EFFECT OF SOME ENVIRONMENTAL FACTORS ON INCIDENCE AND SEVERITY OF ANGULAR LEAFSPOT OF COTTON IN YOLA AND MUBI, ADAMAWA STATE, NIGERIA

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ABSTRACT
Environmental factors such as relative humidity and rainfall generally have been found to increase the incidence, rate of spread and severity of diseases thereby reducing yield of crops. Study was conducted on five cotton varieties, artificially inoculated with bacterial blight pathogen to determine the effects of rainfall and relative humidity on incidence and severity of angular leafspot (ALS) and yield of seed cotton in Yola and Mubi. Results showed that the severity of ALS was higher in Yola (58.65%) at 13 WAS is assumed to be due to higher relative humidity (76-87%) and low rainfall (2 – 40.6 mm) which favours disease development as against that of Mubi location which recorded lower severity (51.11%) due to lower relative humidity (42 – 55%) and rainfall (37 – 73 mm). Results further revealed that SAMCOT-8 had low incidence and severity in both locations with an incidence of 66% and severity of 39% of ALS at 13 WAS in Yola and 82% incidence and 42% severity in Mubi. SAMCOT-10 and SAMCOT-9 varieties were found to be highly susceptible to the disease at the same period. SAMCOT-8 recorded the highest yield of 390.00 kgha^{-1} in Yola and 868.09 kgha^{-1} in Mubi while lowest yields of 227.17 kgha^{-1} was observed on SAMCOT-10 in Yola and 461.61 kgha^{-1} was obtained on SAMCOT-9 in Mubi. There is need to conduct further trials in these locations to confirm the reaction of these varieties.
Keywords: Angular leafspot, Cotton, Rainfall, Relative Humidity, Disease Incidence and Disesase Severirty

INTRODUCTION
Cotton (*Gossypium* spp.) is a valuable agricultural commodity which plays an important role in the economy of many developing countries by serving as a major foreign exchange earner and in domestic production of textile materials, oil, cake and edible oil (Anon, 1981). It is cultivated in over 100 countries with a total production of about 199 million bales of lint (USDA, 2010). In Nigeria, cotton is adopted to most ecological zones producing 1.48 million bales in 2010 (USDA, 2010). However, the production potential of this valuable cash crop has been constrained by the prevalence of a number of fungal, bacterial and nematodes diseases which affect yield and fibre quality (Hussain and Tahir, 1993; Idem, 1999). The incidences and severities of these diseases are restricted by ecological and climatic differences in the crop environment (Poswal and Erinle, 1983; Idem, 1999, Gwary *et al.,* 2009). Among the diseases which affect cotton, bacterial blight incited by *Xanthomonas* pv *malvacearum* is the most devastating disease in all cotton growing regions of the world and Nigeria in particular with an estimated yield loss of 10 – 20% in affected plants (Erinle, 1981). Yield losses of up to 10 – 50% have been recorded in other cotton growing regions (Thaxton and El-Zik, 2001) and such loses on annual basis are dependent on severity of epidemic, cotton species susceptibility and environmental factors (Darlington, 2001, Nahunnaro *et al.,* 2007).
According to Steve (2004) high rainfall, relative humidity as well as warm temperature favours disease development which in turn affects yield. Free water is required for foliar infection and secondary spread is favoured by high humidity following periods of wind and rain which distribute the bacteria within the crop canopy. Provided the relative humidity is 85%, the optimum temperature for disease development is around 36ºC (Hillocks, 1992; Steve, 2004). Presently, there is a growing advocacy by the Nigerian government to boost agricultural productivity to achieve food and raw materials sufficiency in line with the vision 2020. Cotton is one of the major cash crop earmarked for increased production in all the cotton producing zones of the country with the aim of achieving the goals of the government for a sustainable cotton production to revamp our ailing textile industries and also for export.
This study is therefore conducted to ascertain the reaction of some cotton varieties to *Xanthomonas axonopodis* pv. *malvacearum* and the influence of

environmental factors on incidence and severity of angular leafspot.

