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Original Article

Influence of Some Cultural Practices on the Incidence of Leaf Spot Disease in *Telfairia Occidentalis*

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ABSTRACT

Leaf spot disease, caused by *Phoma sorghina*, is the most common and economically important disease in *Telfairia occidentalis*. Limited information is available on the influence of cultural practices on disease control. It is against this backdrop that a field study was conducted in July 2019 and 2020 to investigate how cultural practices viz.: tillage systems and sowing dates, could be harnessed in the management of the disease. A randomized complete block design with three replications and four planting dates was used. The soil physicochemical properties were also determined. Data for disease incidence were submitted to analysis of variance and the means were separated by Duncan's multiple range test at a 95% confidence interval. Calculations for disease incidence and statistical analysis were conducted using the Microsoft Excel program and SPSS, version 23 respectively. It was established that the zero tillage system registered a significantly lower ($p < 0.05$) leaf spot disease incidence than the tilled field. The second sowing date in the zero tilled fields recorded the least disease incidence compared to other sowing dates investigated during the study.
Therefore, both zero tillage and sowing date two if well implemented can better control leaf spot disease and increase productivity.

Keywords: Cultural practices; incidence; leaf spot; *Telfairia occidentalis*.

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INTRODUCTION

Telfairia occidentalis Hook. f. (fluted pumpkin) is one of the highly prized vegetable crops in Cameroon. Growing *T. occidentalis* strongly enhances the livelihoods of poor resource base farmers because it can be harvested and sold throughout the year at weekly intervals. The crop plant has inherent immense nutritional and medicinal values (Odiaka and Schippers, 2004; Kayode and Kayode, 2011), with the potentials of being used industrially as a food supplement (Odiaka and Schippers, 2004).

However, sustainable production is greatly constrained by various diseases each year, of which leaf spot (causal agent: *Phoma sorghina*) in the field is the most important (Annih *et al*., 2020; Mbong *et al*., 2021). Leaf spot disease is one of the most important limiting factors for the cultivation of the seed and leaf vegetable crop in tropical and subtropical areas (Bassey and Opara, 2016).

In the field, leaf spot appears within three weeks after emergence and continues throughout the life of the plant in the field. The translucent white spots enlarge, turn brown and shatter, leaving the leaves with perforations. Under severe attack, the entire leaf dies (Udo *et al*., 2013). The pathogen attacks the leaves of the crop and produces localized lesions of dead or collapsed cells with the consequent effect of reducing the leaf lamina. This has the effect of limiting production and degrading its quality, thereby reducing its market value and profitability. Farmers therefore often face substantial plant losses before harvesting with severe economic losses. In addition, infection of leaves by the pathogen also significantly reduces the nutrient content (Udo *et al*., 2013).

Subsistence farmers in developing countries, including Cameroon, have very few options for the control of leaf spot disease on their crops. A few disease management techniques have been reported in the control of leaf spot disease. Nwufo and Ihejirika (2008), reported that synthetic fungicides can be used in the management of the disease under field conditions. Biweekly spraying of cocktails of synthetic fungicides, the authors argued, was significant in reducing disease incidence in the field. However, the fungicides threaten farmers' health and environment and lead to resistance development of the pathogen against the pesticides while they also impact non-target and beneficial organisms. The chemicals are also not cost-effective (Godwin-Egein *et al*., 2015). In addition, the poor farmers even lack expertise and other accessories in the usage of these chemicals (Udo *et al*., 2013). Improper use of such chemical has led to residue accumulation *on T. occidentalis* (Mbong *et al*., 2019), which may have intoxicating effects in the body when the vegetable is consumed. With limited preferences as such, the subsistence farmers therefore rely mainly on cultural practices as an important aspect of leaf spot disease control. The drawbacks and the growing desire for organic produced food devoid of synthetic chemicals necessitate the need for alternative disease control that are available, cheap, safe and environment friendly.

