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Full Length Research Paper

Combining ability for resistance to Turcicum leaf Blight in maize under highlands of Uganda

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Abstract

Maize (Zea mays L.) production in the highland areas of Uganda is constrained by high prevalence of *Turcicum* leaf blight (caused by *Exserohilum turcicum*) hence the need to breed for resistance to this disease. Gene actions governing TLB has been studied in lowland and mid-altitude maize but no study has been done for the highland agro-ecologies of Uganda. This study was conducted to determine the general (GCA) and specific (SCA) combining ability of selected maize inbred lines and F1 hybrids with resistance to TLB. Eighteen single-cross hybrids and three checks were evaluated following an Alpha Lattice design with two replications in three highland agro-ecologies of Uganda namely: Bulegeni, Rwebitaba and Kalengyere. Results indicated high significant (P≤0.001) differences among test environments for grain yield, plant height, ear height, 50% days to anthesis and 50% days to silking, an indication that environments were distinct. The GCA and SCA effects were significant (P ≤ 0.001) for most traits, indicating the importance of both additive and non-additive gene effects. Genotypes CKMARS10022, CKL14546, AMH704-43, AMH703-35, AMH704-51, AMH10142-29, AMH10142-10, CKMARS10022 x CKDHL120671, CKLTI0028 x AMH704-43, CKLTI0028 x AMH703-35, CKLT10028 x AMH10142-29, CKLTI0028 x AMH10142-10 and CKL14546 x CKDHL120671 showed negative SCA effects for TLB indicating their resistance for TLB. Genotypes which possessed negative combining ability are recommended for TLB breeding.

Keyword: Maize production, turcicum leaf blight, *exserohilum turcicum*, highland agro-ecologies, combining ability, resistance breeding.

INTRODUCTION

Maize (*Zea mays* L.) is one of the major food crops grown all over the world (FAOSTAT, 2011). The crop is utilized directly as food and animal feed, but also as a source of income (Daly et al., 2016). The crop is ranked third most cultivated after banana and beans and most important cereal crop in Uganda. According to FAOSTAT (2016), 1.5 million hectares of land are under maize cultivation by smallholder farmers in Uganda with an average grain yield of 1.8 tons per hectare. The crop is grown in all parts of Uganda although the eastern region accounts for over 50% of total annual production (Okoboi, 2010). With the increasing cost of producing some staple crops like sorghum, cassava, millet and bananas, the importance of maize as a food crop is increasing. Maize solely provides over 40% of the calories in both rural and urban areas of Uganda.

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The TLB disease caused by the pathogen *Exserohilum turcicum* is a serious threat to maize cultivation in Uganda, causing over 60% grain yield loss (Adipala et al., 1993). The disease occurs in all maize-producing agro-ecologies especially where temperature ranges between 18-24 ℃ and relative humidity of 80%. Effective management of TLB requires planting of host resistant varieties (Smith, 1993).

Although the maize crop is important in the highlands of Uganda, research has concentrated on developing varieties for lowland and mid-altitude environments. The few highland varieties, namely Naromaize 731 and Naromaize 733 released in 2017, unfortunately were not adequately screened for TLB and are not as high yielding as some of the commercial hybrids such as H614 from Kenya (Kagoda et al., 2019). Lack of TLB resistance has contributed greatly to the low maize grain yield in the highland areas of Uganda, forcing some eastern Uganda highland farmers to source hybrid maize seed from Kenya. This makes maize growing expensive through increased production costs and sometimes delayed planting (Abalo, 2007). In the south western highlands of Uganda, due to lack of suitable varieties, farmers rely on recycled seed of local unimproved varieties, some of them having been developed for low and mid-altitude environments.

Ultimately, there is need to introgress TLB resistance in the highland maize varieties while ensuring high grain yields. Good enough, parents with good levels of resistance to TLB are available in the maize breeding programme at NARO-Buginyanya ZARDI. These however need characterization for some important traits such as combining ability with respect to TLB resistance before they can be used in the breeding programme. Therefore, this study was undertaken with the objective of determining the combining ability of maize inbred lines for TLB resistance in the highland agro-ecologies of Uganda.

