Host reaction and yield of maize cultivars infected with southern leaf blight disease caused by *Cochliobolusheterostrophus* (Drechs.) Drechs under natural field conditions

Dania, V. O[1]*. and Nurudeen, T. A[2]

[1]Department of Crop Protection and Environmental Biology,
University of Ibadan, Ibadan, Nigeria
[2]Department of Forest Conservation and Protection,
Forestry Research Institute of Nigeria, PMB 5054 Ibadan, Nigeria
* *Corresponding author Email:* victorohileobo@gmail.com

Abstract

Field trial was conducted in 2017 and 2018 during the rainy season to evaluate the effect of Southern leaf blight (SLB) on the growth and yield of fourteen maize genotypes. The experiment was laid out in randomized complete block design (RCBD) with three replications. Disease incidence was evaluated and expressed as percentage, while severity of SLB was determined using a 5-point rating scale. Data were collected on plant height, number of leaves, days to 50% tasseling. Grain yield was determined and expressed in kg/ha^{-1}. Data were analysed using analysis of variance (ANOVA) and significant means were separated using the Duncan Multiple Range Test (DMRT) at $P \leq 0.05$. Three of the genotypes, Local-Y, TZM 1445 and TZM 136 with high incidence and severity rating were found to be susceptible to SLB disease, besides the negative check. The occurrence of SLB did not significantly influence growth parameters among the maize genotypes. Moderately resistant genotype DMR-LSR-SR-Y had the highest yield of 4031 kg/ha^{-1} and 3776 kg/ha^{-1} in 2017 and 2018 trials, respectively and these were significantly higher than other treatments. This study showed that southern leaf blight disease significantly reduced maize yield, among susceptible genotypes. Seeds of genotype DMR-LSR-SR-Y which had combined traits of resistance to disease and high yield are recommended to plant breeders to improve susceptible cultivars and farmers for planting.

Key words: ANOVA, Blight, Genotype, Susceptible, Yield

Introduction

Maize (*Zea mays* L.) is a cereal crop that is widely cultivated across different agro-ecological zones in the world. The white and yellow varieties are the most common and preferred types by most people depending on the region. The grains are rich in vitamins A, C and E, carbohydrates, and essential minerals, and contain 9% protein. FAO (2017) reported that Nigeria produced 10.9 million metric tons of maize in 2016. The crop is one of the most important staple food in Nigeria and it has grown to be local cash crop, especially in the southwestern Nigeria where at least 30% of the arable land has been devoted to small-scale maize production under various cropping systems (Girei *et al.,* 2018).

Maize plant is infected by fungi, bacteria and viruses. The most important fungal diseases affecting maize are leaf blight, stalk rot and smuts. Leaf blight disease of maize is caused by two fungal species, which are southern leaf blight caused by *Cochliobous heterostrophus* and northern leaf blight incited by *Exserohilumturcicum.* Southern leaf blight symptoms occur between the veins in the leaves blade and are approximately 2.5 cm long and 0.6 cm wide. The lesions vary in colour but are usually pale gray or tan and oblong or spindle-shaped at initial infection stage. The lesion become longitudinally elongated, rectangular in shape and turns purple-brown at advanced infection (Maubeen *et al.,* 2017). Symptoms of northern blight usually appear first on the lower leaves. The leaf lesion are long (2.5 to 15 cm) and elliptical, gray-green. Under moist conditions, dark gray spores are produced, usually on the lower leaf surface, which give lesion a "dirty" gray appearance and entire leaves may become severely blighted (Kang *et al.,* 2018).

Southern leaf blight is a very devastating maize disease because of the existence of different strains of the pathogen. Three strains, C, O and T of *Cochliobous heterostrophus* have been identified in maize (Mubeen *et al*., 2017). Strains T and C have pathogenic affinity and specificity to maize cytoplasm and are known to produceT-toxin and C-toxin, respectively. These toxins produced by these strains enhance their infectivity potential. Strain O is very virulent to maize lines with normal cytoplasm because it does not produce any host-specific toxin; it has no specificity for plant cytoplasm. Strain O is mainly prevalent in Nigeria, and is responsible for leaf blight epidemics globally (Ali *et al*., 2011a). It infects a wide range of maize cultivars regardless of the type of cytoplasm and accounts for an estimated 50% yield loss among susceptible genotypes (Rijal *et al*., 2017).The expression of disease symptoms and severity rating is largely determined by the host germplasm and virulence of the pathogen strain.

Cochliobous heterostrophus is a foliar pathogen which has *Bipolaris maydis* as the anamorph stage. It is associated with most maize growing areas of the world but most destructive in hot and humid tropical climate. This pathogen spreads from leaf litter and can produce wind-borne spores within days and disease severity depends on genetic constitution of the cultivars, stage of crop growth during infection, and the prevailing environmental conditions (Akinwale and Oyelakin, 2018).

