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Evaluation of Maize Varieties for Resistance to Northern Leaf Blight under Field Conditions in Ethiopia

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ABSTRACT

A study of reaction of thirteen maize varieties to northern leaf blight mainly caused by *Exserhilum turcicum* (Pass) Leonard and Suggs, were conducted at three locations Gambella, Abobo and Bako during 2003 and 2004 crop seasons. Variation among maize varieties was observed for several disease variables; the number of lesion, size, incidence, area under disease progress curve (AUDPC) and severity rating scale. In general, significant differences among genotypes were observed for data based on lesion number, size, AUDPC and severity rating scale at all locations. Susceptible varieties Gussau, Aboboko and Local- M had high AUDPC, large lesion size, fast onset of disease and many lesions in numbers. The host entries used in this study indicated that Kuleni was the most resistant to northern leaf blight across three locations, with low rating score. There was different response among varieties depending on disease intensity at each location. At Abobo, the final severity increased from 0.00 to 96.66% in 2003 and the results observed from 10.00 to 96.66% at Bako. However, at Gambella the incidence was as low as from 0.00 to 83.33%. Disease assessment methods were generally correlated with one another. Several varieties showed similaly significant reaction to disease in all locations. This meant that there was no virulent difference existing in the pathogen populations from location to location.

Key words: *Exserhilum turcicum*, northern leaf blight**,** resistance, area under disease progress curve

INTRODUCTION

Northern leaf blight is a foliar disease of maize caused by *Exserhilum turcicum*, the residue-borne fungus. This disease occurs sporadically in most temperate, humid areas where maize (*Zea mays* L.) is grown (Lim *et al*., 1974). In Africa where maize is a staple food crop, the northern leaf blight is reported to be widespread and destructive diseases that affects maize in warm and humid growing regions of Ethiopia, Uganda and Tanzania (Adiopla *et al*., 1993: Tilahun *et al*., 2001and Nkonya *et al*., 1988). Maize is the major cereal crop for the people of Ethiopia and grows in diverse ecology in the country but it faces with a major challenge including diseases. Among diseases, as identified by diagnostic survey of farmers fields, it is mainly attributed to foliar diseases (Asfaw *et al.,* 1992). The most common potential economic foliar disease on maize is the

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northern corn leaf blight (NCLB) caused by *Exserhilum turcicum (*Pass.) (Assefa and Tewbech, 1992). According to Assefa *et al* (1996), the northern leaf blight caused the highest mean grain yield loss of 50% and 1000 kernel weight loss of 16.4% of susceptible cultivar OPV POOL 32C19 under the artificial infestation condition. In other experiment conducted at Awasa, the grain yield losses of 34.08, 29.05 and 2.21% were recorded for varieties; Abo-bako, Beletch and BH660, respectively (EARO,1999).On the other hand in Uganda, maize yield losses due to northern leaf blight was estimated to be as high as 60% (Adipala *et al*., 1993). Generally, the increased incidence and economic importance of the disease linked to the environmental conditions and use of susceptible varieties.

Currently the recommended control measurements of the northern leaf blight of maize are the use of relative resistant or tolerant cultivars. Tillage to bury infected residue may also helpful where erosion is not a problem while, crop rotation is also helpful because the disease tends to increase in continuous cropping and the use of fungicides. But significant yield losses still occur when the environmental conditions are favorable for the disease. The use of resistant varieties adds little or nothing to cost of production (Gareth and Cliffored, 1983).Efficient disease control is achieved through the use of fungicide spray including maneb, chlorothalonial and propconzale which offers the most consistent method of control of northern leaf blight (Brunette and Whit,1985). Though, fungicides can be used to control leaf diseases in corn, but usually they are economical only in seed corn production, or sweet corn production.

Most maize cultivation activities are done in the Gambella Regional State (Ethiopia) manually. The predominate cropping pattern is a monocropping system of maize. Hence, the lack of appropriate farming system and the absence of crop rotation practice in the region increase the potential of the disease incident for northern leaf blight such that it becomes a major yield limiting factor in the region.

Northern leaf blight is the major constraint to maize production in Regional State, and the incidence often necessitates instituting control measure. Although among the available control measures, the use of resistant and high yielding varieties has been very cheap and effective, the reaction of several maize varieties to the disease is largely unknown. Therefore, this study was undertaken to examine the effects of northern leaf blight on maize varieties, and to determine the level of resistance to *E.turcicum* in several maize varieties under field conditions.