Combining ability is essential for selection of parental lines with high performance (Legesse *et al*., 2009). Information on combining ability would provide understanding of mechanisms of gene actions involved in controlling quantitative and qualitative traits, which is an important requirement for breeders to select for promising parental lines (Hallauer *et al*., 1988).

MATERIALS AND METHODS

2.1: Experimental sites and germplasm description

The genetic materials for this study consisted of nine inbred lines made up of six TLB susceptible female parents and three TLB resistant male parents (Table 1). The inbred lines were grown at Ikulwe Research station, Mayuge in Uganda between April-August 2019 and cross-pollinated following the North Carolina mating design II to develop 18 single cross hybrids. The region lies at latitude of 01°19'60.00''N, a longitude of 33°29'59.9'E. The generated hybrids were evaluated for TLB resistance at three highland agro-ecologies of Uganda (Rwebitaba, Bulegeni and Kalengyere) in 2019B season. These locations are categorized as montane agro-ecology system (Wortman and Eledu 1999) and are located between 1500 - 3000 m above sea level (masl), with annual average rainfall ranging between 1500 and 2000 mm, while average minimum and maximum temperature range is 15^{o}C- 28^{o}C. Bulegeni lies at a latitude of 01°21'59.9''N, a longitude of 34°08'60.00''E while Kalengyere lies at a latitude of 01°15'N, a longitude of 30°30'E and Rwebitaba is located at a latitude of 0°39'16.65''N, a longitude of 30°16'48.4''E. These areas experience a relative humidity of 80% and are hotspots for TLB, therefore are highlands in nature with generally one long maize planting season.

2.2: Experimental design and field layout

The 18 single crosses and three checks (Naromaize 731, Naromaize 733 and H614) were planted in a 3 x 7 alpha (0,1) lattice design with two replications. Each genotype was sown in 5 m long double rows with inter and intra-row spacing of 0.75 m and 0.3 m. Border rows of the commercial variety H614 were planted around trials in all locations. Two seeds per hill were planted along the row, and thinned to one plant per hill three weeks after germination. To enhance vigor and uniformity of the genotypes, phosphorus in the form of DAP (Diammonium phosphate) was applied at planting at a rate of 125 kg/ha of DAP. In addition, nitrogen in the form of urea was top dressed 3-4 weeks after planting at a rate of 125kg/ha.

2.3: Data collection and evaluation

Turcicum leaf blight disease severity was recorded plus other key agronomic traits. To accommodate any variations and peculiarities of disease progression attributed to the stage of plant infection and prevailing weather conditions, disease severity was recorded four times at intervals of 14 days using a quantitative scoring scale of 1-5, where 1 = no symptoms; 2 = moderate lesion development below the leaf subtending the ear; 3 = heavy lesion development on and below the leaf subtending the ear with a few lesions above it; 4 = severe lesion development on all but the uppermost leaves, which may have a few lesions; and 5 = all leaves dead (Payak and Sharma, 1983). The agronomic traits for which data were taken included days to 50% anthesis, days to 50% silking, plant height, ear height, weight of ears and grain weight following procedures described by Dagne et al. (2008).

2.4: Statistical analysis

Genetic analysis was conducted using AGD-R (Analysis of

Genetic Designs in R software) to determine the general combining ability effects for the parents and specific combining ability of the corresponding hybrids where sources of variation were partitioned into males, females, and the interaction of males with females. The linear model for the phenotype of the NC Design II parents and progenies from the experiment used was as follows:

$Y (male, female) = \mu + GCA_{male} + GCA_{female} + SCA_{male\ x\ female} + error\ term$

Where μ is the grand mean, GCA male + GCA female are the additive effects (breeding values) of the male and female parents. SCA is the non-additive effect due to the combination of genes from male and female parents. Genotypes were considered as fixed effects while environments, replications and blocks within replications as random effects.

