows were early maturing variety of Seed Co SC 513 whose seed has good germination ability. Seed was prepared for two replications of two row plots. So treatments were 35 and replicated to come up with 70. Appendix 1 illustrates the design of the field for the trial. The guide to the design is indicated below.

Field design

REP 1and 2	INCOMPLETE BLKS	TWO ROWS/PLOT	RANDOMISED ENTRY	RANGE
1	**1**	**1**	**17**	**1**
1	**1**	**2**	**20**	**1**
1	**1**	**3**	**14**	**1**
1	**1**	**4**	**23**	**1**
1	**1**	**5**	**30**	**1**
1	2	6	11	**1**

1	2	7	27	**1**
1	2	8	19	2
1	2	9	9	2
1	2	10	8	2

Agronomic Practices-

The field was ploughed to fine tilth using a disc harrow. Planting stations were marked using a marked wire. Opening the holes was done manually using hoes. Spacing were as follows, in-row 25cm and inter- row 75cm respectively. Expecting 53 333 plants hectare.

1 Planting

Two border rows were planted along each side of the trial of SC 513. In each planting station, two seed were placed. The idea was to thin and leave one plant per station.

2 Fertilizer application

Basal fertiliser was applied at planting so that the crop has vigorous initial growth. The rate was cup number 22 per station and gives approximately 350kg/ha and the top dressing was done four weeks after germination at a rate of cup number 8 per planting station and seven weeks later using the same rate and also gives approximately 250kg/ha.

3 Water

The trial was under rain fed. No irrigation was done on the trial fields so that the available conditions were fulfilled. Only the area under misting was supplied with water as the idea was to create a natural region 1 which receives rain throughout the year. Microjets were used to irrigate the area.

4 Weed Control

Hand weeding was the main method used to control weeds. The weeds were good habitat of the pathogens that cause plant diseases so were thoroughly controlled across the sites.

Data Collection (Growth and Performance Data).

Data was collected for the following traits; MSV, GLS, Rust and Turcicum severity by scoring 1-5. Other traits recorded include, grain yield, ears per plant (EPP), anthesis date, silking date, anthesis, plant height, ear height, root lodging, stem lodging, ear aspect and grain texture and yield. An IPAQ, a device used to store data in excel format was used to put all the information captured in the field. The data was later downloaded into the computer that had Fieldbook and GenStat softwares to analyse data. The score indicated that from 1 there was no infection and 5 severely diseased as indicated below.

1= no infection

2= slight infection

3= moderate infection

4= above 50% infection

5= severe infection

Table 2. Traits, time and plant growth stage data recorded.

TRAIT	TIME OF DATA COLLECTING	STAGE OF PLANT GROWTH
MSV	4-8weeks	Vegetative stage
GLS	8-12weeks	Prior to harvest
ET	8-12weeks	Vegetative to physiological maturity stage
RUST	6-10weeks	Physiological maturity
YIELD	16-18weeks	Harvesting and shelling time

On lodging, number of plants were counted and recorded while aspect and texture were also scored from 1-5. Ear rot was measured as the number of ears that are rotten. Texture was consisting of the flintiness or dentiness of the kennels on cobs per plot.

The first thing was to record the planting date of the materials. Flowering dates for both female and male plant parts were taken. In most cases the differences between silking and anthesis dates were slightly reasonable since the plants managed to have cobs. Shelling machine coupled with the moisture meter and the data capturing device were used to shell the cobs and data recording. Calibration of the machine was the first thing to do and regularly during shelling in order to have accurate results and also checking mistakes. According to Pingali and Pandey (2000), the moisture 12.5% is best for maize storage so this moisture level was used when calibrating so as to come up with the right moisture of the grain. Yield and moisture levels of each inbred line were recorded after shelling.

Results

The ANOVA tables on appendix show the results for the factors and the variates' significance levels for the diseases recorded during the project progress. The diseases studied include grey leaf spot (GLS), maize streak virus

(MSV), rust (PS) and turcicum (ET). Yield (GYG) was also analysed as indicated by the objective of the project. All variates were highly significant different at $p<0.001$. Lines of the same genotype performed differently on different environmental conditions.