Practices such as selection, genetic recombination of inbred lines and use of synthetic fungicides have been employed incrop improvement and the control of the disease (Pixley *et al.,* 2006). The cost effectiveness and the possibility of multiple phenotyping enhance the suitability of inbred lines to the evaluation of different traits in diversified environment (Atwell *et al.,* 2010). The development of resistant varieties has been the major method for the control of southern leaf blight disease of maize. However, a wide range of maize genotypes are attacked by *C. heterostrophus*. Although various methods of screening such as detached leaf assay, tissue culture and seedling assay for disease resistance have been evaluated (Pixley *et al.,* 2006; Ali *et al.,* 2011b), conventional breeding remains an effective method of improving maize resistance against southern leaf blight disease. Therefore, screening of maize genotypes for their reaction to leaf blight would provide a useful template to breeders in identifying resistance genes to the disease.

Hence this study was designed to evaluate host reaction to southern leaf blight disease and its effect on maize yield.

Materials and Methods

Field experimental layout and treatments

The field experiments were conducted in 2017 and 2018 at the Teaching and Research Farm, University of Ibadan. The experimental trial was between the months of May and July which coincides with the peak of the rainy season when environmental conditions were favourable for leaf blight disease development under natural conditions in a field plot with previous history of the disease. Soil samples were collected and analyzed to determine physico-chemical properties of the soil following standard procedures (Moll *et al.,* 1982; Klute, 1986; and Kacar, 1997) (Fourteen genotypes of maize seeds used in this study comprised six genotypes: TZESR-W, TZESR-Y, TZPB-SR-W, TZBP-ELD3-W, ART 98/SW1-Y and DMR-LS-SR-Y obtained from the Institute of Agricultural Research and Training, (IAR&T), Apata, Ibadan. Another six genotypes: TZM 408, TZM 1445, TZM 100, TZM 402, TZM 37 and TZM 136 from the International Institute of Tropical Agriculture (IITA), Ibadan, while two famers' preferred cultivars, Local-W and Local-Y were purchased from agro-seed store at Bodija, Ibadan, Nigeria.

The experiment was laid out in a randomized complete block design (RCBD) with the 14 maize genotypes, which served as treatments in three replications. The susceptible check, genotype TZM 37, was sown in two rows round the experimental block to provide a uniform source of inoculum for the treatments. Two maize seeds were sown per hill at a spacing of 75 × 50 cm. The size of each plot was 7 m^2 (5 m x 1.4 m) with three rows of 5 m length per plot. First weeding was done at four weeks after planting (WAP), while the second was at 7 WAP.

Effect of *Cochliobolus heterostrophus* on growth and grain yield of maize

Data were collected on plant height, number of leaves, and days to tasseling. Stem diameter was measured using a Vernier caliper, while plant height was determined as the distance from the ground level to the tallest leaf. Number of grains per cob was counted manually, while grain weight was measured using a digital weighing balance. Yield per hectare was estimated by adjusting the grain moisture to 15% and converted to grain yield in kg per hectare according to Shrestha *et al.* (2015) and Rijal *et al.* (2017):

$$\text{Grain yield (kg/ha}^{-1}\text{)} = \frac{\text{FW (kg/plot) (100-moisture (\%)} \times 10000)}{85 \times \text{harvested area (m}^2\text{)}}$$

Where:

FW = Fresh weight of ear in kg per plot at harvest

Moisture (%) = Grain moisture content at harvest

85 = Required moisture percentage (15%)

S = Shelling coefficient (0.8)

Harvested area = Net harvested plot size (m^2)

Incidence and reaction of maize genotypes to blight disease

Data on disease parameters were collected on a weekly basis from 3 to 8 weeks after sowing. Maize leaves were evaluated for incidence, severity and disease index determined. Disease incidence was calculated by expressing the number of infected plants as percentage of the plant population per treatment:

Disease incidence =
$$\frac{\text{Number of infected plants}}{\text{Total plant population}} \times 100$$

Disease severity and resistance of maize genotypes to blight disease were evaluated on a 1-5-point scale according to the modified method of Kumar (2009), where: 1= No symptom, plants were resistant (R) 2 = Mild blight symptoms on few leaves with 1-10% of leaf area affected with symptom recovery, plants were classified as moderately resistant (MR). 3 = Blighting or extensive necrosis on many leaves with 11-25% of leaf area affected, plants were classified as moderately susceptible (MS), 4 = Severe blighting of 26-50% leaf area, plants were classified as susceptible (S). 5 = Very severe blighting of entire leaves (50-100%) and death, plants were classified as highly susceptible (HS)' Disease index was calculated according to Mir *et al.* (2015) as: Disease index = $\{\Sigma$ (nV) / (NG)$\}$x 100, Where, Σ (n×v) = sum of the score, N = total number of leaves counted, n = number of lesions, v = virulence, and G = highest score.

Data analysis

All data were analysed using one-way analysis of variance and means separated with Duncan's Multiple Range Test (DMRT) at 5% level of probability using Statistical Analysis Software (SAS) package (SAS, 1999).

Results

Effect of *Cochliobolus heterostrophus* on growth performance of maize

The textural class of the soil was sandy loam consisting of 7.0%, 83.7% and 10.3% of clay, sand and silt respectively. The soil contained moderate proportion of total nitrogen, available phosphorus and organic carbon which varied between 3.9 and 12.2 g/kg. There was no significant (p>0.05) difference in height among the test genotypes in both planting seasons. However, DMR-LS-SR-Y was the tallest among the test genotypes (219.2 cm) in 2017, while TZM 37 had the lowest plant height (151.5 cm) in 2018 (Table 1).

