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A Preliminary Assessment of Climate and the Incidence of Maize Downy Mildew in Ilorin and its Environ

MRS R. M OLANREWAJU

Department of Geography, University of Ilorin, Nigeria

Abstract

Out break of downy mildew has been a menace to maize production in Ilorin and its environ. This paper has identified the most crucial climatic parameters for the outbreak of downy mildew, a disease of maize. A comparative analysis of years with and without outbreak was carried out and also the weather before, during and after the outbreak was examined. Climatic data were broken into three sets of March – June, June – October and November – March based on the length of time it takes for each season of planting maize (early, late and dry) to mature in the field. Monthly mean of climatic variables (rainfall, relative humidity, wind run, evaporation, maximum and minimum temperatures and soil temperature) were calculated for five years with outbreak and for five years without outbreak of downy mildew disease. Simple regression analysis was employed to investigate the relationship. The results of the analyses showed a variation in outbreak severity with mean rainfall, relative humidity, wind run and evaporation. However based on the results of correlation analysis only relative humidity, wind run, evaporation and maximum temperature are significant at 95% confidence level. Relative humidity displayed strongest positive relationship followed closely by wind run (+ 0.722 and + 0.711) while evaporation exhibited strongest negative relationship of - 0.642 followed by maximum temperature (-0.574). The weather patterns preceeding, during and after the outbreak is described as hot and slightly humid, warm and humid, hot and dry respectively. The paper suggests application of technology to control outbreak of downy mildew disease.

Introduction

As the human population of Kwara State increases so does the need and demand for food. Maize an important multipurpose crop for man and animal is a key cereal crop grown in Kwara State and indeed in most of the Guinea Savanna ecological zones of Nigeria. This fact is not surprising in view of the many industrial uses to which maize is put. Maize serves as the major raw material in the production of cornflake, biscuit, cornegms, flour, etc. Besides, maize can be domestically processed forming one of the staple carbohydrate foods of a large number of Nigerians.

However, maize is in short supply. For instance, Wudir and Fatoba (1992) recommended 50% increase in maize production to meet the demands of Nigeria's rapidly expanding population. Ilorin, the capital of Kwara State, and its environ is not an exception in this shortage as this cereal is often plagued by disease most prominent of such being downy mildew. For instance, there was a drop in production from 133.82 ton/ha reported in 1991 to 98.89 ton/ha in 1996 and further to 78.87ton/ha in year 2000. This shortage in supply has resulted in sporadic rise in maize prices both in rural and urban markets. For instance, the Monitoring and Evaluation Unit of the Kwara State Agricultural Development Project (KADP) in the annual report for year 2001 noted an increase from N1.80 per kg of maize in 1989 to N36.46 per kg in year 2001 in the urban market. This inflation rate in maize price is not limited to the urban market but it is experienced in the rural market as well. For instance, one kilogram of maize sold for N1.52 in 1989 jumped to N35.84 in year 2001 in rural markets.

Based on the findings of Kitty et al (1995), the downy mildew disease is caused by fungus peronosclero spora sorghi. Both maize and guinea corn are vulnerable to this disease. However, the maize strain of downy mildew can only survive in regions where maize is cultivated throughout the year. This maize disease described by Adejuwon (1962) as crop enemy among others was introduced to Kwara State via Owo in Ondo State area in 1975. It diffuses at a speed of one hundred kilometers

per annum (Aina 1995). Since then, it has spread and the outbreak of the disease localised to some areas. In particular, the downy mildew disease was first experienced in Ilorin in 1990 and has persisted through 1995.

Studies have shown that the periodic outbreak and spread of crop pests are climatically linked (Gourou 1961, Adejuwon 1983, Ayoade 1988, Olanrewaju, 1998 and Olaniran, 2002). Considering the risks introduced to agricultural production through weather variability Ajibade and Ogunbodede (1999) solicit for an understanding of the relationship between weather and crop yield. Thus, the objective of this study is to examine weather pattern associated with years of different degrees in outbreak severity of downy mildew compared with years that witness no outbreak. This study also examines the weather pattern that prevails before the outbreak, during the outbreak and after the outbreak with the aim of identifying the most crucial climatic parameters favouring downy mildew outbreak for efficient agricultural planning.