An evaluation of the cultural disease management methods, to control the disease, such as soil tillage systems and planting date, could help to develop better strategies. In Cameroon, the tillage systems and sowing dates are commonly used as cultural practices. *T. occidentalis* is cultivated on zero-till soil or on till soil on mounds. To safeguard sufficient supplies of the leafy vegetable during the dry season, when the demand is very high, many farmers tend to set up production farms at different planting dates in July. Ibeawuchi *et al*., (2016) reported that demand for *T. occidentalis* is throughout the year, with a significant rise in the dry season, when the market value of produce is very high. In some instances, the farmers most often, in an incessant quest for maximizing time, resort to cutting down or getting rid of any existing vegetation followed by punching and sowing without tilling the soil. Other farmers, however, resort to tilling the soil and constructing mounds before sowing. Some studies have been conducted on the role tillage practices play in the growth and yield of *T. occidentalis* (Okeke *et al*., 2016). The crop performs well in terms of vegetative growth in tilled and zero-tilled soils. Okeke *et al*., 2016, reported that *T. occidentalis* planted on zero-tilled plots competed in terms of growth rate with *T. occidentalis* planted on mound-tilled plots. In another study, Kone *et al*. (2017), reported that sowing date is an important disease management strategy in tropical climates. The authors added that sowing date-based strategies have been successfully used in the avoidance or management of crop plant diseases. Sowing dates have earlier been reported to reduce the effects of diseases on cowpeas (Yayock *et al*., 1988). Limited information is however available on the effect of sowing dates on the incidence of leaf spot disease on *T. occidentalis*. Therefore, there is a knowledge gap on the use of a particular tillage system and specific planting date(s) in managing leaf spot disease of *T. occidentalis* by farmers in Cameroon. Agricultural investors are therefore completely unaware of how the commonly employed soil tillage systems and planting time could be masterminded in the management of leaf spot disease. This is compounded by the fact that reliable data are largely unavailable and the literature on these cultural management techniques is very scant.

In this study, we attempted to evaluate the effectiveness of soil tillage systems and sowing dates in the management of leaf spot disease in *T. occidentalis*.

MATERIAL AND METHODS

Area of Study

The field study was set up in the locality of Santchou within the farming seasons of 2019 and 2020 at the Institute for Agricultural Research and Development (IRAD), research and seed multiplication field in July.

Santchou is located between 5°16′N and 9°58′E. It has an altitude of 786 m with a surface area of 95.05 km^2. The annual average temperature in Santchou is 22.5 °C. Its annual average precipitation is 1,364.4 mm with a relative humidity of 92% (Bamou *et al*., 2021). Santchou has very complex vegetation, and its climate is equatorial to the Guinean type (Santchou council development plan, 2015), similar to the Littoral and Southwest regions, which are hosted by several cultivators of *T. occidentalis*. Rains are heavier from mid-August to October and lower from March to June (Bamou *et al*., 2021). The study area is characterized by two main seasons: the dry season, which runs from mid-November to March, and the rainy season, which runs from March to November.

Experimental Design

The experiment for the two years was laid out in a randomized complete block design (RCBD), with 36 experimental units laid out in three blocks. The factors were two tillage systems and four sowing dates. Within each block, three experimental units were selected randomly and sowed for each of the four separate sowing dates. The experiment was laid out over a surface area of 121 m^2. Each experimental unit measured 2.25 m^2. The experimental units and blocks were both separated by alleys of 0.4 m. The experimental layout for each planting season was the same.

Soil sample analysis

Just before the study was conducted, soil samples were collected randomly with the aid of a soil auger at depths of 0 – 20 cm from the topsoil. The soil samples were scrupulously mixed to obtain a composite sample and taken to the laboratory for physicochemical analysis before field preparation. The soil physical and chemical components were all determined at the Laboratory of Soil Science and Environmental Chemistry of the Faculty of Agronomy and Agricultural Sciences (FASA), University of Dschang. The procedure for soil sampling analysis was conducted with the aid of the publication of Van Reeuwijk (2002).

The soil particle size was determined by using the hydrometer method as described by Rowell (1994). The soil pH was determined using a glass electrode pH meter in a 1: 2.5 soil to water ratio as described by Almaz *et al*., (2017). The cation exchange capacity (CEC) was determined as a direct continuation of exchangeable base determination as described by Pauwels *et al*., (1992). The cation exchange capacity was calculated using the formula:

$CEC = (V_1N_1 - V_2N_2)\ x\ \frac{100}{w}$ where V_1 = volume of standard acid in ml taken initially for ammonia adsorption; N_1 = normality of standard acid; V_2 = volume of standard base in ml, used in back titration of excess acid; N_2 = normality of standard base; w = mass of soil sample in grams.