There was no significant difference (p>0.05) among the genotypes in terms of the number of leaves per plant. Similarly, the stem diameter did not differ significantly (p<0.05) among the treatments. Genotype TZM 136 had the shortest duration of 50.3-52.4 days to tasseling, and was not significantly different (p>0.05) from other treatments. Conversely, genotypes TZBP-ELD3-W and DMR-LSR-SR-Y had the longest duration of 60.7-63.1 and 62.5-64.4 days to tasseling, respectively and were significantly higher than other treatments. The number of days to 50% tasseling did not differ significantly (p>0.05) among the genotypes except for the two late maturing genotypes TZBP-ELD3-W and DMR-LSR-SR-Y.

Incidence and severity of southern leaf blight disease among maize genotypes

The incidence of southern leaf blight disease on maize leaves varied between 5.2-28.7% in 2017 and 5.9-24.9% in 2018 cropping seasons, respectively (Figure 1). Maize genotype TZM 37, which served as susceptible check had the highest disease incidences of 28.7% and 33.5% in 2017 and 2018, respectively. Disease incidence in this genotype was significantly (p<0.05) higher than those of other treatments. Three of the genotypes: Local Y, TZM 1445 and TZM 37 were also susceptible to southern leaf blight disease (Figure 2). Five genotypes, TZESR-W, TZESR-Y, TZPB-SR-W TZPB-ELD3-W and ART98/SW1-Y showed mild symptoms of the disease with mean severity values ranging from 2.2 -2.7 in 2017. However, genotype, TZESR-Y exhibited pronounced necrosis on infected leaves with mean severity of 3.1 in 2018. Also, genotypes DMR-LSR-SR-Y Local-W, TZM 408, 100 and 402 had moderate necrotic lesion.

Genotypes TZM 1445, 136, Local-Y and the susceptible check, TZM 37 all showed severe blighting of leaves with rating which varied between 4 and 4.8. The severity of leaf blight disease was significantly higher ($p<0.034$) in 2018 than in 2017 among most of the treatments. TZM 37 had the highest disease index of 53.2% and 57.6% in 2017 and 2018, respectively but was not significantly higher than other treatments (Figure 3). Disease severity in genotypes TZESR-W and TZPB-ELD3-W was significantly lower ($p<0.05$) in 2017 and 2018, respectively than other treatments.

Table 1. Effect of southern leaf blight disease on growth parameters of maize genotypes under natural field conditions

	2017 Trial				2018 Trial			
Genotype	Plant height (cm)	No. of leaves	Stem diameter (mm)	Days to tasseling	Plant height (cm)	No. of leaves	Stem diameter(mm)	Days to tasseling
TZESR-W	167.3c	9.2a	5.1a	54.1ab	155.6bc	10.0a	6.4a	56.2ab
TZESR-Y	164.1c	11.1a	7.1a	56.8ab	160.3b	9.4a	8.2a	55.2ab
TZPB-SR-W	177.3b	10.2a	8.4a	55.7ab	181.4a	12.4a	8.8a	52.8ab
TZPB-ELD3-W	190.2a	11.0a	6.9a	63.1a	187.2a	10.3a	7.7a	60.7a
ART98/SW1-Y	170.8bc	9.6a	9.1a	55.5ab	175.6ab	11.1a	8.3a	55.2ab
DMR-LSR-SR-Y	181.1a	12.2a	7.6a	64.3a	185.2a	10.2a	8.5a	62.3a
Local-W	166.3c	9.3a	8.0a	51.8ab	159.2b	10.1a	8.7a	53.1ab
Local-Y	163.7c	10.3a	6.8a	55.2ab	170.8ab	10.0a	8.4a	53.0ab
TZM 408	180.2ab	9.0a	7.1a	54.9ab	173.1ab	9.8a	7.8a	51.9ab
TZM1445	181.8ab	11.2a	9.2a	56.0ab	181.7a	10.0a	8.1a	54.6ab
TZM 100	160.4cd	10.3a	8.3a	52.7ab	167.7b	9.8a	6.9a	51.3ab
TZM 402	173.2bc	11.1a	7.0a	55.4ab	170ab	9.7a	9.5a	54.6ab
TZM 37	163.8c	10.2a	8.6a	54.5ab	155.5bc	10.6a	8.0a	52.2ab
TZM 136	178.2ab	9.5a	9a	50.3ab	183.5a	11.0a	9.7a	52.4ab
Level of significance	*	ns	Ns	*	*	ns	ns	*

Means followed by same letter along a column are not significantly different using Duncan Multiple Range Test (DMRT) at $p<0.0\ 5$