Maize cultivation and outbreak of Downy Mildew in Kwara State

The pattern of maize cultivation in most part of Kwara State is that of continuous cropping. The annual survey of farmers by the Kwara Agricultural Development Project confirmed that years of continuous cropping couldn't be an isolated factor affecting the incidence of downy mildew diseases on maize farms. However, it was observed that the level of infestations is high on farms that are continuously under maize cultivation for a period of about 3-5 years.

Maize is planted in sets of early, late and dry season (fadama) maize in most part of Kwara State. Maize plots planted in the early part of the year at the onset of rainfall around March/April are described as early maize, the ones planted around June/July constitute the late maize while the dry season maize is planted in hydromorphic (fadama) plots around November. The growth periods for early, late and dry season maize span between March-June, June-October and November- March of the following year respectively.

Not all the three sets of maize plots described above are vulnerable to attack of downy mildew disease. Based on the report from the field survey carried out by the KADP Monitoring and Evaluation Unit only late maize is susceptible to downy mildew infestation (KADP 1991 and 1993 reports). Contrary to the above view Kitty et al (1995) are of the opinion that downy mildew disease persists in fadama maize plots although at a very low level of infestation but serve as the source of epidemic for the following year.

Moisture on the leaf surface is a condition for sporulation of peronosclerospora fungi and infection to occur. Once spores begin to mature they are dislodged. Spores dislodged may land on a host maize plant and get it infected or on the ground surface and stay in the soil over the season until the condition in the soil is favourable for germination. Once germinated in the soil it may infect maize plant through root.

Table I: The Impact Of DMD On Maize Production And Percentages Of Farmers That Grow Maize In Ilorin and Its Environ

Year	% of respondent having their plots attacked by DMD	Maize production in tons/ha	% of farmers that grow maize
1990	4.0	N.A	96.0
1991	33.0	134.0	98.0
1992	25.0	110.0	97.0
1993	31.0	106.0	98.0
1994	18.0	113.0	96.0

DMD = Downy Mildew Disease.

Source: Kwara State Agricultural Development Projects (KADP)

Table 1, reflects the severity of the outbreak of downy mildew as it affects maize yield. Most farmers (96% - 98%) in Kwara State grow maize. The fluctuation in maize yield that is observed in Table 1 is not unconnected with the downy mildew outbreak among others factors. For instance, when the outbreak severity was put at 33%, 25%, 31% and 18% during 1991, 1992, 1993 and 1994, maize yield in ton/ha was 134.0, 110.0, 106.0 and 113.0 respectively.

Downy mildew infected maize manifests the following symptoms: crazy top, narrow leaf, abnormal plant growth, sterility, chlorosis etc (Hill and walker 1966). It is important to distinguish between the yellow colouration of downy mildew-infested maize and that caused by nitrogen deficiency. While the change in colour from green to yellow commences from the upper leaves and spreads down leaves with downy mildew disease, that of nitrogen deficiency in maize plant starts at the lower leaves and spread up the leaves.

The control measures adopted include the usage of resistant seed, early planting, dressing of seed with Apron plus and uprooting and burying of infected plants as soon as noticed (FAO, 1993).

The study area

Ilorin, the study area, is located at latitude $8^{\circ} 30'N$ and longitude $4^{\circ} 35' E$ (Fig 1). Ilorin has the tropical wet-and-dry climate which supports tall grass vegetation interspersed with short trees. Wet season lasts from April till October with an average rainfall of 1318mm per annum. Temperature is high throughout the year. This climatic condition favours the growing of maize twice per annum and this puts farmland under continuous cropping since it only requires 14 weeks for maize plant to grow and develop to maturity. It is important to note that, this same climatic condition that enhances the growth of maize also encourages sporadic outbreak of crop pests/diseases.