MATERIALS AND METHODS

Plant material and location

The northern leaf blight evaluations were conducted in 2003 at two sites, in Gambella Regional State at South Western Ethiopia, altitude of 500m. A similar but only one experiment was repeated in 2004 in a new field of Bako National Maize experiment in Western Ethiopia at altitude of 1650m.

Because of a widespread of natural inoculums, the plants were left in the field to be infected naturally. Field plots were established in the fields previously planted maize with no fertilizer and herbicide, subsequently hand weeding was performed three times. Selected 12 maize varieties with different levels of resistance to northern leaf blight obtained from Bako National Maize program and Gambella, a local maize variety, were included in this study. Local maize was chosen because it was grown throughout Gambella Region and susceptible to northern leaf blight. They were planted on 23 and 24 July 2003 at Gambella and Abobo and at Bako, 11 June 2004.

Experimental design

The experiments were arranged in a randomized complete block design with three replications. Each plot consisted of four rows, 3.60m long with plant spacing of 0.75×0.30m and two plants per hill. Plot size was 10.8m^2 (3.00×3.60).

Disease assessments

Disease assessment at each location was conducted in the field after onset of the disease. Ten randomly selected plants in the center row were tagged and used for successive disease assessments. Plants were rated at-10 day intervals for percent incidence, the number of lesion on the ear leaf and second leaf above the ear leaf on each tagged were also counted two leaf per plants. Disease severity was rated followed by CIMMYT methods using 1-5 scoring scale. *E.turcicum* severity rating was done as follow;

1.0 = very slightly infected, one or two restricted lesion on lower leaves or trace.

2.0 = slightly to moderate infection on lower leaves, a few scatter lesions on lower leaves.

3.0 = abundant lesions on lower leaves, a few on middle leaves.

4.0 = abundant lesions on lower and middle leaves extending to upper leaves.

5.0 = abundant lesions on all leaves, plant may be prematurely killed by blight.

Lesion size and number

Plants were rated at 10-day intervals for the number of lesions on the ear leaf and second leaf above the ear leaf. Lesion sizes in centimeters of two lesions on randomly selected 10 plants in the center row were measured at 10-day intervals to determine the rate of lesion expansion. Monitored lesions were marked with marker so that lesion could be found each week. Total 20 lesions per experiment were recorded.

Agronomic data

Agronomic parameters such as a number of plants per plot at emergence and harvest, and plant height were recorded from 10 randomly selected plants in each plot. At harvest thousand seed weight (TSW) and total grain yield at 15% moisture were determined for each plant and converted to kilograms per hectare at harvest.

AUDPC analysis

Northern leaf blight recorded at ten-day interval starting from one set of disease, 5-6 times in each location to the entire growing period. To ensure disease evaluation in the field was consistent, a disease progress curve was made. This curve was developed from 10 days severity reading in different locations. By constructing a curve, symptom development and disease severity could be compared over years and locations. The area under disease progress curve (AUDPC) was used to quantify expressing the beginning of the epidemic and the time until the blight reached peak. The derived disease parameter, the area under the disease progress curve (AUDPC) was calculated according to the equation of Campbell and Madden (1991) using the following formula:

$$AUDPC=\sum^{n}_{i}= (y_i + y_{i+1})(t_{i-1} - t_i)/2$$

Where n is the number observations, t_i days after planting for the ith disease assessment and y_i disease severity.

Analysis of disease development could be performed when greater quantification was needed for resistance evaluation. The disease progress curve represent an integration of all host, pathogen and environmental effects occurring during disease development and provided an opportunity for greater in depth analysis, when comparing small differences among cultivars.

Data analysis

Plant growth measurement, disease incidence, lesion number and lesion size at all plant growth stage, area under disease progress curve

(AUDPC), yield, and TSW(thousand seed weight) were analyzed with Duncan multiple range test at $p \le 0.05$ (SAS, 1989, Institute, Inc, Cary, Nc).