Best ten lines from across sites

No	line	%	Avg	StdDev
1	TL115986	188	5	5
2	TL123981	158	6	5
3	TL1311661	172	7	5
4	TL115989	157	7	4
5	VL0511320	164	8	7
6	TL124615	166	8	5
7	TL115974	153	8	3
8	TL117079	144	9	8
9	TL115983	136	11	6
10	TL115993	135	11	9

Yield was used as a guide line to find out the best lines that had performed well under the different diseases attack, ET, RUST, GLS and MSV.

Rel. %GY	Relative grain yield expressed as percentage of the mean grain yield of the trial. Values above 100% indicate above-average performance; values below 100% indicate below-average performance.
Rank Avg.	Average rank for grain yield across all trials. Small values indicate superior performance; large values indicate inferior performance.
Rank Stdev.	Standard deviation of rank for grain yield across all trials. Small values indicate stable performance; large values indicate variable performance.

The least 10 performer of the 35 inbred line evaluated across the site.

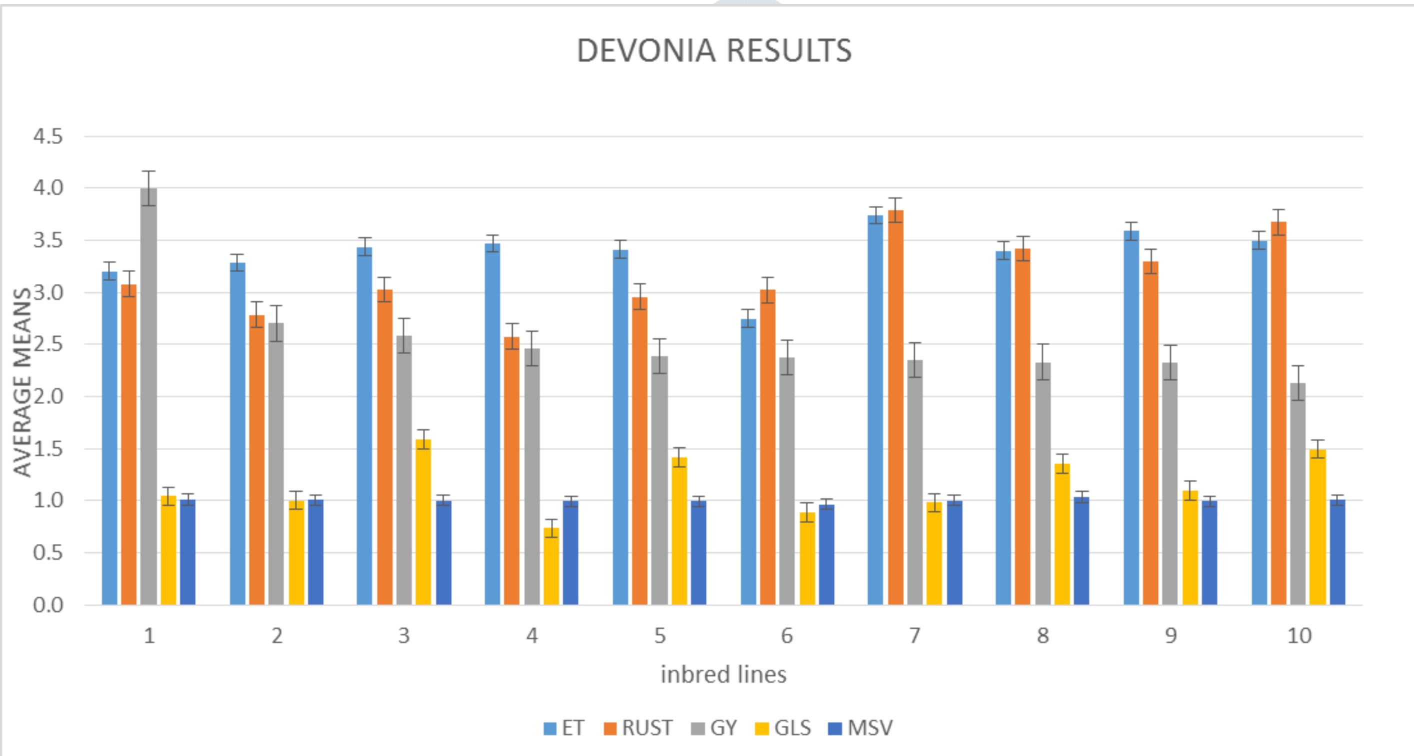
Entry	line	%	avg	Stdev
1	TL122272	53	26	4
7	TL115979	58	26	8
14	TL115994	49	27	5
22	TL115798	39	29	5