RESULTS AND DISCUSSION

3.1: Analysis of variance for TLB severity mean score and selected agronomic traits

The results from combined analysis showed that mean squares due to environments were highly significant ($P \leq 0.001$) for GY, PH, EH and DA and DS (Table 2). This indicates that the test environments were distinct and sufficient differences existed among them. Mean squares due to TLB were non-significant across all sources of variations. Similar results have been previously reported by Legesse et al. (2009) and Wende (2013) who found non-significant mean squares for TLB diseases in combining ability and heterotic grouping of highland transition maize inbred lines. Partitioning the general combining ability into GCA males and GCA females revealed that mean squares due to GCA males was highly significant ($P \leq 0.001$) for GY and EH but non-significant for the rest of traits while GCA females showed highly significant ($P \leq 0.001$) effects for GY, EH, DA with DS recording highly significant ($P \leq 0.01$) effect (Table 2). The GCA sum of squares for females were found to be greater than the GCA sum of squares for males in all traits except PH and TLB indicating that females contributed more favorable genes than males towards higher values of these traits. GCA and SCA mean squares for EH was highly significant ($P \leq 0.001$), an indication that the trait was governed by both additive and non-additive gene action. The DA and DS showed highly significant effects ($P \leq 0.01$) for GCA females' source of variation and significant effects ($P \leq 0.05$) for SCA (Table 2). This implies that the traits were governed by both additive and non-additive gene action. Studies conducted by Abdel-Moneam et al. (2009) and Shushay (2014) also indicated the importance of additive and non-additive gene action for these traits. However, in contrast to this, Alam et al. (2008) and Melkamu et al. (2013a) reported the predominance of non-additive gene action for DA and DS traits in maize inbred lines.

Significant differences ($P<0.05$) detected among females x environment for DA and DS (Table 2) indicated that the response of genotypes for the two traits differed across environments, suggesting that selection for such traits should not be done in a specific environment. Similar findings following combined analyses have previously been reported by various researchers (Bayisa et al., 2008; Kanyamasoro et al*.,* 2012) in their studies using different sets of maize inbred lines.

In this study significant GCA mean squares recorded across various sources of variations implies that the per se performance of the inbred lines used in this study should be a suitable pointer of the performance of their hybrids (Gethi and Smith, 2004; Badu-Apraku et al., 2011). The existence of significant SCA mean squares across various sources of variations implies that heterosis can also be exploited from crossing the different sets of inbred lines used in the study. It is therefore expedient to assess the parental inbred lines with different testers to be able to identify superior hybrids since the performance of the hybrids cannot be based on GCA and SCA alone (Hallauer et al., 2010).

Table 2: Mean squares from the combined analysis of 3*6 North Carolina Design II single crosses for TLB severity and other traits across three highland Uganda agro-ecologies in 2019-2020

Leaf blight, G.Y: Grain yield, P.H; plant height, E.H: ear height, D.A: days to anthesis, D.S: days to silking

3.2: General combining ability effect

Estimates of GCA effects of the nine parental lines for GY, TLB reaction, PH, EH, DA and DS are summarized in **Table 3**. Variability for GCA effects was observed among the parents for the traits studied. Inbred lines CKMARS10022**,** CKL14546**,** AMH704-43**,** AMH703-35**,** AMH704-51**,** AMH 10142-10 and AMH10142-29 showed negative GCA effects for TLB indicating that these inbred lines have a potential for resistance to TLB hence useful in breeding programs to develop TLB resistant varieties. The results of this study are in agreement with the findings of Legesse et al. (2009) and Girma et al. (2015) who found positive and negative GCA mean square effects for TLB in their studies on combining ability. Four inbred lines CKLTI0028**,** AMH704-43**,** AMH703-35, and CKDHL120671 were found to be good general combiners for GY as these lines showed positive GCA effects **(Table 3)**. Inbred line AMH704-43 had a positive and significant GCA for GY an indication that it has a potential to form high yielding cross combinations with different lines. Inbred lines with positive and significant GCA effects for GY are desirable parents for hybrid development as well as for developing synthetic varieties as they may contribute favorable alleles in the synthesis of new varieties. In line with this study, several authors

Table 1: Descriptions of the inbred lines used in this study, origin and their traits of significance.