RESULTS

Disease development

Mean values of the disease assessment were influenced by environment and varieties. The disease onset (DA) of northern leaf blight appeared early 30 days after planting at Gambella and Abobo in 2003(Table1). Disease appearance was delayed at Bako between 78-85days after planting. The dry weather at Bako at planting time, probably delayed the onset of northern leaf blight of corn. Disease symptom appeared on susceptible varieties earlier at Gambella the farmer's field and Abobo research center site in 2003 than 2004 at Bako. The disease growth on susceptible varieties was very fast and reached maximum 94.44% on variety Gussau (Figure 1), while on resistant varieties the growth of disease was very slow and reached maximum between 34.44-75.55% at the end of the growing period (Figure 2). The maximum severity of the rest five moderately resistant varieties were 71.11 to 88.88% (Figure 3).

Lesion number

High variation occurred in lesion numbers of different varieties in different locations at the end of the growing season. In Abobo and Gambella except for Bako locations, the final scores for the number were highly significant different compared with the initial lesion number (Table2). The first lesion numbers recorded ranged 0.00-7.56 at Bako 0.00-5.70 at Gambella and 0.00-5.00 for Abobo location. Since FLN was very few at the initial time, hence no significant reaction was observed in two locations except Bako, while FLN was significantly different. However, increment of the lesion numbers was consistent in resistant and susceptible varieties. Resistant variety, Kuelni, recorded the small final lesion numbers for all locations (Gambella 1.24, Abobo 2.04 and Bako 0.53). In general, the levels of lesion number on susceptible variety, Gussau at Gambella, Abobo and Bako were similarly recorded high (5.70, 5.00 and 7.56, respectively).

Lesion size

Similar results were recorded for lesion size in all locations and among varieties. Gussau had significantly large lesion size in all locations

Table 1 Disease onset (DO) recorded for northern leaf blight under field conditions of different locations.

Genotype	Disease onset (days after emergence)		
	Bako	Gambella	Abobo
BH-QP-	78	36	36
Local-M	78	36	30
Abobak	78	36	30
Gusaw	78	30	30
BH-541	84	36	39
Kuleni	85	45	45
BH660	85	30	43
BH-530	78	42	36
BH140	84	41	39
BH540	84	36	38
Guto	78	36	36
Gibe	78	36	36
BH-670	84	36	36

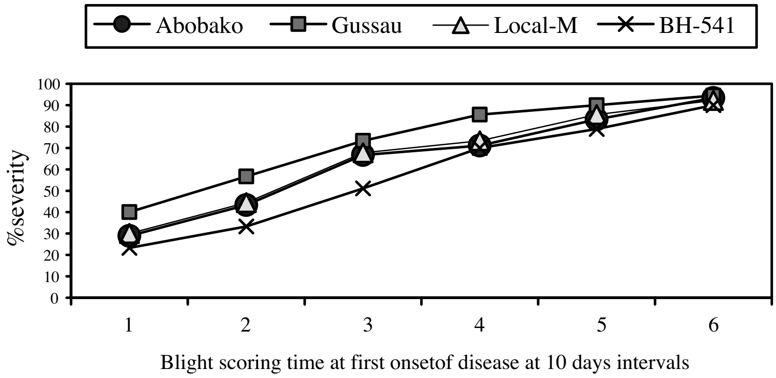

Figure 1 Average progress of northern leaf blight development on susceptible maize varieties, Abobako, Gussau, Local-M and BH-541 at three locations in 2003 and 2004.

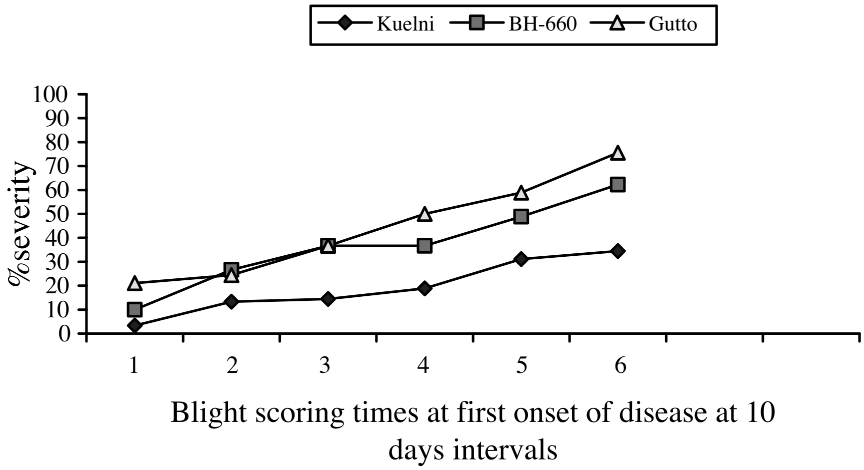

Figure 2 Average progress of northern leaf blight development on resistance variety, Kuelni, BH-660 and Gutto.