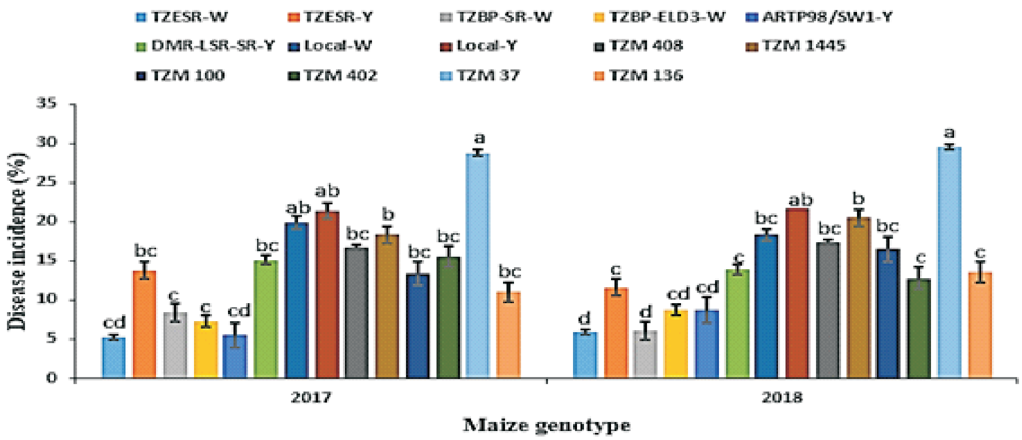


Figure 1. Incidence of southern leaf blight disease among 14 maize genotypes under natural field conditions.

Different letters above the standard error bars within treatments are significant at p<0.05 using Duncan Multiple Range Test (DMRT).

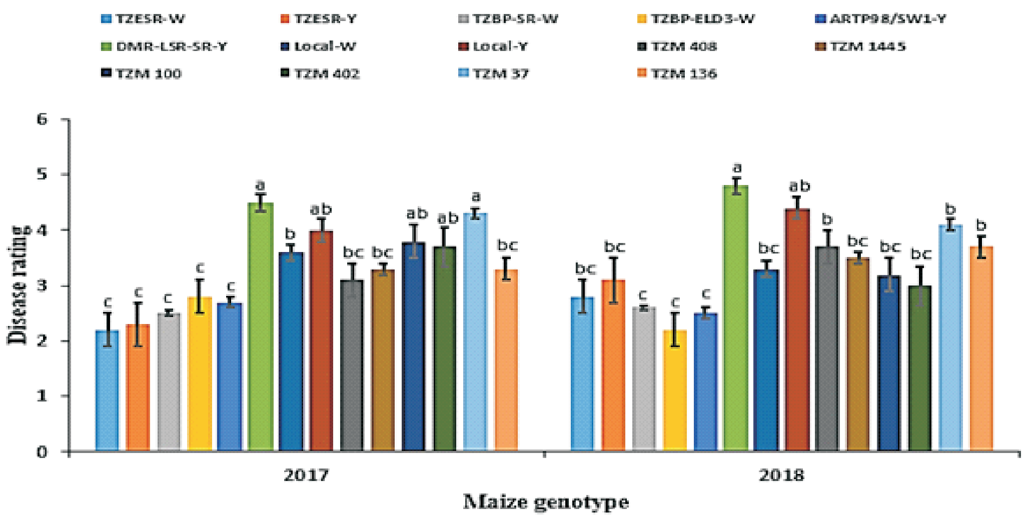


Figure 2. Severity rating of southern leaf blight disease among maize genotypes under natural field conditions.

Different letters above the standard error bars within treatments are significant at p<0.05. using Duncan Multiple Range Test (DMRT)

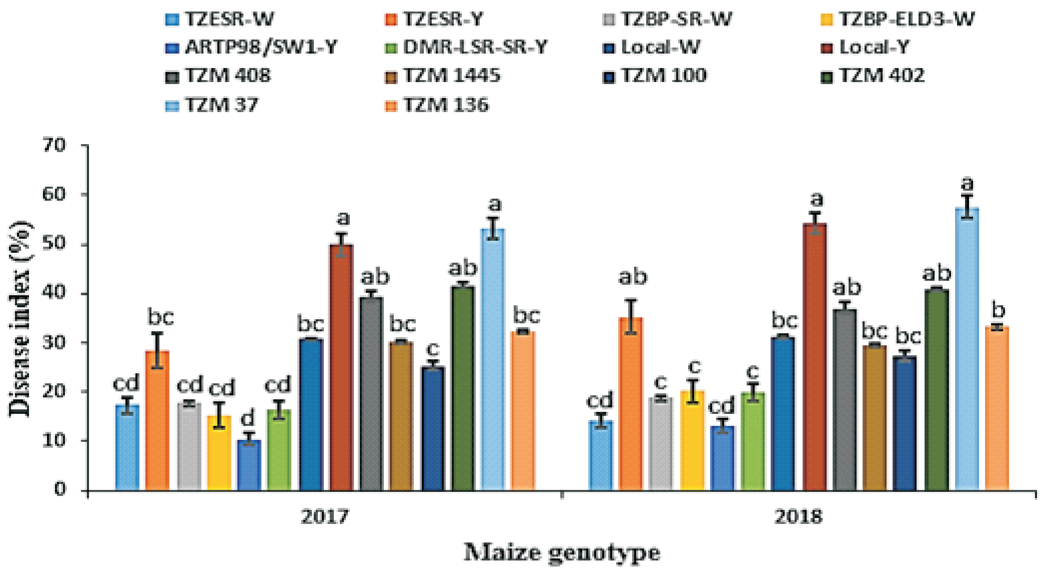
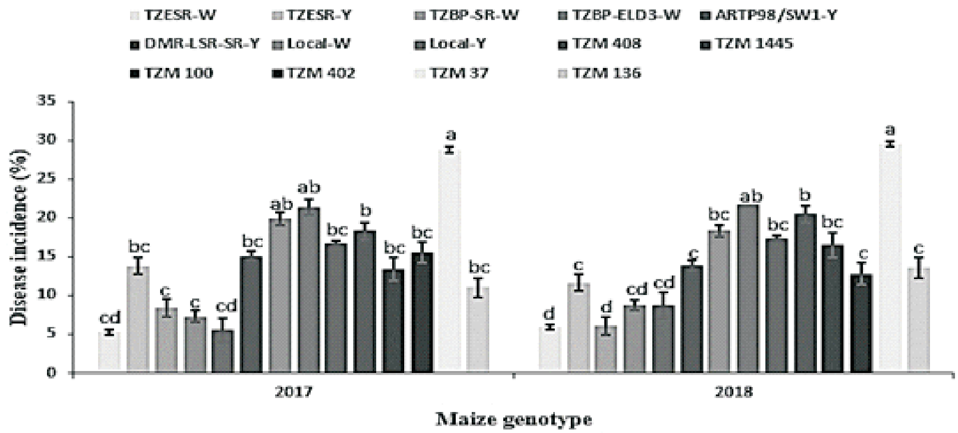