Parent	Origin	Traits
Females		
AMH704-51	CIMMYT Ethiopia	GLS resistant, medium height, semi-dent seed texture, medium seed size, semi erect leaf type.
AMH704-43	CIMMYT Ethiopia	Medium height, dent seed texture, large seed size, early maturity, and semi-erect leaf type.
AMH703-35	CIMMYT Ethiopia	Tall, dent seed texture, large seed size, early maturity and semi-erect leaf type
CKDHL120671	CIMMYT Kenya	MLN tolerant, medium plant height, semi erect leaf type, semi dent seed texture, medium seed size
AMH 10142-10	CIMMYT Ethiopia	Quality protein maize, medium plant height, semi erect leaf type, semi dent seed texture, medium seed size.
AMH10142-29	CIMMYT Ethiopia	Quality protein maize, medium maturity, semi- erect leaf type.
Males		
CKL14546	CIMMYT Kenya	Resistance to TLB, drought tolerant, good male
CKLTI0028	CIMMYT Kenya	Resistance to TLB, closed tips, GLS resistance
CKMARS 10022	CIMMYT Kenya	DH line, resistant to TLB, MLN tolerant

Table 2: Mean squares from the combined analysis of 3*6 North Carolina Design II single crosses for TLB severity and othertraits across three highland Uganda agro-ecologies in 2019-2020.

Sources of Variation	Df	TLB	G.Y	PH	EH	DA	DS
Environment	2	10.48	49.31***	6219.8***	2627***	2675***	26396***
GCA Males	2	3.474	27.57***	448.9	536***	54.83	43.30
GCA Females	5	4.096	13.29***	848.6	941***	47.22***	34.48**
SCA	10	5.491	14.97**	319.7	282***	9.37*	9.73
GCA Males× Env	4	4.134	7.09	473.4	36.4	7.14	6.087
GCA Females × Env	10	5.189	4.355	76.27	94.4	15.98*	22.795**
SCA × Env	20	5.338	5.77	289.4	38	7.37	5.327
Residuals	39	4.804	5.038	405.3	89	4.41	4.398

*Significant at $p < 0.05$, ** Highly Significant at $p < 0.01$, *** Highly Significant at $p < 0.001$ GCA: General Combining Ability, SCA: Specific Combining Ability, TLB: *Turcicum* leaf blight, G.Y: Grain yield, P.H; plant height, E.H: ear height, D.A: days to anthesis, D.S: days to silking.

reported either positive or negative significant GCA effects in their studies on GY in highlands and mid-altitude agro-ecologies (Dagne, 2008; Legesse et al., 2009). Inbred lines CKL14546**,** AMH703-35**,** AMH 10142-10 and AMH10142-29 had positive GCA effects for PH and EH, whereas inbred lines CKMARS 10022**,** CKLTI0028 and AMH704-51 had negative GCA effects for these traits. Torrential rains experienced in highlands

Table 3: Analysis of general combining ability effects for the 9 inbred lines for TLB, grain yield and selected agronomic traits.