6	TL115978	37	29	3
27	TL115766	33	31	1
18	TL124620	16	31	5
25	TL115803	37	31	4
20	TL115831	17	32	3
17	TL124618	21	33	2

35 inbred lines evaluated, Appendix 8 shows the results of the remaining 15 lines arranged in their performance order.

Individual site performance

1. Devonia



Line

1- TL115986

2- TL115989

3- TL115993

4- TL123981

5- TL115990

6- TL117079

7- TL1311661

8- TL124615

9- TL115974

10- CML491

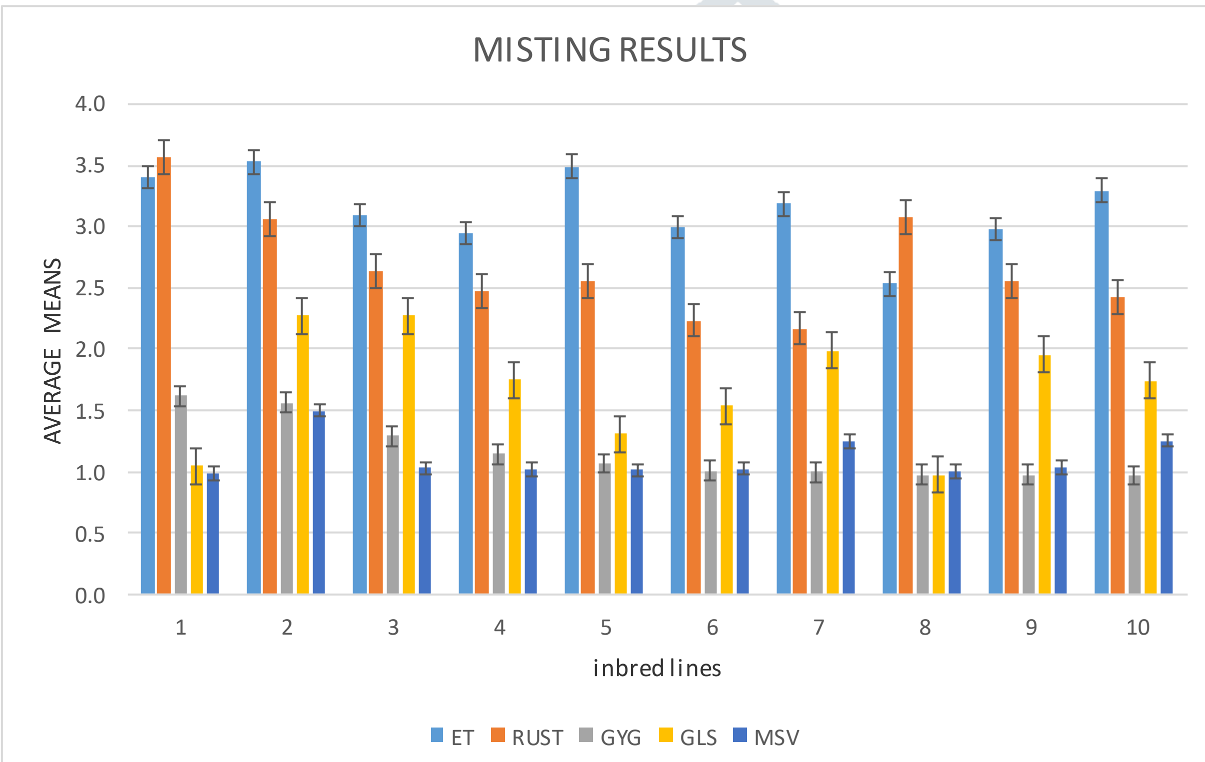
Yield was significantly different at p<0.001. The lines 1-4 were significantly different but line 5 and 6 were not significantly different from each other while 7, 8 and 9 and lastly line 10 was different from the rest at Devonia site.