The amount of available phosphorus in the soil samples was determined using the Bray 2 method described by Pauwels *et al*., (1992). The total nitrogen was determined by making use of the Kjeldahl method (AOAC, 2000). The total nitrogen was calculated using the following equation:

$$\text{Total nitrogen (\%)} = 14 \; \boldsymbol{x} \; (V - V_0) \; x \; N \; x \; \frac{0.1}{m}$$

Where V = volume of 0.01 N H_2SO_4 added to the sample; V_0 = volume of 0.01 N H_2SO_4 added to the standard; N = normality of H_2SO_4; m = mass of soil sample used; 0.1 = correction factor.

The percentage of organic matter in the two soil samples was taken as an average of 58% organic carbon. Its content was calculated from the percentage of organic carbon as shown in the following equation:

$$\text{Percentage organic matter} = \text{percentage organic carbon} \; \boldsymbol{x} \; 1.724$$

Where: 1.724 is a cofactor

The soil organic carbon was determined by Walkley and Black's method (1934). Mathematical calculations were made to determine the amount of organic carbon present in the soil sample using the following equation:

$$\text{Percentage organic carbon} = 40 \; x \frac{(a-b)}{a \; x \; w}$$

where 40 is a cofactor; a = volume of hydrated iron; (ii) sulfate added to the control sample; b = volume of hydrated iron; (ii) sulfate added to the soil sample; w = mass of soil sample in grams.

Planting Material

Intact and mature *T. occidentalis* fruit pods for seeds, harvested from senescent shoots from an intercropped farm in the town of Dschang (Mbong *et al*., 2021), were used as planting material. A minimum number of fruit pods of the same cultivar required for the research were harvested. To extract the seeds, pods were cut open with the aid of a knife, and the seeds were carefully isolated from the pulp manually. The seeds, spread out on a dry surface, were air-dried for two days to prevent decay before sowing. The seeds used in the subsequent year were of the same cultivar. The experimental research and field studies of the cultivated crop plant, including the collection of planting material were within institutional, national, and international guidelines and legislation.

Field Preparation

Separate fields each measuring 121 square meters at the IRAD research field in Santchou were manually cleared of the weeds. The cleared debris was removed and dumped beyond the field experiment. In one of the fields, a hoe was later employed to uniformly plow the field to facilitate the construction of regular experimental units. A decameter, pegs, and cords were exploited to demarcate the tilled field into experimental units, and hoe was again made use of to set up mounds of 1.5 m x 1.5 m separated by passageways of 0.4 m.

In the second field, blocks and experimental units were delineated into three blocks comprising 36 experimental units. The dimensions were all similar to those obtained in the tilled field, and a decameter, pegs, and strong thick cords were used to facilitate the process. In both tilled and no-tilled fields, plots were identified with labeled tags to distinguish each experimental unit as per the sowing date for a methodical and quality disease assessment and ideal follow-up in the field.

Sowing of seeds

The topsoil was used as substrate for sowing. Healthy air-dried seeds were taken to the field and sown by direct seeding at a depth of 3 - 4 cm and covered with topsoil on each experimental unit at a rate of 1 m x 1 m. Four seeds were sown per experimental unit.

For each year, four sowing dates were chosen and staggered seven days apart to determine the most appropriate time that sowing the crop produces minimal leaf spot disease incidence. The four sowing dates were July 4th, 11th, 18th, and 25th for the first, second, third, and fourth sowing dates respectively.

Crop maintenance in the field

After the four-week sowing string, the field was constantly monitored for weed removal and staking with advancing growth. The removal of weeds commenced two weeks after emergence in the field. This was achieved manually once every fortnight to ensure optimal growth voids of other plant competitors and for better monitoring of disease parameters in the field.

Staking with the aid of pegs locally harvested in the vicinity of the field was initiated at three weeks after emergence and continued for an additional period of two weeks. The pegs were trimmed to a height of 1 m. The staked stands were tied with robes drawn from plantain stems. This was meant to train the clambering vines to the trellis and to facilitate their creeping pattern. Bamboo trellises were constructed for each experimental unit to serve as a supporting platform for optimal crop growth and ideal disease assessment.

Data Collection

Disease Assessment in the Field

Disease incidence in the field was established by visual observations of symptoms of *T. occidentalis* leaf spot on the leaves. Data collection for disease incidence commenced three weeks after emergence and was documented for eight weeks. In the process, diseased leaves and the totality of leaves for each stand were counted, and the information was meticulously documented.