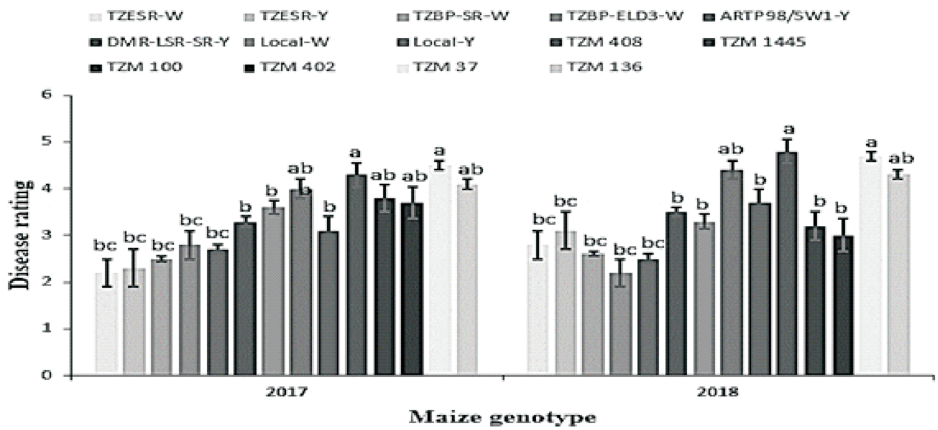
Figure 3. Relative disease index among maize genotypes under natural field conditions.

Different letters above the standard error bars within treatments are significant at $p<0.05$ using Duncan Multiple Range Test (DMRT).

Host reaction to southern leaf blight disease and grain yield of maize

Results obtained in the second trial were not significantly ($p>0.05$) different from the first experiment in 2017. Also, weight of 100 seeds did not differ significantly ($p=0.087$) among the genotypes. Three of the genotypes, Local-W, TZBP-ELD3-W and TZ136 had the best grain fill with number of grains per cob ranging from 508.6-511.3 seeds, and these were significantly higher ($p<0.05$ than other treatments in 2017. TZM 408 and TZM 100 had the highest cob weight of 65.4 and 66.6 g in 2017 and 2018, respectively. Genotype DMR-LSR-SR-Y had the highest yield of 4031 kg /ha^{-1} and 3776 kg/ ha^{-1}during 2017 and 2018 planting seasons, respectively (Table 2). Grain yield varied between 1053 kg/ha^{-1} and 1275 kg/ha^{-1} in genotype Local-W in the two-season trial and was significantly ($p<0.05$) different from other genotypes. Seven of the maize genotypes were moderately resistant to leaf blight disease, while genotypes TZM 408, 100 and 402 were moderately susceptible. Four genotypes TZM 1445, 37, 136 and Local-Y were designated as susceptible to southern leaf blight disease, while none of the genotypes was found to be completely resistant.