MSV was not significantly different at p<0.5. Its score indicated that the lines were highly tolerant to MSV attack.

ET was significant different at p<0.05 in all the line evaluated.

Rust was significantly different on all the lines at p<0.001. There were a lot of variations.

2. Misting



GYG was not highly significant at p<0.001 though their values were not similar.

Lines on the graph

1- TL1311661

2- TL124615

3- TL115986

4- TL115989

5- TL115983

6- TL122257

7- TL115799

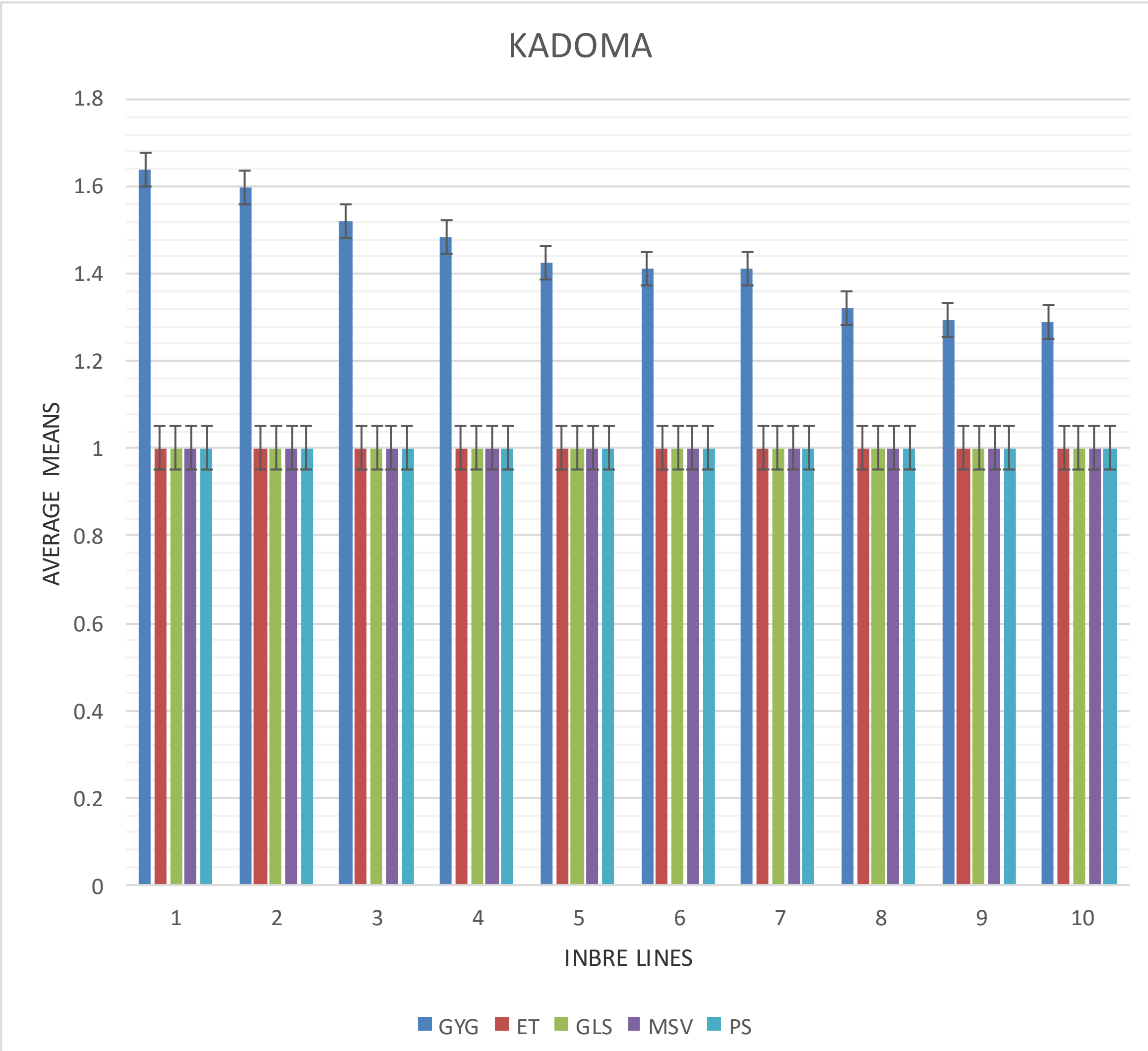