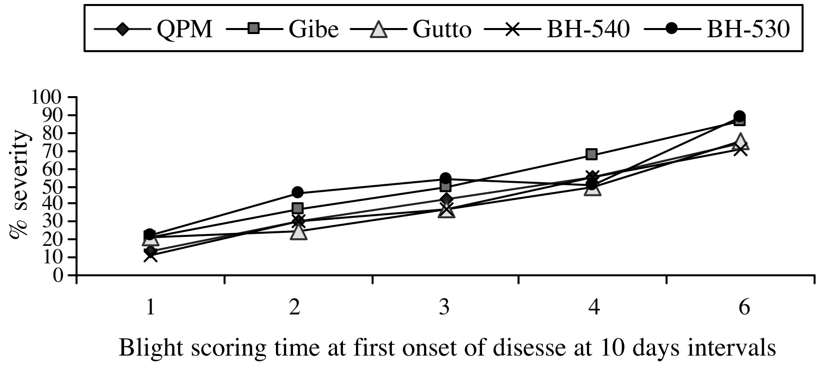

Figure 3 Average progress of northern leaf blight development on moderately resistant varieties, QPM, Gibe, Gutto BH-540 and 530.

at Bako, Gambella and Abobo of 27.40, 14.05 and 16.50cm, respectively, whereas the final lesion size of Kuelni variety was small and consistent in all locations. Significant differences of the final lesion sizes of 4.35, 2.03 and 1.32 were recorded for Bako, Gambella and Abobo locations, respectively (Table 3).

Table 2 Lesion number development of NCLB on 13 maize varieties at three locations.

Varieties	*Gambella*		*Abobo*		*Bako*	
	FLN[1]	LLN	FLN	LLN	FLN	LLN
BHQPM	0.00a	2.93c	0.00a	3.26c	0.43ad	1.56ab
Gibe-2	0.01a	3.95bc	0.00a	3.79bc	0.33ad	1.67ab
Gutto	1.01a	3.80bd	0.00a	3.28bd	0.20ad	1.88ab
BH-670	0.02a	2.10ef	0.00a	3.09ef	0.23ad	1.13ab
BH-540	0.00a	1.96ef	0.00a	3.70ef	0.33ad	1.30ab
BH-140	0.00a	2.33ef	0.00a	3.79bc	0.33ad	1.36ab
BH-530	0.00a	2.33ef	0.00a	3.40ef	0.53dc	1.70ab
BH-660	0.35a	2.23ef	0.00a	3.11ef	0.06b	1.16ab
Kuelni	0.68a	1.24f	0.00a	2.04f	0.00d	0.53b
BH-541	0.00a	4.86ab	0.00a	4.06ab	0.40ad	1.36ab
Gussau	1.33a	5.70a	1.07a	5.00a	0.66a	7.56a
Abobako	0.68a	5.35a	0.93a	4.16a	0.50ab	2.30ab
Local-M	1.01a	4.83ab	0.13a	4.33ab	0.66a	3.00ab
P=0.05	NS	*	NS	*	*	*

* Differed significantly in Duncan multiple range test at p<0.05 probability level.

[1] FLN= First lesion number; LLN= Last lesion number

Table 3 Lesion size development of NCLB on 13 maize varieties at three locations.

Varieties	*Gambella*		*Abobo*		*Bako*	
	FLS[1]	LLS	FLS	LLS	FLS	LLS
BHQPM	0.03b	8.33b	6.00ac	13.51b	0.71ac	17.20ac
Gibe-2	0.33ab	9.67ab	4.33be	5.48c	0.69ac	11.96bd
Gutto	0.10b	12.52ab	1.38ef	4.06c	0.19bc	13.91cd
BH-670	0.03b	12.26ab	1.40ef	5.10c	0.27bc	8.00bd
BH-540	0.00b	12.33ab	2.05df	4.43c	0.68ac	11.81bd
BH-140	0.03b	9.20b	2.33cf	4.20c	0.62ac	14.31bd
BH-530	0.40ab	8.80d	3.00cf	4.60c	0.95ab	8.20ac
BH-660	0.36ab	2.46c	2.66cf	4.48c	0.00c	4.35d
Kuelni	0.00b	2.03c	0.00f	1.32d	0.87ac	20.11ac
BH-541	0.36ab	12.46ab	5.71bd	13.46b	1.22a	27.40a
Gussau	0.83a	14.05c	9.26a	16.50a	0.66a	7.56a
Abobako	0.80a	12.31ab	4.80ce	13.80b	0.84ac	21.05ab
Local-M	0.80a	12.60ab	7.77ab	14.25d	0.91ac	18.18ac
P=0.05	*	*	*	*	*	*

* Differed significantly in Duncan multiple range test at p<0.05 probability level.