Farming constitutes the major occupation with more focus on root and grain crops. The most popular cereals grown are maize and guinea corn with maize incessantly being attacked by downy mildew. In fact, the percentage of farmers that grew maize between 1990 and 1995 was between 96.03% and 98% making maize the most popular cereals grown in Kwara State.

Materials And Methods

Type and Sources of Data

Meteorological and downy mildew outbreak data were utilized in this study. The meteorological data involved are rainfall, evaporation, relative humidity, maximum and minimum temperatures, soil temperature and wind run. Soil temperature data were collected at 10cm depth because spore of peronosclerospora may not go beyond 10cm depth before germination takes place. The downy mildew outbreak data used were the percentage sample of respondents whose plots were infested by downy mildew as reported by the Planning, Monitoring and Evaluation Unit of KADP. The meteorological data were collected from the National Centre for Agriculture (NCAM), Ilorin. Climatic data were collected for five years that witnessed no outbreak of downy mildew (1985-1989) and for another five years that witnessed the outbreak (1990-1994) in different degrees.

Data Processing

The raw climatic data were partitioned into 3 sets of March-June, June-October and Nov-March based on the different lengths of time it takes for each set of maize (early, late, and dry season (fadama) maize) to mature in the field. Also, based on this partitioning the weather pattern that precedes the outbreak, prevail during the outbreak and after the outbreak were observed.

Data Analysis

In addition to investigate the weather pattern that determines the severity of the outbreak, the study also determined the st

Results And

Weather pattern and disease are discussed in the 1990-1994 study. Years that witnessed slightly lower rainfall and very little or no

Table II: Weather Pattern and Downy Mildew

Year	% outbreak	
1985	0	
1986	0	
1987	0	
1988	0	
1989	0	
1990	4.0	
1991	33.0	
1992	25.0	
1993	31.0	
1994	18.0	

Source

Tables (weather pattern, outbreak) and w disease). The m

Data Analysis

In addition to the quantitative summary of the data the simple regression method was used to investigate the relationship between climate and outbreak of downy mildew disease and thereby determine the statistically critical climatic parameters for the outbreak of the disease.

Results And Discussion

Weather patterns associated with years of varying degree in outbreak severity of downy mildew disease are displayed in Table II. While 1985-1989 represents the period of no outbreak the years 1990-1994 stand for the period of outbreak of different degrees of severity of downy mildew disease. Years that witnessed the outbreak experienced higher rainfall amount, relative humidity, wind run but slightly lower maximum temperature and evaporation. Both minimum and soil temperatures showed very little or no distinction between the two periods (Table II).

Table II: Weather Pattern Associated With Years Of Different Degrees In Outbreak Severity Of Downy Mildew Disease In Ilorin And Its Environ.

Year	% outbreak	Rainfall (mm/mo)	R.H (%)	Maxi temp ($^{\circ}$ C)	Mini temp ($^{\circ}$ C)	Wind run (km/hr)	Evap (mm/day)	Soil temp at 10cm ($^{\circ}$ C)
1985	0	113.0	62.4	31.4	22.0	135.1	4.0	29.0
1986	0	155.9	89.6	30.8	21.8	60.8	3.5	31.1
1987	0	135.0	63.1	32.5	22.5	121.1	4.6	30.6
1988	0	92.5	59.7	30.8	22.5	130.7	4.1	31.8
1989	0	145.0	72.41	31.3	21.9	131.4	4.2	30.5
1990	4.0	181.0	84.6	330.6	19.1	149.0	4.0	28.5
1991	33.0	180.0	82.3	30.6	22.0	147.2	3.1	30.2
1992	25.0	161.1	78.1	331.1	22.1	167.4	4.3	31.5
1993	31.0	172.0	78.0	30.0	22.0	153.1	4.0	31.7
1994	18.0	159.7	79.7	31.0	22.2	144.5	2.3	30.8

Source: KWADP and Author's computation 2002.

Tables III -V give the weather characteristics associated with the growing of yearly maize (weather pattern preceding the outbreak), the growing of late maize (weather pattern prevailing during outbreak) and with the growing of fadama maize (weather pattern after the outbreak of downy mildew disease). The monthly means for these three periods were calculated for each of the climatic elements.