MATERIALS AND METHODS

This study was conducted in Yola and Mubi all in northeastern Nigeria during the 2011 cropping season. One of the field trial was conducted at the Teaching and Research Farm of the Department of Crop Protection, Modibbo Adama University of Technology, Yola. Yola is located between latitude 9° 11′ N and 9° 19′ N and longitude 13° 1′ E and 12° 31′ E (Adebayo, 1999). The second field trial was conducted at the Teaching and Research Farm of Agricultural Technology Department, Federal Polytechnic Mubi. Mubi is located between latitude 10° 11′ N and 9° 26′ N and longitude 13° 1′ E and 13° 44′ E (Adebayo, 1999).

The design used for conducting the experiments was Randomized Complete Block Design replicated three (3) times. The experimental fields measured 29 m x 11 m with plots measuring 5 m x 3 m, and alleys of 1m pathway between plots and replicates. The five cotton varieties (SAMCOT-8, SAMCOT-9, SAMCOT-10, SAMCOT-11 and SAMCOT-12) were obtained from the Institute of Agricultural Research (IAR) Samaru Zaria.

The cotton seeds, before sowing were inoculated with infected crushed cotton plant leaves which served as initial inoculums and sown at a spacing of 90 cm x 45 cm with five plants per stand which was later thinned to two plants per stand at 3 weeks after sowing (WAS) (Idem, 1999).

Diuron was applied immediately after sowing at the rate of 1 kg (150mls in 20 litre sprayer) per hectare as a pre-emergence herbicide, while regular hand weeding was done to control weeds which emerge later (CDC, 2007). Cypermethrin (Cymbush) and Imidacloprid (Courage®) application was carried out at the ratio of 20 ml: 40 ml of Smash and Courage respectively per 20 litre knapsack sprayer to control insect pests associated with cotton. Fertilizer containing nitrogen was applied at the rate of 60 kg ha^{-1}, phosphorus in the form of P_2O_5 at the rate of 30 kg ha^{-1}, and potassium in the form of K_2O at the rate of 30 kg ha^{-1}.

Isolated bacterial pathogens (10^8 cfu/ml) were suspended in distilled water and later sprayed under the leaf surfaces of the plants in the evening using a pressurized hand sprayer to increase the chances of infection by the pathogen.

Data were collected on incidences and severity of angular leaf spot from 7-13 WAS and yield (kg ha^{-1}). Weather data were also collected from meteorological stations of two higher institutions in the study locations namely Modibbo Adama University of Technology Yola and Adamawa State University Mubi. Disease incidence was calculated using the formular;

$$\text{Disease Incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants assesed}} \times 100$$

While disease severity was calculated using a scale of 0 – 6 according to the method of Poswal (1989) and the formular used was:

$$\text{Disease Severity} = \frac{\text{Sum of individual ratings}}{\text{Total number of plants assesed x highest score in the ratings}} \times 100$$

The data collected were analyzed using the Generalized Linear Model (GLM) procedure of Statistical Analysis System (SAS) appropriate for RCBD and means were separated using Duncan Multiple Range Test (DMRT).

RESULTS

The results on the influence of relative humidity and rainfall on incidence of ALS revealed a gradual increase in the percentage incidence of the disease at 7-13 WAS at Yola (Table 1) and significant difference ($P \leq 0.05$) among the varieties. At 7 WAS SAMCOT-8 recorded the lowest incidence of 14.00% while SAMCOT-9 had a higher value of 18.00%. At 13 WAS, results revealed higher significant ($P \leq 0.01$) difference between varieties, with SAMCOT-8 still recording the lowest incidence of 66.66% while SAMCOT-10 recorded the highest incidence of 88.00%.

In Mubi location, results also revealed a gradual increase in the percentage incidence of the disease from 7 – 13 WAS (Table 2). It further showed that there was a significant difference ($P \leq 0.05$) between the varieties at 7 – 11 WAS with SAMCOT-8 and 12 recording the lowest percentage incidence of 18.66% at 7 WAS while SAMCOT-9 had a percentage incidence of 24.66%. At 11 WAS, there was no statistical difference between the mean incidences. SAMCOT-8 had the lowest disease incidence and the rest of varieties statistically similar.