8- VL0511320

9- TL115974

10- TL115990

Yield was stable on lines 6-10 as there were no variations but lines 1-5 showed significantly differences from each other at p<0.05. Yield was low at this site. All diseases were highly significantly different at p<0.001. All the lines were not statistically similar in disease tolerant.

3. Kadoma



Key:

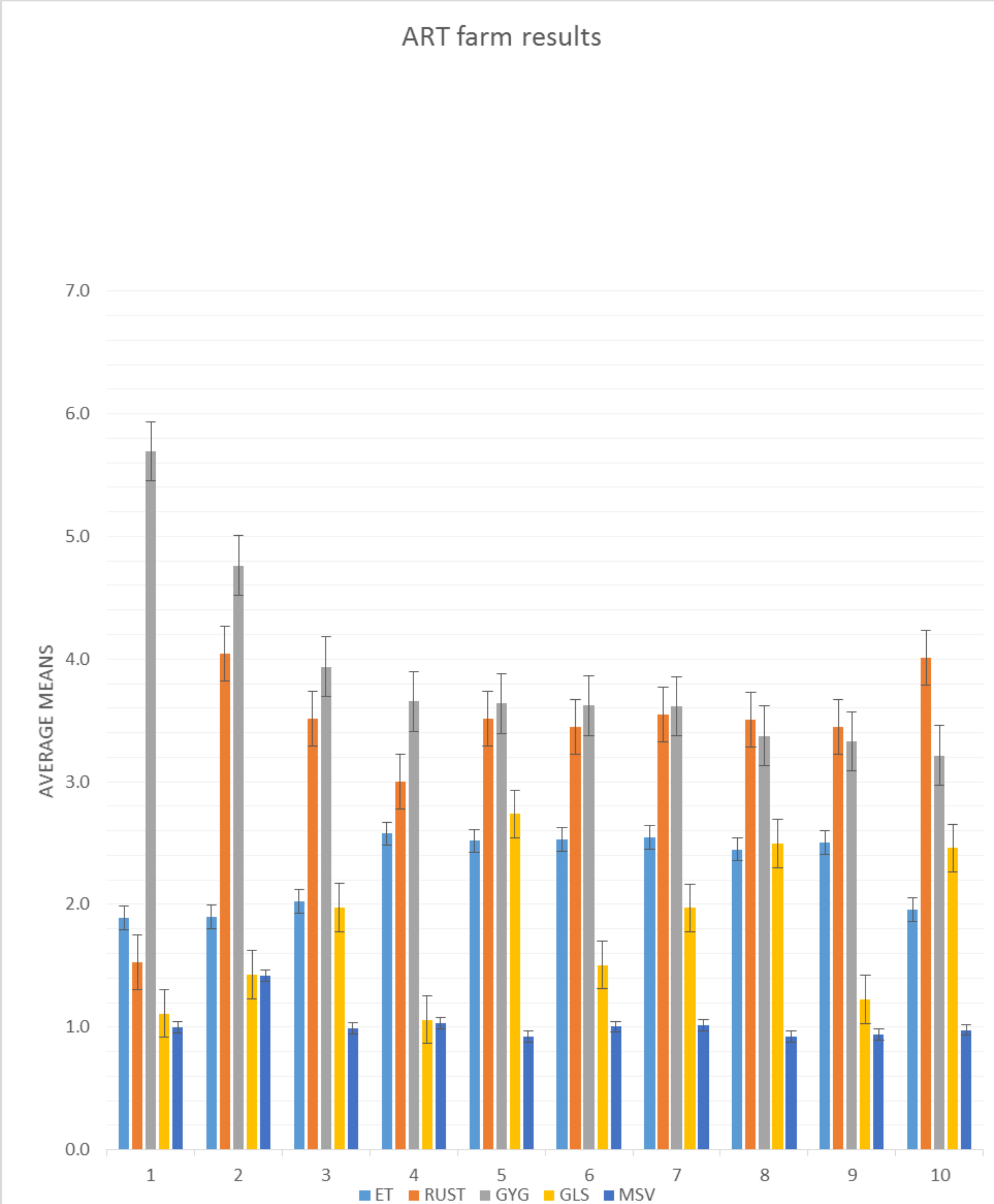
1 TL115986
2 TL115989
3 TL115993
4 VL0511320
5 TL1311661
6 TL115772
7 TL115983
8 TL115990
9 TL123252
10 TL115974