Table III: Weather Pattern During The Growing Of Early Maize (March-June) At Ilorin

Year	Rainfall (mm/mo)	R.H (%)	Maxi Temp (°c)	Mini. Temp (°c)	Evap. (mm/day)	Wind (km/hr)	Soil Temp at 10cm depth (°c)
1985	117.1	61.5	32.6	22.8	5.05	139.0	28.8
1986	137.3	76.7	31.3	22.6	4.47	73.46	21.7
1987	92.3	72.0	34.02	23.7	6.35	125.2	30.0
1988	126.0	60.0	32.1	23.1	4.9	140.4	28.6
1989	87.7	53.5	33.0	22.6	5.5	142.6	29.5
1990	52.7	49.0	34.5	22.2	6.9	136.6	29.7
1991	173.9	79.2	32.0	23.0	4.2	147.5	28.8
1992	109.2	73.2	33.4	23.0	5.8	160.5	29.8
1993	91.2	71.5	30.4	22.7	5.3	148.0	25.0
1994	81.5	76.5	32.8	22.8	4.7	165.0	30.0

Source: Authors field survey 2002

A close study of Table III shows that year-to-year variations exist in most of the climatic parameters examined. For instance, 1985, 1987, 1991 and 1994 recorded rainfall values of 117.1mm, 92.3mm, 173.9mm and 81.5mm respectively. For relative humidity it was 61.50%, 72.2% for 1985 and 1987 while for 1990 and 1994 it was 49% and 76%. Temperatures (maximum, minimum) are constantly high and evaporation follows the same trend. Soil temperature varied between 21.7°C and 30.0°C during the period. Wind velocity is high except during 1986 when it dropped to 73.46km per hour. The value ranges between 73.46km -165km/hr. Generally speaking the weather preceding the outbreak of downy mildew disease is hot and slightly humid.

Table IV: Weather Pattern During The Growing Of Late Maize (June-Oct) At Ilorin

Year	Rainfall (mm/mo)	R.H (%)	Maxi Temp (°c)	Mini Temp (°c)	Evap. (mm/day)	Wind (km/hr)	Soil Temp at 10cm depth (°c)
1985	124.2	61	30	21.1	2.9	133.9	20.8
1986	188.5	84	29.3	21.1	2.8	48.1	24.0
1987	167.5	59.2	30.5	21.8	3.0	1105.1	27.35
1988	178.4	74.6	29.8	21.6	3.6	125.1	28.3
1989	230.0	66.2	30.0	21.6	3.0	126.1	28.5
1990	182.0	66.1	28.5	21.6	2.8	140.6	22.5
1991	173.8	85.0	29.0	21.4	2.3	162.5	25.0
1992	229.3	82.0	29.1	21.2	3.0	165.7	26.0
1993	185.0	84.2	29.0	21.3	2.6	164.5	25.2
1994	196.6	82.6	29.3	21.6	2.6	170.7	23.4

Source: Author's field survey 2000

Table IV depicts the climatic pattern during the growing of late maize which is also the weather pattern prevailing during the major outbreak of downy mildew. High rainfall, relative humidity, wind run of mild fluctuations characterize this period. Rainfall amount ranges between 124mm/mo in 1985 and 299.3mm/mo in 1992. Wind run is high throughout except 1986 that recorded the speed of 48.1km per hour. Air and soil temperatures are not too high. Maximum temperature ranges between 29°C and 30.5°C, minimum temperature is 20.1°C-21.8°C and soil temperature is between 20.8°C (1985) and 28.5°C (1989). Evaporation is generally low the highest being 3.6mm/day

while the lowest is 2.3mm/day. The weather pattern displayed during this period can be described as warm and humid.