Calculations for Disease Incidence

The information recorded in the field was used to calculate the percentage of the proportion of leaves infected per plant within the speculated period using the following formula for disease incidence (DI):

$$\text{Disease incidence} = \frac{\text{Number of leaves infected}}{\text{Total number of leaves sampled}} \times 100\ \%$$

Statistical Analysis

The information documented on the total number of leaves and number of diseased leaves from each stand at the corresponding sowing date was submitted to analysis of variance (ANOVA), and the means were separated by Duncan's multiple range test (DMRT) at a 95% confidence interval. The disease incidence was calculated using the Microsoft Excel program, while SPSS was used for ANOVA.

RESULTS AND DISCUSSION

Results

Soil physiochemical properties

The preliminary status of the soil analyzed before the commencement of the field preparatory activities revealed that the soil was subtlety fertile about the physical and chemical properties (Table 1).

Table 1: Physicochemical properties of the soil

Parameter	Property
pH_{water}	6.0
pH_{KCl}	5.4
Organic carbon (%)	5.42
Organic matter (%)	9.35
Nitrogen (g/kg)	3.27
C/N	17
Calcium (meq/100 g)	3.68
Magnesium (meq/100 g)	12.32
Potassium (meq/100 g)	0.31
Sodium (meq/100 g)	0.16
Sulphur (meq/100 g)	16.47
Phosphorus (mg/kg)	16.28
CEC (meq/100 g)	25.37
Sand (%)	48
Silt (%)	24.5
Clay (%)	27.5

Comparative assessment of leaf spot disease incidence at sowing dates in the tillage systems

Statistical analysis revealed that the disease incidence was rife when *T. occidentalis* sowed on the third sowing date (July 23rd) in the tilled field. In contrast, the second sowing date in the tilled field, corresponding to July 11th, recorded a very low leaf spot disease incidence.

The least leaf spot disease incidence (13.29 %) observed at the second sowing date of the investigation in the zero-tilled field was statistically different from disease incidences documented in the study, with no signification. In contrast, the highest disease incidence (33.49 %) observed when the perennial vegetable was planted in the tilled field on the third sowing date was statistically dissimilar, yet not significant, from all incidences registered during the investigation.

However, the disease incidences documented when the highly prized leafy vegetable was planted at sowing dates two and four in the zero tilled fields, including the third sowing date in the tilled field, recorded relatively low and statistically related disease incidences that were dissimilar from the incidences registered at sowing dates one and four in the tilled and zero tilled fields respectively (Table 2).

Table 2: Disease incidence according to treatments for both seasons and mean values

Year	Tillage system	Sowing date	DI (%)	SEM	*p*-value	Mean DI (%)	SEM	*p*-value
2019	Till	July 04	43.46	1.64	0.12	26.46	1.40	0.06
2020			9.46	1.06	0.20			
2019	No-till		37.00	1.56	0.62	25.33	1.27	0.06
2020			13.66	1.47	0.16			
2019	Till	July 11	38.15	1.72	0.62	26.17	1.30	0.06
2020			14.19	1.34	0.16			
2019	No-till		19.47	1.64	1.00	13.29	1.08	1.00
2020			7.12	1.20	0.20			
2019	Till	July 18	47.22	1.44	0.12	33.49	1.28	1.00
2020			19.77	1.38	0.06			
2019	No-till		29.79	1.54	0.66	25.01	1.14	0.06
2020			20.22	1.58	0.06			
2019	Till	July 25	30.79	1.88	0.66	23.30	1.16	0.06
2020			15.81	1.01	0.16			
2019	No-till		29.68	1.70	0.66	23.11	1.12	0.07
2020			16.54	1.24	0.06			

% = percentage

SEM = Standard error of mean.

p = probability value for statistical significance.

DI = disease incidence

Assessment of disease incidence between tillage systems

In the study conducted, *T. occidentalis* planted in the zero tilled field recorded a significantly ($p < 0.05$) low leaf spot disease incidence compared to the incidence observed in the tilled field during the investigation (Table 3).