Parent	TLB	GY	PH	EH	DA	DS
CKMARS10022	-0.143	-0.6163	-3.270	-2.417	-0.546	-0.046
CKLT10028	0.356	1.0245	-3.582	-3.820	-0.712	-0.990
CKL14546	-0.21	-0.3887	6.691	5.0752	1.3198	1.0039
AMH704-43	-0.11	2.39278*	-5.252	5.8633	-0.212	0.1203
AMH703-35	-0.17	0.05979	1.5120	5.7332	0.0327	1.1534
AMH704-51	-0.25	-2.3017	-6.165	-5.345	2.0498	1.2987
CKDHL120671	0.967*	0.85973	0.516	-2.498	2.2314	1.0648
AMH10142-29	-0.17	-0.2253	2.374	-6.786	-1.935	-1.4351
AMH 10142-10	-0.25	-0.7464	6.691	0.7081	-2.046	-2.2685

*Significant at $p < 0.05$, GCA: General Combining Ability, SCA: Specific Combining Ability, TLB: *Turcicum* leaf blight, G.Y: Grain yield, P.H; plant height, E.H: ear height, DA: days to anthesis, DS: days to silking

accompanied by strong wind speed is a common phenomenon in the Uganda highlands causing lodging and therefore yield reduction. Therefore, maize varieties with resilient stems or medium PH and reduced EH are needed to circumvent lodging under this agro-ecology. Therefore, inbred lines which had negative GCA effects for PH and EH were considered as good parents for hybrid development. Previous authors have similarly reported lower PH and EH reduced lodging in maize (Mosa, 2010; Rahman et al*.,* 2012). Inbred lines CKMARS 10022**,** CKLTI0028**,** AMH704-43**,** AMH 10142-10 and AMH10142-29 revealed negative GCA effects for DA, which is important in developing early flowering hybrids in areas having short growing periods and unexpected droughts (Table 3). Inbred lines CKMARS 10022, CKLTI0028, AMH 10142-10 and AMH10142-29 revealed negative GCA effectsfor DS trait. (Table 3). These can be used in a breeding program to develop early maturing varieties in low moisture areas, and the reverse is true for areas receiving rainfall for longer periods. Inbred lines with positive and significant GCA effects for DS such as CKL14546**,** AMH704-43**,** AMH703-35**,** AMH704-51 and CKDHL120671 have the tendency to increase maturity periods of the hybrids, indicating that they could be used in a breeding program to develop late maturing varieties in long rain season receiving areas like Kalengyere. Similarly, negative and positive GCA effects were reported by Girma et al. (2015).

3.3: Specific combining ability effect

Estimates of SCA effects for the 18 hybrids averaged across three test environments revealed that hybrids CKMARS10022xAMH703-35**,** CKL14546 x CKDHL120671 had significant positive SCA effects for GY. These hybrids can be selected for increased GY breeding. These results are in conformity with the findings of Hailegebrial et al. (2015), who also found positive and negative SCA effects for grain yield. Hybrids CKMARS10022 x CKDHL120671, CKLTI0028 x AMH704-43, CKLTI0028x AMH703-35, CKLT10028 x AMH10142-29, CKLTI0028 x AMH10142-10 and CKL14546 x CKDHL120671 showed negative SCA effects on TLB, indicating their resistance against this pathogen (Table 4). Hybrids CKLT10028x AMH703-35, CKLT10028x AMH10142-10 and CKL14546 x AMH704-43 had negative significant SCA effects for PH. These hybrids can be used for breeding lodging tolerant varieties especially in highland areas which receive torrents of rain like Kalengyere. Hybrids such as CKLT10028 x AMH704-43had significant positive SCA effects for PH hence such crosses are not desirable owing to their likely vulnerability to lodging (Table 4). In general, 8out of the 18 hybrids had negative SCA effects for EH while hybrids CKLT10028x AMH703-35 and CKLT10028x AMH10142-29 revealed negative significant SCA for the trait suggesting increased lodging tolerance (Table 4). Hybrids CKMARS10022 x AMH704-43, CKMARS10022x AMH703-35, CKMARS10022x AMH10142-29, CKMARS10022x AMH10142-10, CKLTI0028x AMH704-43, CKLTI0028x AMH703-35, CKLTI0028xAMH704-51 and CKLTI0028x CKDHL120671 showed negative SCA effects for DA, an indication that these hybrids have an ability to flower early as opposed to genotypes which exhibited positive SCA effects for the trait. Genotypes which recorded negative SCA effects for DA are desirable for drought prone areas such as Bulegeni. Hybrid CKMARS10022 x CKDHL120671 exhibited positive and significant SCA effects for DA which could be used in late maturity maize variety development breeding program especially in long rain season areas like Kalengyere (Table 4). Eight out of Eighteen hybrids revealed negative SCA effects for DS while one hybrid CKMARS10022 x CKDHL120671 exhibited positive and significant SCA effect for the trait (Table 4). Negative and significant SCA effect for DS is