About GYG, line 1-5 were significantly different from each other at p<0.001. Line 6 and 7 were not significantly different from each other. Line 8 was differently from each other.

Lastly, line 9 and 10 were significantly differently from the rest lines at this site.

About the diseases all the line were not significantly different at $p<0.05$ from each other because there was no infection by pathogens. Kadoma is known as stress site so the environmental conditions were not favourable of the diseases outbreak.

4. ART Farm



Inbred lines

Key:

1- VL0511320

2- TL115782

3- TL115974

4- TL123981

5- TL115986

6- TL124615

7- TL115766

8- TL124622

9- TL122260

10- TL115989

Yield was significantly different at p<0.001 and line 1-3 were differently in average yield. Then lines 4-7 were similar but different from the first 3 lines. Lines 8-10 were also significantly different from the rest.

ET, lines 1-3 were significantly different in the disease attack, lines 4-9 were not significantly differently on disease attack and line 10 was also different from the rest line at p<0.001.

Rust, line 1, 2, 4 and 10 were significantly different from the rest of the lines. However, 3, 5, 7 and 8 were not significantly different from each other.

GLS, all the lines were differently from each other. A lot of variations were indicated by separation of means graphically.

MSV, no variations on this disease attack at p<0.001.

However, each site' s performance data was used to come up with the information of across site analysis. Across site results help to fine out the effects of genotype by environment performance.

Discussion of the results

Grain Yield

The data collected showing the significant variations observed at all the sites for yield indicated that there was considerable amount of variation for yield among the entries. The optimum sites had the highest mean yields indicating that the crop at these sites received the optimum conditions for good performance. In breeding experiments optimum sites are used to determine the yield potential of experimental material. Under misting, it was to make sure that the yield obtained is of a line that was successfully tolerates the fungi diseases analysed. Yield was the key variate to guide other factors to find out the most appropriate lines to choose. 35 inbred lines tested or evaluated in terms of per se performance from across site include;

Entry	line	%	Avg	StdDev
10	TL115986	188	5	5
35	TL123981	158	6	5
32	TL1311661	172	7	5
11	TL115989	157	7	4
33	VL0511320	164	8	7
15	TL124615	166	8	5
5	TL115974	153	8	3
34	TL117079	144	9	8
9	TL115983	136	11	6
13	TL115993	135	11	9

From top to bottom are lines arranged in performance order from across the sites.

According to Banziger et al (2004) gave an example of a line released **CML540 (CZL00009) whose characteristics are, a**n early-maturing, **drought tolerant** late-maturing resistance to maize streak virus (MSV), turcicum leaf blight (TLB), common rust (PS), and gray **leaf spot** (GLS). This line is classified as a CIMMYT heterotic group A line and combines well with CML395 and CML444. The line is producible as a male or female parent. Similar to the above new lines evaluated under this research have managed to tolerate the various diseases and also their yields were very stable so they can perform in the same manner with **CML540.**

Common Rust (*Puccinia Sorghum)*

A significant difference of $p< 0.001$ as per ANOVA was observed where diseases were scored. However Kadoma proved to be an area which is dry and cannot promote fungal diseases outbreak and the scores were one out of five. On Misting site there were a lot of moisture or humidity that promoted fungal spore germination of rust thereby increase its severity.

Turcicum Leaf Blight (*Exserohilum turcicum*)

From all the lines tested those lines mentioned above were affected by this disease but the lines managed to tolerate produce good yields. There was a high significant of disease severity noted by $p<0.001$.