Table 3: Disease incidence between tillage systems

Year	Tillage system	DI (%)	SEM	*p*-value	Mean DI (%)	SEM	*p*-value
2019	Till	39.90	0.88	< 0.001	27.35^{a}	0.65	< 0.001
2020		14.81	0.62	0.65			
2019	Zero till	28.99	0.84	< 0.001	21.69^{b}	0.59	< 0.001
2020		14.39	0.72	0.65			

$^{a,\,b}$ Means in the same column with the same superscript are not significantly different at $p > 0.05$ (DMRT).

% = percentage

SEM = Standard error of mean.

p = probability value for statistical significance.

DI = disease incidence

Comparison of disease incidence between the years of the study

During the second year, 2020, of the investigation, a significantly ($p < 0.05$) low leaf spot disease incidence was established compared to the incidence registered in the second year of the investigation (Table 4).

Table 4: Disease incidence in the study period

Year	Disease incidence (%)	SEM	*p*-value
2019	34.45^{a}	0.63	< 0.001
2020	14.60^{b}	0.47	< 0.001

$^{a,\,b}$ Means in the same column with the same superscript are not significantly different at $p > 0.05$ (DMRT).

% = percentage

SEM = Standard error of mean.

p = probability value for statistical significance

DISCUSSION

The study established the vulnerability of *T. occidentalis* to leaf spot disease under field conditions. The nitrogen content of the soil was found to be very high. Adequate nitrogen levels are necessary for disease resistance. However, Rajan and Sudhir (2020), explained that excess nitrogen may promote favorable conditions for plant disease. The authors argued that excess nitrogen promotes thinner and weaker cell walls and delays the maturity of plant tissues and therefore increases the risk of disease infection and development. Ekwere *et al*., in 2019 reported that the total percentage of nitrogen recommended by Black (1965), as the critical value for good crop production, is 2 %. The nitrogen in the soil was therefore in excess. The excess soil nitrogen therefore aided in rendering *T. occidentalis* stands more predisposed and coupled with suitable environmental conditions, except for sowing date two, when the disease incidence was high. The prevalence of leaf spot disease was further compounded in the tilled field, which was characterized by a more humid microclimate compared to the zero-tilled experimental units.

In addition, the amount of phosphorus in the soil available for the crop was high. However, its role in resistance is variable and seemingly inconsistent. Jones *et al*., in 1989 stated that increasing phosphorus rates above the level needed for plant growth increased the prevalence of *Fusarium* wilt in cotton and muskmelon. In this study, the high phosphorus content of the soil could have favored a high leaf spot disease incidence in the field when climatic conditions became more suitable for rapid and new infections to occur particularly during the first, third, and fourth sowing dates of the study.

The findings in this study revealed that the zero-tilled field registered a lower leaf spot disease incidence than the tilled field. This result is unique in its kind and innovative in the management of leaf spot disease in *T. occidentalis*. Previous investigations by Edna and Ime (2017) obtained other results. Contrary observations were also reported by Charles (2005). Despite the advantages of soil tillage as highlighted by Edna and Ime (2017), the growing stages of the stands in this study in the tilled field could have been more susceptible to infection by *Phoma sorghina*. In addition, the microclimatic conditions could have been more conducive.

Santchou is characterized by a terrain that is low land and extensively flat, which makes drainage following intense precipitation within this period virtually impossible, if not difficult. As the rainy period progressed and became increasingly intense, the land became inundated. This period coincided with the short season when the study was being conducted. During this period, high rainfall caused the water table to rise significantly, and with no drainage pathways due to the uniformly flat nature of the terrain, floods became unavoidable. In effect, the field was submerged in water. In addition, the soil became completely soaked and soggy, with the result that the microclimate of the field was modified with conditions rendered more humid and sustained throughout the short season. A buildup of these uninterrupted humid conditions could have been particularly significant where the field was tilled. This observation is consistent with the findings of Edema *et al*. (1997), who reported that the high incidence of scab and anthracnose was probably due to a relatively humid microclimate, which favors epidemics of these diseases. Soil tillage loosens the soil, creating pores and spaces for water to readily seep and flood the topsoil. These very high and persistent humid conditions could have facilitated the rapid multiplication of the leaf spot pathogen, and with a large number of spores produced coupled with the susceptibility of the growing stages of the crop in the field, fresh infections were inescapable. This consequently led to a heightened leaf spot disease incidence that was cataloged in the tilled field.