Table V: Weather Pattern During The Growing Of Dry Season Fadama Maize. (Nov-March) At Ilorin

Year	Rainfall (mm/mo)	R.H (%)	Maxi Temp ($^{\circ}$ C)	Mini. Temp ($^{\circ}$ C)	Evap. (mm/day)	Wind (km/hr)	Soil Temp at 10cm depth ($^{\circ}$ C)
1985	42.8	38.6	34.0	21.8	6.9	100.0	29.18
1986	15.8	41.4	34	21.0	7.5	108.8	32.8
1987	29.5	4.3	34	20.6	7.8	125.6	33.0
1988	6.3	21.4	34.0	20.5	8.8	155.5	32.5
1989	1.1	27.8	34.8	22.2	9.8	127.3	30.8
1990	39.6	37.0	34.1	22.6	6.6	147.4	29.7
1991	0.1	24.2	34.2	21.5	12.0	119.3	32.5
1992	22.1	31.0	34.6	20.9	8.8	128.3	32.2
1993	15.4	36.3	34.9	21.6	8.9	118.2	31.5
1994	8.3	22.0	34.0	30.4	8.0	103.0	31.6

Source: Author's field survey 2002.

Table V represents the weather during the growing of dry season maize i.e the weather after the outbreak of downy mildew disease. Rainfall is low, the range is between 0.1 during 1991 and 42.8 in 1985. Relative humidity follows the same trend but evaporation and temperatures are exceptionally high throughout the period. For instance, maximum temperature ranges between 34.0° C and 34.9° C, soil temperature between 29.1° C and 32.8° C while evaporation is between 6.9mm/day and 12.0mm/day. The weather experienced during this season is dry and hot.

Table VIa: Average Climatic Pattern During Various Maize Planting Periods (1985-1994) At Ilorin And Its Environ

Type of maize cropping	Growing period	Rainfall amount (mm/mo)	R.H (%)	Maxi temp ($^{\circ}$ C)	Mini Temp ($^{\circ}$ C)	Wind (Km/hr)	Soil temp ($^{\circ}$ C)	Evaporation (mm/day)
Early Maize	March-June	106.9	62.9	32.5	22.8	137.3	28.2	5.1
Late Maize	June-October	150.0	74.5	29.4	21.3	134.1	24.0	3.0
Dry Season (fadama) Maize	Nov-March	18.9	35.6	34.3	21.3	123.3	31.1	8.5

Source: Author's computation 2002.

A comparison of weather pattern during the three periods is attempted as indicated in Table VI above. Late maize growing period recorded the highest monthly mean rainfall amount of 150mm, relative humidity of 74.5% but lowest maximum temperature of 29.4° C, evaporation of 3.0mm/day and soil temperature of 24.0° C (Table VIa). These findings agree with the discovery of Webster and Wilson (1980) that rapidity of spread of downy mildew of maize is directly linked with warm and humid weather. On the other hand, early maize growing period recorded the highest minimum temperature of 22.8° C and wind run of 137.8 km per hour. The growing period of fadama maize recorded the lowest rainfall of 18.9mm/month, relative humidity of 35.6%, and lowest wind run of 123.3km per hour. However, temperatures and evaporation are high. The highest maximum temperature and soil temperature of 34.3° C and 31.1° C were recorded and evaporation attains 8.5mm/day level.

Since only late maize is vulnerable to downy mildew outbreak in Ilorin and its environ, one may suggest that rainfall amount, relative humidity, wind and evaporation play significant role in the outbreak of downy mildew disease.

The climatic pattern during various maize planting periods for years which experienced no outbreak of downy mildew diseases (1985 - 1989) and those years which experienced outbreak (1990 - 1994) were also compared (Table IVb and IVc).

Table VIb: Average Climatic Pattern During Various Maize Planting Periods For Years Which Experienced No Outbreaks Of Downy Mildew Disease (1985-1989)

Type of maize cropping	Growing period	Rainfall amount (mm/mo)	R.H (%)	Maxi temp (°c)	Mini Temp (°c)	Wind (Km/hr)	Soil temp (°c)	Evaporation (mm/day)
Early Maize	March-June	121.0	60.3	33.8	23.0	129.8	27.6	5.1
Late Maize	June-October	238.0	72.1	30.3	21.4	126.3	25.0	3.0
Dry Season (fadama) Maize	Nov-March	24.5	32.6	34.3	21.2	118.6	31.1	7.9

Source: Author's computation 2002.