MSV

The scores for this disease were really very low across all the sites. MSV is known as a destructive weapon on maize yield. However the most selected ten lines were slightly affected and managed to produce yield and hence the lines tolerated the disease attack. Their significant difference was noted at $p<0.001$ as per ANOVA analysis.

GLS

This disease was really a problem in most of the lines. However the top ten managed to tolerate the attack and produce a reasonable yield. Their highly significant difference levels $p<0.001$ were note. This means the entries were affected by changes in environmental conditions.

Conclusion

The level of grain yield potential and that of diseases resistance in the experimental lines was variable. The top ten lines below are the ones that can be selected for breeding purpose as their results of per se performance are now known and the rest under the experimental period can be improved to meet the breeders' needs.

TL115986
TL123981
TL1311661
TL115989
VL0511320
TL124615
TL115974
TL117079
TL115983
TL115993

The lines that did not produce high yields as a result of failure to tolerate the diseases attack cannot be ranked as poor but can still undergo extra work to improve their stability in disease attack. Those that had proven to be best can be used on breeding programs. Yield of each entry was used as a guiding tool to find out the ability of every line tested in disease tolerant. However, Kadoma is a drought prone area and thereby reduce the fungal disease infection. Misting was done so as to create natural region one to induce the fungal infection. ET was artificially inoculated, hence this site had a high percentage of ear rots. ART farm is known as a good site in terms of crop management so as to get highest potential yields. Devonia was used as individual farm management site. Generally, the lines managed to give better results that are comparable.

Recommendations

Multi-locational trials have to be conducted in different environments and also screen the selected inbreds for biotic and abiotic stresses over a number of years so that the stable lines are obtained. This is to make sure that if there are changes they will be observed and analysed. The lines that had performed top ten from across sites can be released for the benefits of the public and private seed companies.

TL115986, TL123981, TL1311661, TL115989, VL0511320, TL124615, TL115974, TL117079, TL115983, TL115993 were very stable in yield performance meaning that they managed to tolerate diseases.

Farmer is the end user of the varieties produced from the crossings of the different lines. The other inbreds that were not performed well that is below the average yield, in the trials should be further developed and screened for high yield potential and diseases resistance. For example

TL122272, TL115979, TL115994, TL115798, TL115978, TL115766, TL124620, TL115803, TL115831 and TL124618, they were far from the average yield.

The above line are not suitable for release to be used at the moment. The trial should be repeated over a number of seasons to determine the effect of genotype by location by time. Germination test has to be conducted before planting the seeds in trials as most of the seed used failed to have a higher germination percentages across all the sites. Lastly, the inbreds can be used as males or females in crossings for breeding programs. However, the inbreds have to be used in crossings rather than use them directly as commercial seed as their yield is very low unless they have been crossed, the yield is higher. Generally they have good combining ability, tolerant to disease attack and have a high yielding potential.

REFFERENCES

1) Banziger M., Setimela, P.S., Hodson, D.and Vivek B, (2004). Breeding for improved biotic stress tolerance in maize adapted to southern Africa
2) Banziger, M., Betran, F.J and Lafitte, H.R., (1997). Efficiency of high nitrogen selection environments for improving maize for low nitrogen target environments. Crop Sci.37, 1103-1109. 14 June 2014.
3) Bolanos, J. and Edmeades, G.O. (1993). Eight cycles of selection for drought tolerance in lowland tropical maize. I Responses in grain yield, biomass and radiation utilization. Field Crops Res. 31,233-252. 22 September 2014.
4) Boyer J.S., (1982). Plant productivity and environment science 218, 443-448. 1 April 2014.
5) Carson, M.L. (1999). " Helminthosporium" Leaf Spots and Blights. In Donald G. White (Ed), Compendium of Corn diseases. St. Paul, Minnesota: The American Phytopathology society. Pp 16-17. 22 September 2014.

6) Dolezal, B., A. Sayers and S. Butzen, (2007). Common and Southern Rust in Corn. Pioneer AgronomyResources.https://www.pioneer.com/growingpoint/agronomy/crop_insight/common_rust.jsp (01 October 2014).