[1] FLS= First lesion size; LLS= Last lesion size

Severity and AUDPC

Disease severity scores in all locations and each location were significantly different. In all locations, varieties with low severity scoring values to northern leaf blight were considered as resistant, on the other hand varieties with high severity score values considered as susceptible. Final severity score and AUDPC value provided adequate evaluation of the reaction of the varieties to *E. turcicum* at Gambella, Abobo and Bako (Table4). Disease severity expressed as area under disease progress curve (AUDPC) was significanly different ($p \leq 0.001$ and $p \leq 0.05$) at Bako, Gambella and Abobo locations. Higher area under disease progress curves were recorded on susceptible varieties than resistant varieties. At Bako, varieties considered as susceptible such as Abobako, Gussau and Local-M had AUDPC values were as high as 5159, 3571 and 5015, while Kuelni and BH-660 varieties had consistently lower AUDPC values of 1332.5 and 1650, respectively. Varieties such as BH-140, BH-530, BH-670, QPM, Gibe, Gutto, BH-540 and 541 showed high value of area under disease progress curve (Table 4).

Correlation analysis

The result of Pearson correlation analysis indicated highly significant and positive relationship between all disease assessment observed at Abobo and Bako locations due to high disease pressure in that area. However, non-significant correlation was observed between the disease indices with AUDPC only at Gambella. The reason for non-significant correlation in Gambella was probably due to low disease pressure (Table 5).

Correlation among the various northern leaf blight evaluation with yield and seed weight was determined (Table 6). There were significantly negative correlation between severity to thousand seed weight and yield in all locations. Area under disease progress was negatively correlated to seed weight in all locations. Except for blight incidence score, lesion size and number with blight incidence

Table 4 Area under disease progress curve and severity (1-5) scale recorded 13 maize varieties at three locations.

Varieties	*Gambella*		*Abobo*		*Bako*	
	AUDPC[1]	SEV	AUDPC	SEV	AUDPC	SEV
BHQPM	2783ab	2.66ce	3217.5ac	3.33ab	3034cf	3.00ce
Gibe-2	4010ab	2.66ce	4124.5ab	3.00b	3040.8cf	3.33bc
Gutto	4093ab	3.66ac	2164.2ac	3.66ab	4059.0ad	3.33bd
BH-670	3578ab	2.33df	3707.7ac	3.66ab	2289.3eg	2.00e
BH-540	3127ab	3.33ad	3127ab	3.33ab	2879.3eg	3.00ce
BH-140	2871ab	3.00be	2871ab	3.33ab	3450.8be	3.33bd
BH-530	3056ab	3.66ae	3056ab	3.33ab	4674.0ac	4.00ac
BH-660	2959ab	2.00ef	2959ab	3.33ab	1650.8fg	2.33bd
Kuelni	1617b	1.33f	784.0e	1.33c	1332.5g	2.00e
BH-541	4187a	4.00ab	4679.5a	3.66ab	4339.2ad	3.33bd
Gussau	4010ab	4.33a	3571.8ac	4.33a	3571.8ac	4.66a
Abobako	4805a	4.33a	3470.8ac	4.00a	5159.2a	4.33ab
Local-M	3410ab	4.00ab	2090.7ce	4.00a	5015.5ab	4.33ab
P=0.05	*	*	*	*	*	*

* Differed significantly in Duncan multiple range test at p<0.05 probability level.

[1] AUDPC= Area under disease progress curve; SEV= Severity scale

Table 5 Pearson correlation (r) among disease assessments used to quantify northern leaf blight reaction at Abobo, Gambella and Bako.