Table VIc: Average Climatic Pattern During Various Maize Planting Periods For Years Which Experienced Outbreaks Of Downy Mildew Disease (1990-1994)

Type of maize cropping	Growing period	Rainfall amount (mm/mo)	R.H (%)	Maxi temp (°c)	Mini Temp (°c)	Wind (Km/hr)	Soil temp (°c)	Evaporation (mm/day)
Early Maize	March-June	136.0	75	32.8	22.6	143.2	28.7	5.4
Late Maize	June-October	216.6	82.5	29.4	21.4	138.0	23.8	2.6
Dry Season (fadama) Maize	Nov-March	15.5	60	34.2	20.8	124.7	32.6	8.4

Source: Author's computation 2002.

This was done to further shed light on the role each climatic variable plays on the outbreak of the disease (Table VIb and VIc). The climatic pattern displayed when the period of study was considered as a whole (1985 - 1994) differs slightly from the climatic pattern observed when this period was grouped into five years of no outbreak of downy mildew disease (Table IVb) and another five years which witnessed outbreak of the disease (Table IVc). For instance during the late maize growing period, higher rainfall amount of 238.0mm was recorded when there was no outbreak of downy mildew as compared with 216.6mm when there was outbreak. However, higher relative humidity of 82.5%, lower maximum temperature of 29.4°C, higher wind run of 138.0km/hour and lower evaporation of 2.6mm/day were observed when there was outbreak. This suggest that rainfall amount may not be as significant as relative humidity in outbreak of downy mildew disease of maize. These observations call for further investigation into the relationship between downy mildew outbreak

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Table VII:
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and these climatic parameters in order to isolate the parameter (s) that is most crucial for the outbreak hence, the result of a correlation analysis carried out is presented in Table VII.

Table VII: Correlation Between Climatic Parameters And Outbreak Of Downy Mildew Disease In Ilorin And Its Environ.

Climatic Parameter	Correlation Coefficient (r)	Remark
Rainfall (mm)	+ 0.231	Mild positive
Relative Humidity (%)	+0.722*	Strong positive
Maximum Temp ($^{\circ}$ C)	-0.574*	Strong negative
Minimum Temp ($^{\circ}$ C)	+0.279	Mild positive
Evaporation (mm/day)	-0.642*	Strong negative
Wind (km/hrs)	+0.711*	Strong positive
Soil Temperature at 10cm depth ($^{\circ}$ C)	-0.061	Mild Negative

Source: Author's field survey 2002. * Significant at 95% confidence level.

The result of correlation coefficient carried out is presented in table VII above. The result revealed relative humidity, wind run, evaporation and maximum temperature as the climatic variables having the strongest relationships with outbreak of downy mildew disease. Relative humidity displayed strongest positive relationship followed closely by wind run (+0.722 and +0.711). On the other hand strongest negative relationship was displayed by evaporation and followed by maximum temperature (-0.642 and -0.574), thus confirming the findings in Tables VIb and VIc.

The implication of the above findings is that as relative humidity and wind speed increase the outbreak of downy mildew becomes more severe. On the contrary severity in outbreak diminishes with rise in evaporation rate and maximum temperature.

Conclusion and Planning Implications

The link between climate and maize downy mildew disease was established in this study based on data analysed for Ilorin and its environ. It was found that hot and subhumid weather precedes the outbreak, that during outbreak the weather is warm and humid while the weather after outbreak can be described as hot and dry. Correlation analysis carried out showed relative humidity to have the strongest positive relationship with maize downy mildew disease followed closely by wind run while high evaporation and high daytime temperature do not encourage the incidence of the disease.

From the foregoing discussions, two planning options suggest themselves:

- (a) Discontinuation of planting late maize. (b) Application of technology to control outbreak of downy mildew during the period of planting late maize.

Since Nigeria is not yet self-sufficient in feeding its rapidly growing population, the latter would seem to be a better option.

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