TZESR-W
TZESR-Y
TZBP-SR-W
TZBP-ELD3-W
ARTP98/SW1-Y
DMR-LSR-SR-Y
Local-W
Local-Y
TZM 408
TZM 1445
TZM 100
TZM 402
TZM 37
TZM 136
Disease incidence (%)
2017
2018
Maize genotype


TZESR-W
TZESR-Y
TZBP-SR-W
TZBP-ELD3-W
ARTP98/SW1-Y
DMR-LSR-SR-Y
Local-W
Local-Y
TZM 408
TZM 1445
TZM 100
TZM 402
TZM 37
TZM 136
Disease rating
2017
2018
Maize genotype

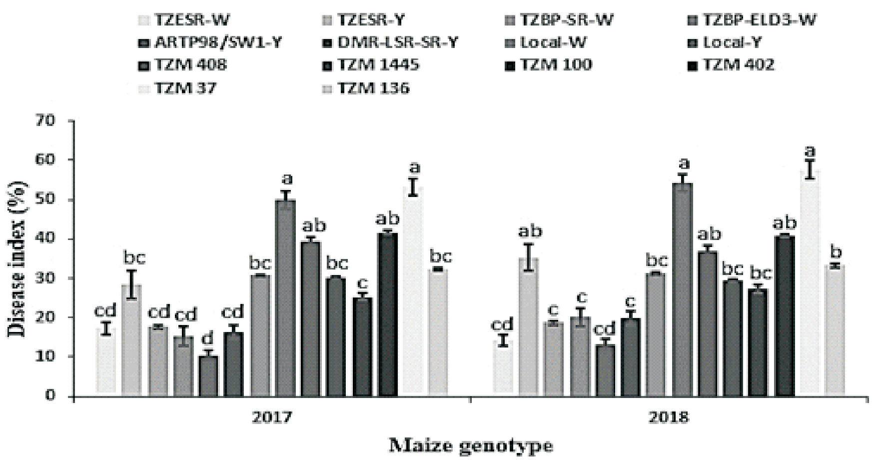

TZESR-W
TZESR-Y
TZBP-SR-W
TZBP-ELD3-W
ARTP98/SW1-Y
DMR-LSR-SR-Y
Local-W
Local-Y
TZM 408
TZM 1445
TZM 100
TZM 402
TZM 37
TZM 136
Disease index (%)
2017
2018
Maize genotype

Table 2. Host reaction to southern leaf blight disease and grain yield of maize under natural field conditions

	2017 Trial					2018 Trial				
Genotype	100 grain wt (g)	Grains per cob	Cob weight (g)	Grain yield kg/ha^{-1}	Host reaction	100 grain wt (g)	Grains per cob	Cob wt (g)	Grain yield kg/ha^{-1}	Host reaction
TZESR-W	13.4a	408.0bc	40.4c	3182b	MR	11.8a	389.1de	48.9bc	2633cd	MR
TZESR-Y	15.2a	391.7c	52.6b	2708cd	MR	17.3a	401.0cd	50.3bc	2501d	MR
TZPB-SR-W	15.5a	466.3ab	60.4ab	3093bc	MR	14.4a	444.2bc	55.7b	3413ab	MR
TZPB-ELD3-W	17.3a	508.6a	53.8b	3867ab	MR	16.4a	467.3b	55.2b	2010e	MR
ART98/SW1-Y	13.3a	447.7b	63.5a	3376c	MR	11.6a	389.3de	60.7ab	3332b	MR
DMR-LSR-SR-Y	15.2a	400.2bc	44.3c	4031a	MR	14.8a	415.8c	50.8bc	3776a	MR
Local-W	13.5a	511.3a	58.7ab	1053gh	MR	12.2a	478.7bc	61.5ab	1275fg	MR
Local-Y	16.6a	399.1bc	52.2b	1522ef	S	14.2a	407.3cd	50.3bc	1640ef	S
TZM 408	12.5a	449.1b	65.4a	1156g	MS	10.8a	500.3a	62.1ab	2807c	MS
TZM1445	17.7a	377.5d	47.2bc	2389d	S	16.2a	402.4cd	46.4c	2046e	S
TZM 100	14.1a	464.9ab	55.7b	1220fg	MS	14.7a	420.0c	66.6a	2940bc	MS
TZM 402	13.7a	380.4cd	53.1b	1734ef	MS	13.0a	398.2d	50.7bc	1583f	MS
TZM 37	14.2a	405.8bc	44.4c	2230de	S	15.5a	470.0b	48.8c	2884c	S
TZM 136	12.2a	509.3a	56.1b	1773e	S	12.4a	490.5b	60.8ab	2545de	S
Level of significance	ns	*	*	*		ns	*	*	*	

Means followed by same letter along a column are not significantly different using Duncan Multiple Range Test (DMRT) at $p<0.05$

MR =Moderately resistant, MS =Moderately susceptible, S=Susceptible

Discussion

Plant height is a vital attribute which affects the cumulative grain yield of maize. Late maturing genotypes, TZBP-ELD3-W and DMR-LSR-SR-Y, were the tallest among the maize genotypes. Late maturing varieties of maize have been reported to grow very tall than early cultivars due to the longer duration of the physiological growth and development of the plants (Pixley *et al.,* 2006; Ali and Ahsan, 2015). Dwarf and very tall varieties lead to reduction in crop yield (Mubeen *et al.,* 2017). Differences in plant height among the maize genotypes may have been influenced by effect of the host genetic make-up. The genetic constitution of plants and the inheritance pattern of genes have been reported to have a direct influence on plant height (Agrios, 2005).