7) FAOSTAT, (2003). Statistical Database of the Food and Agriculture Organization of the United Nations. http://www.fao.org/waicent/portal/statistics_en.asp

8) Friesen, D.K., Waddingiton S.R., Diallo, A.O. and Kanampiu, K., (2002). Breeding and agronomic approaches to managing abiotic stresses in maize pp. 214-222. In: Mandefro Nigussi, Tanner, D. and Twunosi-Afriyie (Eds). Enhancing the contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia, Addis Ababa, 12-16 November 2001. CIMMYT and EARO, Addis Ababa, 21 September 2014.

9) Hooker, A.L., (1981). Resistance to *Helminthosporium turcicum* from *Tripsacum floridanum* incorporated into corn. Maize Genetics, Coop. Newl. 55:87-88. 22 May 2014.

10) Lipps, P.E. and Mills D., (2002). Northern Corn Leaf Blight. Extension Fact Sheet AC-20-02. Columbus: Ohio State University.)http://ohioline.osu.edu/ac-fact/pdf/0020.pdf(16 August 2014)

11) Lu H., and R. Bernardo, (2005). Molecular marker diversity among current and historical maize inbreds. Theor. Appl. Genet. 103:613-617. 16 August 2014.

12) Muchena P., (1987). Pest and disease control in maize and the role of plant protection research institute. Proceedings of the 2nd Eastern, Central and Southern Africa regional maize workshop. Harare, Zimbabwe.

13) Oerke E. and Dehne H., (2004). Safeguarding production losses in major crops and the role of crop protection. Crop protection 23, 275-28. 1 June 2014.

14) Pataky, J.K. (1999). Common rust. In Donald G. White (ed.), *Compendium of Corn Diseases.* St. Paul, MN: The American Phytopathology Society. Pp. 35-8. 1 November 2014.

15) Poehlman, J.M. and Sleper, D.A., (1995). Breeding Field Crops, 4th Edition, Oxford and IBH Publishing Co.

16) Pingali, P.L. and Pandey S., (2000). World Maize facts and Trends. Mexico, D.F. CIMMYT

17) Raymundo, A.D., Perkins, J.M. and Hooker, A.L., (1981). Effect of gene HtN on the development of Northern corn leaf blight epidemics. Plant disease 65: 327-330. 18 September 2014.

18) Rukuni M and Eicher C K., (2004) *Zimbabwe's agricultural revolution, Revisited*. University of Zimbabwe Publications. Harare. Zimbabwe.

19) Rukuni, M., Tiwonezvi, P. and Eicher, C., (2006). Zimbabwe' s Agricultural Revolution Revisited. University of Zimbabwe Publications: Harare

20) Sangoi, L., (199)6. An ideotype of maize for conditions of high temperature and low moisture. Ames, IA, 350 p. PhD. Dissertation, Iowa State University.

21) Singh, Mani, V.P., Karagon, K.S., Bisht, G.S., Khandelwal, Bhadari, P. and pant, S.K., (2004). Identification of additional sources of resistance to *Exserohilum turcicum* in maize.

22) Singh B.D., 2003. Plant breeding: Principles and Methods. Kalyani Publishers, Ludhiana, New Delhi, India.

23) Sinha, H.A., (1996). Breeding for abiotic resistance. In Singh, B.D. (Ed.). Plant Breeding: Principles and Methods. Kalyani Publishers, Ludhiana, Punjub, India

24) Troyer, A.F. (2001). Temperate corn background, behavior and breeding. In Specialty Corns, 2nd Ed. CRC Press LLC, Florida, USA.

25) Wen l, Xia X. C. , J. C. Reif, A. E. Melchinger, Frisch, D. A. Hoisington, D. Beck, K. Pixley, and M. L. Warburton, (2005). Genetic Diversity among CIMMYT maize inbred lines investigated with SSR Markers: II.subtropical, tropical, midaltitude, and highland maize inbred lines and their relationships with elite U.S. and European Maize. Crop Sci. 45:2573-2582. 23 October 2014.

26) Yu L., Y. Shi, Y. Cao and T. Wang, 2004. Establishment of a core collection for maize germplasm preserved in Chinese National Genebank using geographic distribution and characterization data. Genet. Resour, and Crop Evol. 51: 845– 852. 22 Otober 2014