Table 4: Analysis of specific combining ability effects for TLB, grain yield and selected agronomic traits.

Females	Males	TLB	GY	PH	EH	DA	DS
AMH704-43	CKMARS 10022	0.060	0.57	1.15	-6.19	-0.17	0.43
AMH703-35	CKMARS 10022	0.282	2.53*	6.59	8.73	-0.20	-0.47
AMH704-51	CKMARS 10022	0.199	-1.40	-3.43	-2.01	0.47	0.33
CKDHL120671	CKMARS 10022	-1.10	-1.44	1.76	1.21	1.71*	0.990*
AMH10142-29	CKMARS 10022	0.28	0.104	-5.27	5.01	-1.28	-0.84
AMH 10142-10	CKMARS 10022	0.282	-0.40	-0.48	-4.43	-0.45	-0.56
AMH704-43	CKLTI0028	-0.60	-0.82	9.72*	-1.60	-1.06	-0.89
AMH703-35	CKLTI0028	-0.46	-0.04	-9.39*	-9.24*	-0.09	-0.31
AMH704-51	CKLTI0028	-0.30	1.306	-5.10	4.38	-0.24	0.172
CKDHL120671	CKLTI0028	2.22*	-0.99	-5.37	-2.35	-0.34	-1.34
AMH10142-29	CKLTI0028	-0.38	0.89	6.91	5.33	0.82	0.65
AMH 10142-10	CKLTI0028	-0.46	-0.36	3.55	5.82	0.99	1.60
AMH704-43	CKL14546	0.54	0.23	-10.7*	5.11	0.94	0.40
AMH703-35	CKL14546	0.18	-2.5*	2.95	4.17	0.77	0.72
AMH704-51	CKL14546	0.10	0.08	8.69	7.23	1.34	-0.57
CKDHL120671	CKL14546	-1.12	2.41*	3.76	2.31	0.94	0.29
AMH10142-29	CKL14546	0.101	-1.01	-1.48	-9.18*	0.94	0.12
AMH 10142-10	CKL14546	0.185	0.74	-2.90	-0.22	0.94	-1.09

Significant at $p < 0.05$, ** Highly Significant at $p < 0.01$, GCA: General Combining Ability, SCA: Specific Combining Ability, TLB: *Turcicum* leaf blight, G.Y: Grain yield, P.H; plant height, E.H: ear height, DA: days to anthesis, DS: days to silking.

desirable in breeding programs to develop early maturity maize varieties, while positive and significant SCA effects for the trait is desirable to develop late maturity varieties for regions like Kalengyere. In contrast to this, Melkamu et al. (2013b) reported no hybridwith significant SCA effects for DS. However, Legesse et al. (2009) and Nedi et al. (2018) found differential SCA effects in various traits studied.

CONCLUSIONS AND RECOMMENDATIONS

4.1: Conclusion

This study was undertaken to generate knowledge and information to facilitate breeding for TLB disease resistance and improved productivity of maize in Uganda's highland environments. The study was done under natural disease infestation with an objective of determining combining ability of maize inbred lines for *Turcicum* leaf blight resistance, grain yield and selected agronomic traits in highland agro-ecologies of Uganda.