Table 1: Mean effect of relative humidity and rainfall on incidence of Angular leaf spot at 7 – 13 WAS at Yola

	Weeks after sowing (WAS)						
	7	8	9	10	11	12	13
<u>Variety</u>							
SAMCOT-8	14.00^{b}	21.33^{d}	30.00^{b}	36.66^{c}	43.33^{d}	50.66^{d}	66.66^{c}
SAMCOT-9	18.00^{a}	29.33^{a}	36.66^{a}	44.00^{b}	57.33^{ab}	74.00^{b}	84.66^{a}
SAMCOT-10	17.33^{ab}	25.33^{bc}	39.33^{a}	49.33^{a}	60.66^{a}	79.33^{a}	88.00^{a}
SAMCOT-11	16.66^{ab}	26.66^{ab}	36.00^{a}	46.00^{b}	56.66^{b}	70.00^{b}	83.33^{a}
SAMCOT-12	15.33^{ab}	23.33^{cd}	32.00^{b}	39.33^{c}	48.66^{c}	58.66^{c}	76.66^{b}
Probability of F	0.1716	0.0002	0.0002	< .0001	< .0001	< .0001	< .0001

Column means with the same letter(s) are not significantly different according to DMRT.

Table 2: Mean effect of relative humidity and rainfall on incidence of Angular leaf spot at 7 – 13 WAS at Mubi.

	Weeks after sowing (WAS)						
	7	8	9	10	11	12	13
<u>Variety</u>							
SAMCOT-8	18.66^{c}	25.33^{b}	30.66^{b}	36.66^{b}	63.33^{bc}	72.00^{c}	82.66^{c}
SAMCOT-9	24.66^{a}	29.33^{a}	36.00^{a}	44.00^{a}	68.66^{a}	80.00^{c}	86.00^{c}
SAMCOT-10	21.33^{b}	29.33^{a}	37.33^{a}	45.33^{a}	68.00^{a}	81.33^{c}	86.00^{c}
SAMCOT-11	22.00^{b}	27.33^{ab}	36.00^{a}	42.66^{a}	63.33^{ab}	79.33^{c}	84.00^{c}
SAMCOT-12	18.66^{c}	28.00^{ab}	36.00^{a}	44.00^{a}	59.33^{bc}	74.66^{c}	82.66^{c}
Probability of F	0.0001	0.1733	0.0153	0.0009	0.0058	0.0015	0.6314

Column means with the same letter(s) are not significantly different according to DMRT.

Table 3: Mean effect of relative humidity and rainfall on severity of Angular leaf spot at 7 – 13 WAS at Yola

	Weeks after sowing (WAS)						
	7	8	9	10	11	12	13
<u>Variety</u>							
SAMCOT-8	12.67^{b}	17.64^{d}	21.65^{d}	28.23^{b}	31.14^{c}	35..347^{c}	39.08^{d}
SAMCOT-9	16.98^{a}	23.92^{a}	32.32^{a}	37.94^{a}	44.34^{a}	50.72^{b}	55.28^{b}
SAMCOT-10	16.94^{a}	24.16^{ab}	30.38^{ab}	39.19^{a}	46.27^{a}	52.74^{a}	58.15^{a}
SAMCOT-11	15.68^{b}	20.87^{bc}	29.72^{bc}	36.88^{a}	44.16^{a}	49.88^{b}	56.26^{b}
SAMCOT-12	15.22^{b}	20.72^{cd}	27.97^{cd}	33.64^{b}	35.40^{b}	38.80^{c}	40.45^{c}
Probability of F	< .0001	0.0028	< .0001	< .0001	< .0001	< .0001	< .0001

Column means with the same letter(s) are not significantly different according to DMRT.