Locations	*Disease assessments*				
	Disease assessments	Blight incidences	Severity	Lesion number	Lesion size
Gambella					
	AUDPC[a]	0.60	0.52	0.55	0.52
	Blight incidence		0.73*	0.74*	0.73*
	Severity			0.75**	0.71*
	Lesion number				0.85**
Abobo					
	AUDPC[a]	0.85*	0.73***	0.66*	0.61*
	Blight score		0.81*	0.67*	0.79**
	Severity			0.81**	0.82**
	Lesion number				0.63*
Bako					
	AUDPC[a]	0.91**	0.85**	0.74**	0.76**
	Blight score		0.81*	0.78**	0.71**
	Severity			0.70*	0.89**
	Lesion number				0.85**

* Significant :* p≤0.05, ** p≤0.01and*** p≤0.001.

[a] AUDPC= Area under disease progress curve, Blight incidences = Last blight incidence.

Table 6 Pearson correlation among the difference of northern leaf blight assessment with yield and seed weight at different locations.

Locations	Disease assessments	Agronomic characters	
		Yield	Seed weight
Gambella			
	Severity	-0.58*	-0.72**
	AUDPC	0.52	-0.58*
	LBI[a]	-0.64**	-0.86**
	Lesion number	-0.68*	-0.67*
	Lesion size	0.40	-0.68*
Abobo			
	Severity	-0.72**	-0.94**
	AUDPC	0.40	-0.66*
	LBI[a]	-0.67*	-0.89*
	Lesion number	0.14	0.18
	Lesion size	-0.83**	-0.65*
Bako			
	Severity	-0.64*	-0.73**
	AUDPC	0.56	-0.66*
	LBI[a]	0.17	0.40
	Lesion number	-0.64*	0.65
	Lesion size	0.49	0.60

** and * Correlation is significant at p<0.01 and p<0.05levels, respectively.

[a] LBI= Last blight incidence.

score were correlated with seed weight at Abobo locations but non significantly. This indicated that all those parameters effectively measured the disease progress and had effect on yield and seed.

DISCUSSION

There was significant variation among varieties for AUDPC, disease severity, lesion number, lesion size, yield and TSW. The severity of the disease (AUDPC), however, varied from location to location depended on the difference in the environmental conditions, appearance of disease and other related factors. Levy (1991) also indicated that for northern leaf blight development, pathogenic fitness and environmental conditions were the important factors. The severity of the disease was highest at Bako. Eventhough the appearance of the disease was delayed because of the dry period at the time of planting, after the early dry period, the environmental conditions were generally favorable for northern leaf blight development during the reaming crop season. At Gambella, the low rainfall in cropping season was not suitable for disease development (personal observation), thus, the severity (AUDPC) was less than that at Bako and Abobo. Varieties with low AUDPC, lesion number, lesion size were considered to be resistant to the disease .In this study, variety Kuelni exhibited low AUDPC value at all locations, thus considered to be resistant variety. Variety Gussau, Abobako and Local-M have high AUDPC values at all locations were considered as suseptiable.This suggested that resistant or susceptible varieties showed similar reaction at all locations, which meant that there was no difference in virulence in the pathogen populations at all locations.

Maize variety such as Kuelni showed the good level of resistance at Bako, Abobo and Gambella.The resistance shown was of quantitative type. These results were similar with Adipola *et al*. (1993) who observed that the maize response to northern leaf blight, disease was clearly different in the field trials in Uganda. When NLB was severe, the reaction of most resistant varieties could not be differentiated in other locations, when conditions were less conducive for the development of NLB. Hence, these data showed that there were potential losses incurred by northern leaf blight on yield. Therefore, this finding justified the establishment of the breeding program national maize to develop increase adult plant resistance(ADP) germplasm which was the major breeding for an effective disease control strategy. When considering the overall location mean, the additional variety BH- 660 tended to be resistant.

CONCLUSION

From the disease progress curve, maize varieties showed similar reaction to pathogen, which indicated the there were not pathogenecity variation existing among pathogen population. NCLB development was influenced by humidity and susceptibility of maize varieties. NCLB preferred higher humidity 30 days after planting. The number of lesion varied by the locations that might be due to the influence of encironment, but the increment of the lesion number was consistent in resistant and susceptible varieties. The lesion size was also consistent in all locations. Most of criteria showed the final score of disease severity or incidence at one stage of plant growth as compared to AUDPC that identified the development of disease for all stages of plant growth. AUDPC is more appropriate to obtain the information both disease reaction at any stage and disease development for a period of time. The result expressed the highly significant between AUDPC and any criteria for disease reaction.

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