The incidence of disease is a measure of its prevalence which is indicated by the number of infected plants expressed as a percentage of the total plant population. Disease incidence and severity differed significantly ($p<0.05$) among the maize genotypes that were evaluated. This is consistent with the findings of Akinwale and Oyelakin (2018) who reported variability in the incidence of *Curvularia* leaf spot disease among early maturing maize varieties evaluated for resistance in the humid rainforest. The incidence of plant diseases, especially in arable crop production such as maize is significantly influenced by time of planting. Girei *et al.* (2018) reported that maize planted early in the growing season between March and April are less susceptible to diseases due to very low relative humidity and high temperatures which make plant pathogens dormant and discourage the development of primary and secondary inocula. On the contrary, late planting predisposes crops to diseases due to favourable environmental conditions.

Disease severity rating which indicates the relative proportion of the plant tissue that is affected by disease is enhanced by varietal response, prevailing environmental factors under field conditions in the cropping season and the presence of virulence genes in the invading pathogens (Tirtha *et al*., 2017). Three genotypes: Local Y, TZM 1445 and 37 had higher severity rating and susceptibility to southern leaf blight disease. Ali *et al.* (2011b) and Mubeen *et al.* (2017) attributed variability in disease severity among maize genotypes to diversity in their genetic constitution. The reproductive spores of several sporulating disease-causing fungi in plants such as blights, mildews and anthracnose are released into the air and can be dispersed by air or strong wind over distances ranging from a few metres to hundreds of kilometres.

There was distinct variability in the response of the test genotypes to southern leaf blight disease ranging from moderate resistance to susceptibility. This could be due to differences in the genetic composition of the maize plants.

Rijal *et al*. (2017) and Tirtha *et al.* (2017) reported significant differences in the reaction of maize cultivars to blight disease in the summer season. The maturity period of maize varieties could also affect the rate of susceptibility to disease. Akinwale and Oyelakin (2018) reported that the early maturing varieties of maize are more susceptible to leaf blight than the late maturing types. This suggests that during the breeding process for days to maturity and other traits of interest, the rate of susceptibility or resistance of maize cultivars to disease infection may be altered. In addition to deliberate human manipulation of genes of the plant, some of the genes can also independently undergo mutation which could drastically change the reaction of the affected plant to disease infection.

The number of days to 50% tasseling did not differ significantly ($p>0.05$) among the genotypes, except genotype DMR-LSR-SR-Y which had the longest duration to tasseling. Early maturing maize cultivars have fast growth rate and are known to attain physiological and reproductive maturity ahead of the late maturing types (Karasu *et al*., 2015). However, this result disagrees with previous findings of Akinwale and Oyelakin (2018) that reported significant variation among 40 early and extra early maize genotypes in the number of days to 50% tasseling and silking in the humid rainforest. Differences in rainfall pattern across agro-ecological zones (AEZs) may affect the rate of growth and maturity of maize. Rainfall is a critical environmental factor that either enhances or delays maize growth and yield performance. Maize grown in the humid rainforest tend to have greater access to rainfall which enhances its rapid growth and tends to reach maturity early and less prone to blight disease. Conversely, the derived savanna AEZ has less rainfall which comes later than the rainforest. Therefore, rainfall could be a limiting factor to early maturity of maize in the derived AEZ. Leaf blight disease decreases crop yield due to the reduction in photosynthetic area of infected leaves. The maize genotypes evaluated in the study differed significantly ($p<0.05$) in overall yield per hectare. Mubeen *et al.* (2017) reported significant variability in yield among maize cultivars inoculated with the blight pathogen, *Cochliobolus heterostrophus*.

Generally, the moderately resistant genotypes produce higher yields than those that are either moderately susceptible or susceptible. Resistant cultivars of maize have been reported to help stabilize grain yield through significant reduction in the incidence and severity of blight disease, while yield obtained from susceptible maize genotypes was significantly lower than those obtained from the resistant types (Rijal *et al.,* 2017). This finding was corroborated by the report by Mubeen *et al. (*2017**) who evaluated** maize germplasm for resistance to *Helminthosporium maydis and* reported a negative correlation between maize yield and susceptibility to disease. The susceptibility and resistance of maize genotypes to a pathogen may also depend on whether they are inbred lines, varieties or hybrids. Highly significant differences in severity of southern leaf blight disease between two maize populations (Shah *et al*. 2006) and among maize varieties for resistance to the disease (Rahman *et al.*, 2005) have been reported. The value of disease index can be used in the determining the degree of plants susceptibility to disease. Genotype TZM 37 showed the highest disease index, which is an expression of the overall effect of blight disease on the test genotypes based on disease incidence and severity. Since absolute resistance is difficult to achieve in biological systems, maize genotypes identified with moderate level of resistance could serve as sources of resistance genes in maize breeding programme, before ultimate release to farmers.

Conclusion

This study showed that southern leaf blight disease significantly affected yield among the maize genotypes evaluated. Genotype DMR-LSR-SR-Y which was moderately resistant produced the highest yield. Generally, the moderately resistant genotypes had better yield performance than the susceptible types. Besides the negative check, three of the genotypes, TZM 1445, 136 and Local-Y were susceptible to southern leaf **blight disease.** Therefore, genotype DMR-LSR-SR-Y with combined traits of resistance to disease and high yield is recommended to plant breeders and farmers.

References

Agrios, G.N. (2005). Plant Pathology, 5th Edition. Academic Press, Inc., San Diego, USA. 922pp.