Similar trend were observed with regards to severity of angular leafspot in Yola (Table 3). There was a highly significant (P ≤ 0.01) difference between varieties at 7 WAS and 13 WAS with SAMCOT-8 recording the lowest severity of 12.67% and 39% respectively. The highest severity at 7 WAS and 13 WAS was observed on SAMCOT-9 (16.98) and SAMCOT-10 (58.60%) respectively. In Mubi, result revealed highly significant (P ≤ 0.01) variation from 8 – 13 WAS (Table 4) the lowest severity of 15-80% was observed on SAMCOT-10 while SAMCOT-12 had the highest severity of 25-35% at 8 WAS. At 13

Table 4: Mean effect of relative humidity and rainfall on severity of Angular leaf spot at 7 – 13 WAS at Mubi

	Weeks after sowing (WAS)						
	7	8	9	10	11	12	13
<u>Variety</u>							
SAMCOT-8	13.36^{a}	15.80^{cd}	18.72^{b}	24.57^{d}	32.52^{c}	36.61^{c}	40.32^{c}
SAMCOT-9	14.10^{a}	25.30^{a}	29.79^{a}	40.24^{a}	46.14^{a}	50.54^{a}	53.62^{a}
SAMCOT-10	12.72^{a}	23.64^{ab}	28.73^{a}	36.08^{b}	42.84^{b}	49.3^{a}	52.80^{a}
SAMCOT-11	13.25^{a}	22.91^{bc}	28.73^{a}	36.26^{b}	44.82^{ab}	49.31^{a}	51.98^{ab}
SAMCOT-12	14.20^{a}	20.52^{d}	24.56^{b}	30.16^{c}	32.14^{c}	38.13b^{a}	40..45^{b}
Probability of F	0.3415	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001

Column means with the same letter(s) are not significantly different according to DMRT.

Table 5: The relative humidity and rainfall data of Yola and Mubi during the 2011 cropping season

	Yola		Mubi	
WAS	R/H (%)	Rainfall (mm)	R/H (%)	Rainfall (mm)
7	87	4.4	47	73.5
8	76	14.3	55	67
9	82	40.5	42	42
10	86	10.4	44	37
11	86	23	46	46
12	77	2	48	48
13	83	19	45	59

Source: Department of Geography Meteorological Station, Modibbo Adama University of Technology, Yola and Department of Meteorological Services, Adamawa State University, Mubi (2011).

Table 6: Mean effects of relative humidity and rainfall on yield (kgha^{-1}) of seed cotton in Yola and Mubi

	Yield (kgha^{-1})	
	Yola	**Mubi**
Variety		
SAMCOT-8	390.00^{a}	868.9^{a}
SAMCOT-9	291.00^{c}	461.61^{bc}
SAMCOT-10	227.17^{d}	470.08^{d}
SAMCOT-11	255.55^{d}	523.44^{d}
SAMCOT-12	341.66^{b}	559.11^{b}
Probability of F	< .0001	< .0001

Column means with the same letter(s) are not significantly different according to DMRT.

WAS, SAMCOT-8 recorded the lowest severity of 40.32, while the rest had similar ALS severities.

The results on influence of rainfall and relative humidity on incidence and severity of angular leaf spot revealed a gradual increase in the percentage incidence and severity of the disease with steady increase in relative humidity (55%) and 517 mm of rainfall in Mubi and relative humidity (87%) and rainfall of 239 mm in Yola (Table 5).

Results for yield of seed cotton (Table 6) indicated highly significant ($P \leq 0.01$) differences in both locations between the varieties. In Yola, it was observed that SAMCOT-8 had the highest mean value of 390.00 kg ha^{-1}, while lower value of 227.17 kgha^{-1} was observed on SAMCOT-10. In Mubi location, similar trend was observed with SAMCOT-8 recording a much higher yield value of 868.09Kgha^{-1}, while SAMCOT-9 had the lowest weight of 461.61 Kgha^{-1}.

DISCUSSION

Disease severity is an important factor in determining the performance and yield of crops as high disease severity favoured by influence of relative humidity and rainfall has been found to affect photosynthesis which in turn ensures reduction of assimilates for the plant (Khan, 2000). In this study, results obtained revealed a significant variation in varietal resistance and susceptibility of cotton to *Xanthomonas axonopodis* pv *malvacearum* at 7 – 13 WAS. SAMCOT-8 and SAMCOT-12 varieties were consistently observed to record the lowest incidence, severity and high yield of seed cotton in both locations, while high disease susceptibility were observed on SAMCOT-10 in Yola and SAMCOT-9 in Mubi at the same period.