Furthermore, Ashley *et al*. (2018) reported that species of *Phoma* are widely distributed in the environment, most commonly found in aquatic systems and soil. The highly flooded field could have therefore been host to an important number of inoculum, and weather conditions were encouraging for the pathogen to prevail and cause infection. Earlier findings by Bonzi *et al*. (2013) and later Lin *et al*. (2015) confirmed that the optimum temperature for the growth of mycelial spores of *Phoma sorghina* lies in the range of 20 - 25°C. The average temperature in Santchou that prevailed within the study period was within the range of 20 - 25°C, and it is probable that this temperature highly favored conidial germination and further multiplication of the pathogen within a very short period. This could have therefore resulted in a very high inoculum density, and coupled with the vulnerability of the perennial vegetable plant, further heightened the infection rate within the host plants, resulting in the high disease incidence in the tilled field.

The second sowing date within the zero-tilled fields recorded a very low and statistically significant leaf spot disease incidence. This result highlights the vital relationship between tillage systems and adjustment of sowing dates in the prevalence of crop diseases under field conditions. This present study revitalizes the investigations of Nwufo (1992), who reported that disease incidence was significantly affected by different planting dates.

The findings in this study confirm the holistic aspect (tillage systems and adjustment of sowing dates) of the management of plant diseases by creating an environment more suitable for plant growth but not for disease development. The second sowing date within which *T. occidentalis* leaf spot disease incidence was minimal could have coincided with growing stages of the crop that were less susceptible, more resistant, to infection and spread of the leaf spot pathogen, resulting in leaf spot disease avoidance. The results in this study are also in agreement with previous investigations carried out and reported by Akhileshwaria *et al*. (2012). The researchers affirmed that the adjustment of planting dates is an important cultural practice that can be exploited to minimize crop losses due to disease. The authors intimated that there was a decrease in powdery mildew severity in sunflower following strategic manipulation of sowing dates. The authors ascertained that such a cultural technique avoided coincidence with the susceptible stage of the crop, consequently resulting in disease escape. Subsequent reports by Apeyuan *et al*. (2017) confirmed that strategic alteration in planting dates was effective in the control of some plant diseases. Previous reports (Mbong *et al*., 2010, Jitendiya and Chhetry, 2014) established that sowing dates significantly influenced the epidemiology of crop diseases under field conditions. The observations established in this study and other empirical studies, as reported by Mbong *et al*. (2010), Jitendiya and Chhetry (2014), and Apeyuan *et al*. (2017), further confirm the fact that this cultural disease management technique, manipulation of planting time, is vital in reducing food crop diseases under field conditions.

Furthermore, the observations in this study are similar to the earlier empirical viewpoints of Helen and Michele (1997), who reported that changing the usual sowing time of a crop can exploit weather conditions that are not favorable for the spread of pathogens and reduce crop losses.

The very high disease incidence observed on the third planting date could be due to a more favorable microclimate and very high vulnerability of the growing stages of crop plants to infection. Therefore, the more conducive microclimate coupled with a conceivably high initial inoculum population could have encouraged the proliferation of the already populated fungal spores and their germination and rapid multiplication, which favored new and rapid infections, resulting in extremely high leaf spot disease incidences and severities. These results corroborate previous investigations of Kone *et al*. (2017), who suggested that warm and humid weather conditions favored the propagation of disease in cucurbits under field conditions. In addition, Ilondu (2013) acknowledged that leaf spot diseases are favored by humid weather conditions, where they destroy a greater portion of the foliage. Humid conditions are required for spore germination. With warm and massively humid conditions, as was the case in this study, the spores readily germinated within a brief period, resulting in further spread of the disease among the more vulnerable stands.

CONCLUSION

In this study, it was established that the zero tilling technique significantly reduced leaf spot disease incidence under field conditions. In addition, the second sowing date (July 11) investigated proved better in minimizing the prevalence of the disease in the field. These cultural disease management techniques which have never been exploited in the management of leaf spot disease of *T. occidentalis* if properly implemented will significantly reduce leaf spot disease and increase crop yields.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

ETHICAL STANDARD

We state that this research complies with ethical standards.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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AUTHORS' CONTRIBUTIONS

1. Andrew Kebei Kpu carried out the field study, analyzed and wrote the manuscript.
2. Mbong Grace Annih conceptualize, developed the methodology and supervised the field study and recorded the disease assessment parameters to ensure that the research was carried out within the ethics that govern scientific research of this magnitude.
3. Agyingi Lucy Ambang – supervised the field and edited the manuscript.

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