Akinwale, R.O., and Oyelakin, A.O. (2018). Field assessment of disease resistance status of some newly-developed early and extra-early maize varieties under humid rainforest conditions of Nigeria. *Journal of Plant Breeding and Science* 10 (3):69-79.

Ali, F., Muneer, M., Rahman, H., Noor, M., Shahwar, D., Shaukat, S., and Yan, J. (2011a). Heritability estimates for yield and related traits based on testcross progeny performance of resistant maize inbred lines. *Journal of Food Agriculture and Environment* 99:438-443.

Ali, F., Rahman, H., Durrishahwar, Nawaz, I., Munir, M., and Ullah, H. (2011b). Genetic analysis of maturity and morphological traits under maydis leaf blight (MLB) epiphytotics in maize (*Zea mays* L.). *Journal of Agriculture and Biological Science* 6:13–19.

Ali, Q., and Ahsan, M. (2015). Correlation analysis for various grain contributing traits of *Zea* *mays* L. *African Journal of Agricultural Research* **10:**2350-2354.

Atwell, S., Huang, Y.S., Vilhjalmsson, B.J., Willems, G., Horton, M., Meng, D., Platt, A., Tarone, M., and Hu, T.T. (2010). Genome-wide association study of 107 phenotypes in *Arabidopsis thaliana* inbred lines. *Nature* 465:627–631.

FAO (2017). GIEWS - Global Information and Early Warning System: Country briefs, Nigeria. Accessed online on 18 June, 2019 http://www.fao.org/giews/countrybrief/country.jsp?code=NGA

Girei, A., A1 Saingbe, N., Ohen, D.I., and Umar, K. O. (2018). **Economics of small-scale maize production in Toto Local Government Area, Nasarawa State.** ***Agrosearch 18 (1): 90 – 104.***

Kacar, B. (1997). Chemical Analyses of plants and soils. African Union Agriculture Faculty Publication 705pp.

Kang, I.J. Shim, H.K., Roh, J.H., Heu, S., and Shin, P. (2018). Simple detection of *Cochliobolus* fungal pathogens in maize. *Plant Pathology Journal 34(4): 327-334.*

Karasu, A., Kuscu, H., Mehmet, O.Z., and Bayram, G. (2015). The Effect of different irrigation water levels on grain yield, yield components and some quality parameters of silage maize (*Zea mays* L.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca***43**: 138-145.

Klute, A. (1986). Water retention: Laboratory methods of soil analysis Part 1. 2nd ed. American Society of Agronomy Madison. Pp 635-660.

Kumar, P.L. (2009). Methods for the diagnosis of plant virus diseases. Laboratory manual. International Institute of Tropical Agriculture. Pp28-33.

Mir, S. D., Ahmad, P., Razvi, M. and Gul-Zaffar, T. (2015). Screening of maize inbred lines under artificial epiphytotic conditions for *Turcicum* leaf blight (*Excerohilumturcicum*). *African Journal of Microbiology Research* 9 (7): 481-483.

Moll, R.H, E.J. Kamprath, and Jackson, W.A. (1982). Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization. *Agronomy Journal* 74:562-564.

Mubeen, S., Rafique, M., Munis, M.F.H., and Chaudhary, H.J. (2017). Study of southern corn leaf blight (SCLB) on maize genotypes and its effect on yield. *Journal of Saudi Society of Agricultural Sciences* **16**(3): 210-217.

Pixley, K.V., Dhliwayo, T., and Tongoona, P. (2006). Improvement of maize populations by full-sib selection alone versus full-sib selection with selection during inbreeding. *Crop Science* 46: 1130–1136.

Rahman, H., Raziq, F., and Ahmad, S. (2005). Screening and evaluation of maize genotypes for southern leaf blight resistance and yield performance. *Sarhad Journal of Agriculture* 21:231–235.

Rijal, T.R., Koirala. K.B., and Karki .M. (2017). Evaluation of maize genotypes against southern leaf blight (*Bipolaris Maydis*) during summer seasons at Rampur, Chitwan**.** *International Journal of Applied Science and Biotechnology 5(4): 532-536.*

S.A.S. (1999). Statistical Analysis System User's Guide, A.A. Ray, (Ed.), SAS Institute, Inc. Cary, NC.

Shah, S.S., Rahman, H., Khalil, I.H., and Rafi, A., (2006). Reaction of two maize synthetics to maydis leaf blight following recurrent selection for grain yield. *Sarhad Journal of Agriculture* 22:263–269.

Shrestha, J., Koirala, K., Katuwal, R., Dhami, N., Pokhrel, B., Ghimire, B., Prasai, H., Paudel, A., and Pokhrel, K. (2015). Performance evaluation of quality protein maize genotypes across various maize production agro-ecologies of Nepal. *Journal of Maize Research and Development* 1(1): 21-27.

Tirtha, R.R., Koirala, K.B. and Karki, M. (2017). Evaluation of maize genotypes against southern leaf blight (*Bipolaris maydis*) during summer seasons at Rampur, Chitwan. *International Journal of Applied Science and Biotechnology 5(4):532-536.*