The difference in percentage incidence and severity of ALS amongst cotton varieties may be attributed to their levels of resistance to the pathogen in association with environmental factors prevailing during period of plant growth since all varieties were exposed to the same quantity of inoculum. The higher percentage susceptibility observed on SAMCOT-9, SAMCOT-10 and SAMCOT-11 may be attributed to low levels of resistance inherent in the plants. This agrees with the report by Nahunnaro *et al.* (2007) who assessed the susceptibility of SAMCOT-11 and SAMCOT-13 and recorded high incidence and severity of ALS which may be related to their inherent genetic makeup to be susceptible to the disease (Allerd, 1999 and Sinsiri *et al.*, 2006), and influence of rainfall and relative humidity as these varieties especially SAMCOT-8 is bred to adapt to the environments of eastern cotton growing zone of Nigeria (Idem, 1999). Poswal (1989) and Nahunnaro *et al.*, (2007) had earlier reported on the continual loss of resistance to bacterial blight by Nigerian cotton varieties including SAMCOT-8, however, results obtained from this study had proved the contrary as this variety was found to perform better.

The increase in incidence and severity of this disease followed the pattern of the percentage relative humidity and rainfall in the respective locations. In Yola for instance, there was a high relative humidity ranging from 76 – 87% with an irregular rainfall distribution, however, the combination of these weather elements most likely have influenced high incidence and severity of the disease. This finding agrees with Mohammed *et al.*, (1999) who reported on positive correlation between environmental conditions and disease severity in India. They further reported that maximum disease severity was observed at temperature of 26 – 27ºC, 100 – 147 mm rainfall and 67-77% relative humidity. Nahunnaro *et al.* (2012) also reported that environmental conditions of relative humidity, rainfall and temperature had influenced the incidence and severity of *Cercospora* leafspot on some cowpea varieties in Yola.

In contrast, Mubi location was characterized by low but uniform relative humidity (42 – 55%) and rainfall (34 – 74 mm). The combination of these factors might have proved unfavourable for severe foliar infection but favoured good and vigorous plant growth and subsequently high yield. These observations agree with Charles (2005) who reported that vigorous growing leaves rarely become infected by a pathogen. Yields of seed cotton was higher in Mubi due to favourable weather conditions which ensured good crop growth and restricting the spread of the disease as compared to those obtained in Yola location. Thaxton and El-Zik (2001) reported that yield loses of up to 10 – 50% have been reported in some cotton growing regions of the world due to severe infection by the Bacterial blight pathogen.

Gwary and Nahunnaro, (2007) had earlier reported on the significant increase in severity of this disease with time as influenced by rainfall and relative humidity in Kem, also in Adamawa State. Wheeler *et al*. (2007) further reported that the principal factors influencing *Xanthomonas axonopodis* pv *malvacearum* incidence and severity in cotton were rainfall, relative humidity, temperature, solar radiation, quantity of the inoculum and the resistant gene in the genotypes. They further reported that disease incidence increased by 3.4% for each degree rise in average mean temperature, 12% increase when inoculum was increased from 10^6 to 10^7 cfu/ml, 1% increase in relative humidity and 3.7% increase in for each degree increase in temperature. Results recorded in both locations appear to show a sort of relationship between disease severity, yields and weather elements.

Results from these studies have revealed a relationship between the incidence and severity of ALS and weather elements in the two locations. Rainfall and relative humidity favoured the expression of the pathogen which was variable on the different varieties. In conclusion, yields obtained from Mubi were higher than those recorded in Yola where the high relative humidity and rainfall favoured high severity and low yields amongst the varieties. Varieties such as SAMCOT-8 and SAMCOT-12 were found to be resistant to the disease and recorded higher yields in both locations. Therefore, more trial need to be conducted on these and other cotton varieties to ascertain their level of resistance to *Xanthomonas axonopodis* pv *malvacearum* these two and other locations.

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