The study demonstrated the importance of both additive and non-additive gene action for the traits studied. The highly significant (P<0.001) GCA effects on yield, EH, DA and DS indicated the predominance of additive gene action, hence the possibility of breeding through recurrent selection and backcrosses as a way to incorporate candidate genes to moderately resistant parents. The existence of significant SCA mean squares across various sources of variations also implied that heterosis can be exploited from crossing sets of inbred lines used in the study.

Inbred lines CKMARS10022, CKL14546, AMH704-43, AMH703-35, AMH704-51, AMH 10142-10 and AMH10142-29 were found to have considerable resistance to TLB hence can be used in breeding program to develop resistant hybrids. Particularly, inbred line AMH704-43 had a positive and significant GCA for GY meaning that it can be used to improve grain yield in highland breeding program. Inbred lines CKMARS10022**,** CKLTI0028 and AMH704-51 showed negative GCA effects for PH and EHtherefore good combiners if the breeding target is plants with short stature. Inbred lines CKMARS10022, CKLT10028, AMH10142-29 and AMH 10142-10 showed negative GCA effects for DA and DS, therefore important in developing early flowering hybrids. Inbred lines with negative GCA effects for DS are best general combiners and can be used in breeding program as they can be utilized to develop early maturing varieties in low moisture areas and the reverse is true for areas receiving rainfall for longer periods. Inbred lines with positive and significant GCA effects for DS have the tendency to increase maturity periods of the hybrids, indicating that they could be used in breeding program to develop late maturing varieties in long rain season receiving areas like Kalengyere. Nowadays, parental lines with negative and significant GCA effect for DA and DS are desirable in maize breeding to develop early maturing varieties especially in this fluctuating weather patterns in the highlands of Uganda caused by climatic changes.

Hybrids CKMARS10022 x AMH703-35, CKL14546 x CKDHL120671showed significant positive SCA effects for GY as these hybrids can be selected for increased GY breeding. Hybrids CKMARS10022 x CKDHL120671,CKLTI0028 x AMH704-43, CKLTI0028 x AMH703-35, CKLTI0028 x AMH10142-29 CKLTI0028 x AMH 10142-10 and CKL14546 x CKDHL120671 showed negative SCA effects for TLB reaction indicating their resistance reaction against this pathogen. Hybrids CKLTI0028 x AMH703-35, CKLTI0028 x AMH 10142-10 CKLTI0028 x AMH704-43 and CKLTI0028 x AMH703-35 revealed significant negative SCA effects for PH and EH respectively suggesting increased lodging tolerance. Hybrid CKMARS 10022 x CKDHL120671 exhibited positive and significant SCA effects for days to anthesis and days to silking therefore could be used in late maturity maize variety development breeding program especially in long rain season area like Kalengyere.Negative and significant SCA effect for DS is desirable in breeding programs to develop early maturity maize varieties, while positive and significant SCA effect for DS is desirable to develop late maturity variety since the genotypes have an ability to late flowering and such genotypes are suitable in regions with prolonged rain periods like Kalengyere.

4.2: RECOMMENDATIONS

In general**, s**ince TLB appears in early stages of the crop development hence causing high yield loss, use of resistant cultivars is the only management strategy which is feasible and economical to reduce yield loss. Therefore, the single cross hybrids which were found to have a substantial level of resistance can be used as breeding material for the development of three-way cross hybrids, backcrossing to fix the genes and also development of double crosses if necessary.

The following specific recommendations are outlinedfrom the study.

- Parental genotypes and hybrids which possessed negative GCA and SCA for TLB can be used for breeding of resistant cultivars
- Molecular techniques can be employed to determine the nature of the resistance governing the genotypes tested.
- The TLB resistant parents used in this study need to be challenged with more severe TLB by testing using artificial inoculation and additional hotspots.
- TLB isolates from different areas of Uganda, including the highlands, should be tested for differential response to different TLB resistance sources.

CONFLICT OF INTERESTS

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